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Draft Feasibility Study

Peterson/Puritan, Inc. Superfund Site – Operable Unit 2

Cumberland and Lincoln, Rhode Island

March 2013

Revised July 2014

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STATEMENT OF LIMITATIONS

This Draft Feasibility Study (FS) for the Peterson Puritan Superfund Site - Operable Unit 2 in Cumberland and Lincoln, Rhode Island (dated July 2014) is a revision of the version prepared by Arcadis in March 2013, for the PRP Group under the requirements of the Administrative Order by Consent (AOC), U.S. EPA Docket No. 1-87-1064, May 29, 1987; as amended. Revisions were made to the March 2013 version by the United States Environmental Protection Agency (EPA) with assistance from its oversight contractor, AECOM.

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Executive Summary

This *Feasibility Study* (FS) documents the results of the screening and selection of alternatives for the Peterson/Puritan, Inc. Superfund Site – Operable Unit 2 (OU2), located in the towns of Cumberland and Lincoln, Rhode Island (site). As currently defined, OU2 is approximately 5,600 feet long and varies in width from approximately 1,200 to 1,900 feet, which corresponds to a total area of approximately one third of a square mile, or 200 acres. Collectively, the areas today known as the J.M. Mills Landfill, the Nunes Parcel, and the Unnamed Island were owned and operated by Joseph and Linda Marszalkowski through their business of J.M. Mills, Inc., during the time of disposal from approximately 1954 to 1986 and together are defined as the principal source of contamination found at OU2.

Preliminary conclusions based on OU2 characterization, risk assessments, development of Preliminary Remediation Goals (PRGs), and applicable or relevant and appropriate requirements (ARARs) review have been reached:

- *J.M. Mills Landfill* – Conditions and risk identified at the J.M. Mills Landfill support a presumptive containment approach. The presumptive approach is appropriate when waste is present in large volumes and is a heterogeneous mixture of municipal waste co-disposed with industrial waste.

  The general principals of the presumptive approach relates primarily to containment of the landfill mass and collection and/or treatment of landfill gas. In addition, measures to control landfill leachate, affected groundwater at the perimeter of the landfill, and/or upgradient groundwater that is causing saturation of the landfill mass may be implemented as part of the presumptive approach. The presumptive containment approach does not address exposure pathways outside the source area (landfill), nor does it include the long-term groundwater response action.

  Site conditions, as well as other information, indicate that large volumes of industrial and commercial waste, and some municipal waste, were disposed of at the J.M. Mills Landfill. Subsurface waste deposits are a principal source of contamination at the J.M. Mills Landfill. The estimated volume of waste in the main area of the landfill is approximately 2 million cubic yards (cy). The areal extent of the waste deposits is fairly defined and has been generally mapped based on available data. Soil with elevated levels of cadmium that present an unacceptable ecological risk will be included as part of the presumptive approach. Soil with exceedances of Rhode Island Department of Environmental Management's (RIDEM's) regulatory criteria will also be included as part of the presumptive approach. Recent data collection along the Blackstone River will provide additional understanding of the ecological risks and whether certain metals along the riverbank have an upstream origin.

Piles of surface debris are also sporadically distributed at locations within the J.M. Mills Landfill. Data collected from air emissions at the vents at the J.M. Mills Landfill suggest that there is some evidence of landfill gas generation that will be evaluated during remedial design.

During the remedial investigation, no active seeps were reported at the J.M. Mills Landfill. However, all sampling was conducted in mid-summer to late fall. During that time, active seeps are less obvious due to drier conditions and heavy vegetation, obscuring seeps and aiding in absorption of seeps.

- *Nunes Parcel* – Conditions and risk identified at the Nunes Parcel also support a presumptive containment approach. Site conditions, as well as other information, indicate that large volumes of industrial and commercial waste, and some municipal waste, were disposed of at the Nunes Parcel. Subsurface waste deposits are a principal source of contamination at the Nunes Parcel. The projected volume of buried waste is estimated to be approximately 56,000 cy. The areal extent of the waste deposits is fairly defined and has been generally mapped based on available data. Soil sampling has indicated there are also high levels of lead and other contaminants in surface soil that present an unacceptable human health risk, which will be included as part of the presumptive approach. Similarly, soil with exceedances of RIDEM's Direct Exposure Criteria and Leachability Criteria should also be included as part of the presumptive approach.

  Piles of surface debris are also sporadically distributed at locations within the Nunes Parcel. Some materials inventoried on the Nunes Parcel (i.e., motor capacitors and roofing shingles and liquids in 55-gallon drums and tanks) may require further testing during the remedial design stage to more accurately determine appropriate handling and disposal procedures. Finally, modeling was used in determining that there is the potential for elevated levels of some contaminants to occur in indoor air at certain portions on the property. This would need to be further evaluated with any remedy proposed at the site.

  Nunes Parcel (RIDEM Soil Removal Area) – Soil remaining near this area contains elevated levels of lead that present an unacceptable human health risk. Similarly, sampling has indicated that there are elevated levels of contaminants that exceed RIDEM's Direct Exposure Criteria and Leachability Criteria which will be included as part of the presumptive containment approach for the Nunes Parcel.

- *Unnamed Island* – Unique characteristics of this area and site conditions identified at the Unnamed Island do not support a presumptive containment approach. Although waste material disposed in this area is similar to that in the J.M. Mills Landfill and Nunes Parcel, the continual flooding of this area make it unsuited for a presumptive containment approach. Subsurface waste deposits are located on the Unnamed Island. The estimated volume of subsurface waste is approximately 40,000 cy. The areal extent of the waste deposits is fairly defined and has been generally mapped based on available data. Waste deposits are the likely source of contaminated sediment in ponds located on the Unnamed Island. Piles of surface debris are also sporadically distributed at locations on the Unnamed Island. Soil

sampling has indicated that there are elevated levels of BEHP, lead, and zinc in soil that present an unacceptable ecological risk, and soil with exceedances of RIDEM's regulatory criteria, which will be addressed.

- *Ponds* – Sediment and/or surface water contaminant concentrations are elevated in a number of ponds for one or more of the following contaminants: polycyclic aromatic hydrocarbons (PAHs), aluminum, barium, cadmium, copper, chromium, lead, manganese, and zinc. Of particular significance is the ecosystem located on the Unnamed Island, comprised of a series of vernal pools and ponds. These ponds may serve as "sinks" for both particulate matter entrained in the Blackstone River and site-related contaminants.

- *Groundwater* – Groundwater impacts have historically appeared across the site, although recent groundwater sampling has indicated a reduction in historic contaminant concentrations. Concentrations of a limited number of volatile organic compounds (VOCs) (primarily benzene), with most detections below applicable maximum contaminant levels (MCLs), have been observed at monitoring wells located at the toe of the J.M. Mills Landfill, primarily limited to its western end adjacent to the Blackstone River, and on the Unnamed Island and Nunes Parcel. Polychlorinated biphenyls (PCBs)/pesticides and semivolatile organic compounds (primarily PAHs) were detected at various locations across the site, and metals were detected at elevated levels at many site wells. Groundwater was not impacted at depths greater than approximately 30 feet below the water table. Furthermore, strong upward hydraulic gradients cause groundwater to preferentially discharge to the Blackstone River. There is no evidence of chlorinated VOC sources that have been observed in groundwater at Operable Unit 1 that have contributed to the conditions within the landfilled areas at OU2 in recent sampling events.

Other Areas Investigated

- *Blackstone River* – Although investigations of the Blackstone River indicate that contamination in both sediment and surface water is present in the river and that consumption of fish from the river presents health risks, these issues occur throughout the river and are not significantly different within the boundaries of OU2. As a result, there does not appear to be a significant site-related component to these problems, and specific alternatives will not be developed to directly address the Blackstone River (sediment, surface water, and biota), although actions that may be taken may have indirect impacts on the river by reducing contaminant contributions from the site. Measures will be considered to conduct public outreach, monitoring, and/or other actions related to fish consumption.

- *Quinnville Well Field and Southern Bank/Pratt Dam* – Sampling has indicated that there are elevated levels of BEHP, cadmium, lead, and zinc in soil, but the United States Environmental Protection Agency's (EPA's) ecological risk assessment refinement memoranda and human health risk refinement included in this FS concluded no current exceedance of risk criteria or unacceptable risk which would

drive a remedial action. Based on their locations relative to the site source areas and lack of a clear contaminant migration pathway, contaminants detected at these two areas are considered to be not significantly site-related. No action is necessary in these areas at this time.

- *Wetlands A-D* – The wetlands adjacent to the J.M. Mills Landfill (labeled A through D) are influenced by the Blackstone River during floods, although they do not appear to be influenced by groundwater transport from OU2 source areas. Based upon sampling data, these wetlands appear to be minimally impacted from OU2 activities, and based on the EPA's ecological risk assessment refinement memoranda, no action will currently be necessary.

Remedial Action Objectives (RAOs)

Based on the information provided above, the EPA has determined that general principals of the presumptive approach, in this case "containment," is applicable to the J.M. Mills Landfill and the Nunes Parcel. Based on a review of OU2 characterization data, the conclusions of the Human Health Risk Assessment (HHRA) and Baseline Ecological Risk Assessment (BERA), the applicable and relevant and appropriate ARARs, and the consideration of the presumptive containment approach, the following RAOs for each area are proposed for OU2:

Groundwater:

- Prevent potential exposure from ingestion/dermal contact/inhalation by a current or future resident to concentrations of contaminants in excess of ARAR and risk-based standards within the compliance boundary for the waste management area.

- Prevent migration of site contaminants in groundwater from beyond the edge of the compliance boundary of the waste management area.

- Prevent contaminant migration from the source areas to the Blackstone River via groundwater.

J.M. Mills Landfill:

- Prevent direct contact with landfill contents.

- Prevent direct human contact/ingestion/inhalation with contaminated soils that exceed ARAR standards.

- Prevent exposure to ecological receptors from soil contaminants that present an unacceptable ecological risk.

- Prevent soil leaching and landfill cover infiltration and resulting contaminant migration to groundwater.
- Control surface water runoff and erosion.
- Prevent infiltration and washout during flooding, up to a 500-year flood event.
- If necessary, collect and treat leachate to prevent further contaminant migration to the Blackstone River, based on federal and State water quality standards and Resource Conservation and Recovery Act (RCRA) Subtitle C landfill closure standards.
- Control and, if necessary, treat landfill gas, based on federal and state air pollution control standards and RCRA Subtitle C landfill closure standards.
- Prevent potential future exposure to contaminated indoor air.
- Prevent migration of contaminated soil/debris to pond sediment.

Nunes Parcel (including the RIDEM Soil Removal Area):

- Prevent direct contact with landfill contents.
- Prevent direct human contact/ingestion/inhalation with contaminated soils that exceed ARAR and risk-based standards.
- Prevent exposure to ecological receptors from contaminants in soil that present an unacceptable ecological risk.
- Prevent soil leaching and landfill cover infiltration and resulting contaminant migration to groundwater.
- Control surface water runoff and erosion.
- Prevent infiltration and washout during flooding, up to a 500-year flood event.
- If necessary, collect and treat leachate to prevent further contaminant migration to the Blackstone River, based on federal and State water quality standards and RCRA Subtitle C landfill closure standards.
- Control and, if necessary, treat landfill gas, based on federal and state air pollution control standards and landfill closure standards.

- Prevent potential future exposure to contaminated indoor air.
- Prevent migration of contaminated soil/debris to pond sediment.

Unnamed Island:

- Prevent direct contact with waste deposits.
- Prevent direct human contact with contaminated soils that exceed ARAR standards.
- Prevent exposure to ecological receptors from contaminants in soil that present an unacceptable ecological risk.
- Prevent soil leaching and resulting contaminant migration to groundwater.
- Prevent washout of waste/contamination during flooding, up to a 500-year flood event.
- Prevent migration of contaminated soil/debris to pond sediment.

Ponds:

Note that because of the periodic flooding of Ponds A, C, D, E, I, N, and P by the Blackstone River, it is not appropriate to directly address surface water in these locations. Instead, surface water exceedances will be addressed by remediating contaminant sources in sediment and from the landfills, with appropriate monitoring of surface water to ensure RAOs are achieved.

- Prevent exposure to ecological receptors from contaminants in sediment that present an unacceptable ecological risk.
- Minimize migration of contaminants from sediment to surface water that present an unacceptable ecological risk.
- Reduce contamination in surface water from CERCLA sources within OU2 to acceptable ecological risk levels.
- Prevent washout of contaminated sediment during flooding, up to a 500-year flood event.

Preliminary Remediation Goals/Performance Standards

The PRGs/Performance Standards have been developed to prevent exposure to groundwater, soils, and sediment with site-related contaminant concentrations above limits developed through the HHRA, BERA, and supplemental refinement memoranda, as well as in accordance with relevant ARARs.

Remedial Alternatives Development

Groundwater remedial alternatives were developed based upon a review of technologies and process options that were evaluated within the FS. The following groundwater alternatives were assembled and evaluated further.

Remedial Alternatives for Groundwater

Components	GW-1: No Action	GW-2: Limited Action (Monitoring)	GW-3: Active Remediation	GW-4: Active Remediation
No Action	X			
Institutional Controls (ICs)		X	X	X
Long-Term Monitoring		X	X	X
Phytoremediation			X	
Chemical Oxidation				X

Based on a review of groundwater monitoring results and the establishment of a groundwater compliance boundary around the site waste management unit, only two of the groundwater alternatives were carried through to detailed evaluation: GW-1: No Action and GW-2: Long-Term Monitoring.

A presumptive containment approach has been applied to the waste areas at the Nunes Parcel and the J.M. Mills Landfill.

By using the presumptive approach, the technology screening step is eliminated and the only alternatives considered are the appropriate components of a presumptive containment approach and the required No Action alternative.

A presumptive approach has not been applied to the areas of waste and soil impacts at the Unnamed Island.

The remedial alternatives for soil are developed based upon the presumptive approach for the J.M. Mills Landfill and the Nunes Parcel and the technologies and process options that were retained for the Unnamed

Island. To assemble the remedial alternatives, general response actions and the process options retained are combined. The following alternatives for soil have been assembled:

Remedial Alternatives for Source Area – J.M. Mills Landfill

Components	JM-SO-1: No Action	JM-SO-2: Presumptive Approach	JM-SO-3: Presumptive Approach
No Action	X		
Deed Restrictions		X	X
Fencing and Signage		X	X
Soil Removal from Riverbank and Floodplain with Bank Restoration		X	X
Full RCRA Subtitle C Cap		X	
Hybrid Landfill Cap			X

Remedial Alternatives for Source Area – Nunes Parcel

Components	NP-SO-1: No Action	NP-SO-2 Presumptive Approach	NP-SO-3: Presumptive Approach
No Action	X		
Deed Restrictions		X	X
Fencing and Signage		X	X
RCRA Subtitle D Cap (meeting RIDEM Solid Waste ARARs)		X	
RCRA Subtitle C Cap			X

Remedial Alternatives for Source Area – Unnamed Island

Components	UI-SO-1: No Action	UI-SO-2:	UI-SO-3:
No Action	X		
Deed Restrictions		X	
Remove/Consolidate waste/soil (0 to 2 feet) Exceeding PRGs		X	
Geotextile with Riprap		X	
Remove/Consolidate waste/soil Exceeding PRGs			X
Waste Removal			X

Sediment remedial alternatives are developed based upon a review of technologies and process options that were evaluated within the FS. The following sediment alternatives were assembled and evaluated further.

Remedial Alternatives for Sediment

Components	SE-1: No Action	SE-2: Sediment Removal to PRGs	SE-3: Sediment Removal and Subaqueous Cover	SE-4: Subaqueous Cover
No Action	X			
Deed Restrictions			X	X
Subaqueous Cover			X	X
Sediment Removal to PRGs		X		
Sediment Removal to 1 foot			X	

Remedial Alternatives Comparative Analysis

As noted above, based on a review of groundwater monitoring results and the establishment of a groundwater compliance boundary around the site waste management unit, only two of the groundwater alternatives were carried through for detailed evaluation: GW-1: No Action and GW-2: Long-Term Monitoring.

Each of the detailed alternatives discussed above for the source areas and sediments were carried through the detailed evaluation and the comparative analysis. Table ES-1 presents a brief summary of the comparative analysis performed.

Acronyms and Abbreviations

AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
BBL	Blasland, Bouck & Lee, Inc.
BEHP	bis(2-ethylhexyl)phthalate
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
bgs	below ground surface
CalEPA	California Environmental Protection Agency
C-EE	C-E Environmental
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/sec	centimeters per second
COC	contaminant of concern
CSF	cancer slope factor
CSM	Conceptual Site Model
CWA	Clean Water Act
cy	cubic yards
DDT	dichlorodiphenylthrichloroethane

DEC	Direct Exposure Criteria (RIDEM)
DF	debris field
EPA	United States Environmental Protection Agency
^{o}F	degrees Fahrenheit
FS	*Feasibility Study*
ft	feet
GCL	geosynthetic clay liner
HELP	Hydrologic Evaluation of Landfill Performance
HHRA	human health risk assessment
HI	hazard index
IC	institutional control
IRIS	EPA's Integrated Risk Information System
LEDPA	least environmentally damaging practical alternative
MassDEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
mg/day	milligrams per day
mg/kg	milligrams per kilogram
MOM	management of migration
NAWQC	National Ambient Water Quality Criteria
NCP	National Contingency Plan
NGVD29	National Geodetic Vertical Datum of 1929

NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OHEA	EPA's Office of Health and Environmental Assessment
OSWER	Office of Solid Waste and Emergency Response
OU1	Operable Unit 1
OU2	Operable Unit 2
O&M	operation and maintenance
P&W	Providence and Worcester (Railroad)
PAH	polycyclic aromatic hydrocarbon
PAL	project action level
PAL Report	Public Archaeology Laboratory, Inc. Report
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PRG	Preliminary Remediation Goal
PS	Performance Standard
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RI Report	*Remedial Investigation Report*

RIDEM	Rhode Island Department of Environmental Management
RIDOT	Rhode Island Department of Transportation
ROD	Record of Decision
RSL	Regional Screening Level
SGA	Substrate Growth Area
Shield	Shield Environmental Associates, Inc.
SLERA	Screening-Level Ecological Risk Assessment
SQT	sediment quality triad
SVOC	semivolatile organic compound
TBC	to be considered
TCE	trichloroethene
TMDL	Total Maximum Daily Load
TSCA	Toxic Substances Control Act
µg/dL	micrograms per deciliter
USCS	Unified Soil Classification System
USGS	United States Geological Survey
VOC	volatile organic compound
WWTP	waste water treatment plant

1. Introduction

This *Feasibility Study* (FS) documents the screening and the evaluation of remediation options for the Peterson/Puritan, Inc. Superfund Site – Operable Unit 2 (OU2) (United States Environmental Protection Agency [EPA] ID #RID055176283), located in the towns of Cumberland and Lincoln, Rhode Island (site).

This FS has been reviewed and revised as appropriate by EPA from a draft submittal prepared by ARCADIS on behalf of the performing Potentially Responsible Parties consisting of KIK Custom Products, Inc. (formerly CCL Custom Manufacturing, Inc., and prior to that, Peterson/Puritan, Inc.), Conopco, Inc. d/b/a Unilever (formerly Bestfoods and prior to that CPC International, Inc.), Waste Management of Massachusetts, Inc., Waste Management Disposal Services of Massachusetts, Waste Management of Rhode Island, Inc., and Clean Harbors of Braintree Inc. (collectively referred to as the "Group"). Pursuant to the terms of the amended 1987 Administrative Order on Consent (AOC) entered into consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Docket No. 1-87-1064, the Group agreed to perform and finance the remedial investigation (RI) and FS at OU2 in accordance with the November 2000 *Statement of Work for Remedial Investigation and Feasibility Study for the Peterson/Puritan, Inc. Operative Unit 2: JM Mills Landfill*. The final *Remedial Investigation Report* (RI Report) was submitted to the EPA in August 2012 (ARCADIS, 2012).

1.1 Purpose

The purpose for preparing this FS is to: 1) establish the remedial action objectives (RAOs) and 2) establish and evaluate remedial technologies and remedial alternatives considered most suitable for OU2.

1.2 Report Organization

This FS follows the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA/540/G-89/004, Office of Solid Waste and Emergency Response [OSWER] Directive 9355.3-01, October 1988), and *Conducting Remedial Investigation/Feasibility Studies for CERCLA Municipal Landfill Sites* (EPA/540/P-91/001, OSWER Directive 9355.3-11, February 1991).

This FS is organized as follows:

- *Section 1 – Introduction*: This section describes the purpose and FS organization.
- *Section* 2 – *Background Information*: This section explains OU2 site history, current site conditions, physical setting, and provides a summary of the nature and extent of contamination.

- *Section 3 – Basis for Site Remediation*: This section includes summaries of human health and ecological risk assessments, including conclusions regarding unacceptable risk for the various media at OU2, descriptions of applicable or relevant and appropriate requirements (ARARs), and development of site-specific RAOs.

- *Section 4 – Identification and Screening of Applicable Technologies*: This section identifies the potentially applicable technology types and process options for each impacted medium at OU2.

- *Section 5 – Development of Remedial Alternatives*: This section provides an evaluation of the potential technologies for achieving the RAOs developed in Section 3 for groundwater, soil, and sediment that were retained from the initial screening.

- *Section 6 – Alternatives Screening Process*: This section describes the screening of the entire assembled alternatives on the basis of effectiveness, implementability, and cost.

- *Section 7 – Detailed Analysis of Alternatives:* This section provides a detailed analysis of retained alternatives against each of the nine evaluation criteria.

- *Section 8 – Comparative Analysis of Alternatives:* This section consists of a comparative analysis that focuses upon the relative performance of each alternative against the nine evaluation criteria.

- *Section 9 – References*: This section lists the sources of information cited in this FS.

2. Background Information

EPA included this site (EPA ID # RID055176283) on the National Priorities List (NPL) on September 8, 1983. Pursuant to the terms of AOC Docket No. 1-87-1064, the Group agreed to perform and finance the RI/FS for OU2.

2.1 Site Description

In 1990, the EPA divided the original site into Operable Unit 1 (OU1) and OU2. As shown on Figure 2-1, OU2 includes the area adjacent to and extending approximately 1 mile in length along the Blackstone River between the Towns of Lincoln and Cumberland, Rhode Island. OU2 is located immediately southeast and downstream of OU1.

The following description is taken directly from the final Statement of Work (SOW) for the RI/FS for OU2:

> *OU2 of the Peterson/Puritan, Inc. Superfund Site (hereinafter referred to as the Site) is predominately located in the town of Cumberland in the north-central portion of the State of Rhode Island, and includes a small segment within the town of Lincoln. OU2 is known locally, and in part, as the J.M. Mills Landfill. The Site is surrounded by industrial, residential, and semi rural/suburban properties. Bordering the Site to the north is the Hope Webbing Company property located at 88 Martin Street. To the south is the Stop and Shop Market (and strip mall) on Mendon Road (Route 122). To the northeast are the Mackland Sand and Gravel operations and wetlands also known locally as "New River." Finally, to the south of the Site is the Blackstone River and Canal.*

The EPA redefined the OU2 boundary in May 2005. Figure 2-2 shows the boundary, now called the "RI Site Study Area," as revised by the EPA, as well as key features in this area. The OU2 portion of the site contains many parcels within the immediate floodplain of the river, including the J.M. Mills Landfill, the Nunes Parcel, and an unnamed island (Unnamed Island); all of which contain waste deposits and were owned and operated during the time of disposal as a single landfill facility (the "Facility") and where contamination from these combined landfill operations came to be located within the immediate floodplain of the river corridor. Figure 2-3 shows OU2 divided into individual subareas, as defined by their geographical and physical characteristics. As currently defined by the boundary shown on these figures, OU2 is just over 1-mile-long (5,600 feet) and varies in width from approximately 1,200 to 1,900 feet, which corresponds to a total area of approximately one third of a square mile, or 200 acres. Bordering OU2 to the north is the Hope Global Company property and the southern portion of OU1. To the south of OU2 is the Stop and Shop Market (and strip mall) on Mendon Road, Cumberland (Route 122) and the Pratt Dam. The eastern boundary of OU2 includes the Providence and Worcester Railroad (P&W) tracks, along the western edge of the large wetlands complex (east of OU2) forming the eastern extent of P&W's right-of-way. The western boundary of OU2 is the Blackstone River. OU2 includes the Unnamed Island in the southern portion of the

site. The main channel of Blackstone River flows east around the island, and a secondary channel of the river flows west of this island.

OU2 consists of approximately 74 acres of filled and/or altered floodplain formerly owned and operated as the Facility by Mr. and Mrs. Joseph Marszalkowski and his agent(s)/associates for the purposes of waste transfer and disposal. The Facility included a subarea referred to as the J.M. Mills Landfill which reportedly accepted wastes from 1954 through the mid-1980s. Entry to the Facility occurred from an access road connecting from Mendon Road south of the site and crossing over the Nunes Parcel subarea of the Facility, where at the time of disposal, the J.M. Mills, Inc. conducted waste segregation, disposal, business, and accounting operations. EPA believes that waste disposal and operations within the J.M. Mills subarea of the Facility largely came to a close by 1986 (although not officially closed until 1991) due largely in part to collaborative records and description of site operations concerning this and the other areas of the Facility, including the property today referred to as the Nunes Parcel. A section of the Providence and Worcester Railroad line runs within the eastern border of OU2 and forms the eastern extent of the J.M. Mills landfill slope and Nunes Parcel property bounds while the river forms the landfill's western boundary.

The following areas within OU2 (the OU2 RI Study Area) were investigated and correspond to those areas evaluated in the risk assessments (see Figures 2-2 and 2-3):

1) *J.M. Mills Landfill* – This area includes the land formerly owned or operated as a mixed industrial and solid waste landfill by Joseph and Linda Marszalkowski through their business, J.M. Mills, Inc. and his agent(s)/associates for the purposes of waste transfer and disposal. This land is commonly referred to as the J.M. Mills Landfill, and accepted wastes from approximately1954 to 1986. The J.M. Mills Landfill occupies approximately 38 acres and is oriented in a northwest-southeast direction between the Blackstone River and the Providence and Worcester (P&W) railroad tracks. The J.M. Mills Landfill, which is shown on Figure 2-3, extends approximately 85 feet above local ground level. At least five vent pipes are present at the top of the J.M. Mills Landfill. Because the J.M. Mills Landfill was never formally closed, cover soil is thin-to-lacking in some areas. Vegetation covering the J.M. Mills Landfill consists of trees (up to 30 years old), brush, grasses, and weeds.

2) *Nunes Parcel* – This area includes the transfer station properties (now or formerly owned by Nunes Disposal, Inc.), also known as the solid waste transfer station and/or the Nunes Parcel, which contains both buried and surface waste. During the period of disposal (approximately 1954 to 1986) this parcel was owned and operated by Joseph and Linda Marszalkowski through their business J.M. Mills, Inc. Within the Nunes Parcel is an area where the Rhode Island Department of Environmental Management (RIDEM) conducted a removal action (the "RIDEM Soil Removal Area") that addressed contaminated soil. A building and structures are also located on the Nunes Parcel that were used for transfer station operations. The building potentially contains structural elements of an earlier canal gate house that stood at this location. The associated power canal was present on the east side of the Nunes Parcel

until the mid-1960s when it was filled as part of the landfill operations. (See: Phase I Cultural Resources Reconnaissance Survey (The Public Archaeology Laboratory, Inc., 2012) (Appendix F)).

3) *Unnamed Island* – This area includes an unnamed island within the Blackstone River currently bounded by the Blackstone River main channel and a backwater channel to the southwest; the Unnamed Island includes areas containing soil contamination, surface waste, and buried waste deposits originating from site disposal operations. During the period of disposal (approximately 1954 to 1986) this parcel was owned and operated by Joseph and Linda Marszalkowski through their business J.M. Mills, Inc.

4) *Quinnville Well Field* – Investigations included the former Quinnville Well Field, located west of the J.M. Mills Landfill, across the Blackstone River.

5) *Southern Bank/Pratt Dam* – This area is located south of the Unnamed Island, between the Blackstone Canal and the backwater section of the Blackstone River. This piece of land is connected to Pratt Dam and has a bike path running along the top of bank.

6) *Debris Fields* – There are multiple visible debris fields (DFs) at the site, with three (DF-1, DF-2, and DF-3) located northwest of the J.M. Mills Landfill and one (DF-4) located next to/on the J.M. Mills Landfill near the Unnamed Island.

7) *Wetlands A-D* – There are multiple wetlands on the opposite side of the railroad tracks next to the J.M. Mills Landfill where investigations were performed.

8) *Blackstone River* – The Blackstone River runs through OU2. Samples of surface water, sediment, and fish tissue were collected from the Blackstone River as part of the RI.

9) *Ponds* – This area includes nine ponds/inlets located throughout OU2, which were included as part of the RI.

10) *Groundwater* – This area includes the aquifer located within OU2. This includes, but is not limited to, the Quinnville Well Field and Lenox Street Well.

11) *Site-Wide Soil* – As part of the baseline ecological risk assessment (BERA), evaluations were performed for exposure by birds to site-wide soil. While individual soil samples were associated with the subareas noted above, this FS also considers impacts to ecological receptors exposed to soil in multiple subareas.

2.2 Site History

2.2.1 History of Surrounding Area

The earliest residents of the Blackstone Valley were the Paleo-Indians, who arrived in this region approximately 12,000 years ago. By the early 17th century, three principal tribes lived here: the Narragansett, the Nipmuc, and the Wampanoag tribes. The Blackstone River Valley was first settled by Europeans in the 17th century, and the area soon became one of the earliest sites for industrial development in North America. Almost everyone living in the Blackstone River Valley during the colonial era farmed, but by the mid-1600s, the settlers had begun to tap into the waterpower opportunities of the region with grist mills, saw mills, and iron forges. The steep drop and relatively abundant flow of water in the Blackstone River provided power for numerous mills that were built between Worcester, Massachusetts and Providence, Rhode Island. Industrial development began with the Slater Mill, the first textile mill in the country, which was built downstream of OU2 in Pawtucket in 1790. In the 1820s, the Blackstone Canal was constructed. Between 1870 and 1920, more than 1,000 manufacturing facilities were present in the Blackstone River Valley, most notably cotton and wool textile mills, but also producers of flour, rubber, wood products, steel, and machinery.

In the vicinity of OU2, the Lonsdale Company (owned by a Providence mercantile firm, Brown and Ives) built three mills between 1847 and 1886: the Ashton Mill, downstream of Ashton Dam (later operated by Owens Corning to manufacture fiberglass products); the Berkeley Mill, between the Ashton and Pratt Dams (in the area of the current industrial park near Martin Street); and the Lonsdale Mill (which included two main facilities: one downstream of Pratt Dam between the Blackstone River and the Blackstone Canal and one farther downstream on the Blackstone River, approximately 2,000 feet to the east).

The Blackstone Canal was built between 1825 and 1828 as a means of conveying goods from central and western Massachusetts to Providence, so that Providence merchants could compete with Boston traders. The Blackstone Canal was not suitable for year-round navigation and it competed with the mills for water. The P&W railroad was constructed in 1847 as a more reliable means of transport between Worcester and Providence. In the late 19th century, Pratt Dam was expanded and improved to support a railroad spur crossing the Blackstone River to a portion of the Lonsdale Mill.

Historical maps show a large dammed reservoir present in the Blackstone River Valley upstream of Pratt Dam as early as 1870. On the 1949 United States Geological Survey (USGS) topographic quadrangle map, this reservoir is labeled as “New Pond,” while it is shown as “New River” on other maps. At that time, land on both sides of the P&W railroad track was under water, and the track apparently was built on a levee running through the pond. The reservoir had two outlets: one at Pratt Dam into the main channel of the Blackstone River and one into a canal parallel to and just southwest of the P&W railroad track. This canal led under Mendon Road to the eastern part of Lonsdale Mill (which later became the original Ann & Hope department

store and warehouse) and discharged to the Blackstone River at this location (near the area that later became the Lonsdale Drive-In Theater).

Based upon a review of aerial photographs, it appears that the reservoir (New Pond) was drained in the early 1950s. The land northeast of the tracks did not drain completely at the time, and it remained a wetlands area with standing water. Substantial revegetation of this area has occurred since that time. Additional siltation of the wetlands occurred as a result of sand and gravel extraction activities that began in the late 1940s or early 1950s on the land northeast and north of the wetlands. The mills built in the 19th century were closed or were converted to new uses in the 1920s. Modern industrial development along Martin Street began in the late 1950s.

The headwaters of the Blackstone River are located near the City of Worcester in south-central Massachusetts. The river flows from there to the Seekonk River in Pawtucket, Rhode Island. The Blackstone River has a total length of 48 miles with a drainage area of 540 square miles. The river is the second largest freshwater tributary to the Narragansett Bay. The Blackstone River is an important natural, recreational, and cultural resource to both Rhode Island and Massachusetts.

Historically, the Blackstone River provided both water supply and wastewater drainage for the industries and municipalities along the valley. The wastewater treatment plant (WWTP) for the City of Worcester discharges to the Blackstone River's headwaters, and the WWTP for Woonsocket is another major discharger upstream of OU2. In studies performed by Metcalf & Eddy, Inc. in 1948 and by the USGS in 1974 (described in the *Remedial Investigation Report for the Peterson/Puritan Site* [C-E Environmental {C-EE}, 1990]), the Blackstone River waters were found to be noticeably degraded by municipal sewage and industrial discharges. The Worcester and Woonsocket WWTPs were upgraded to secondary treatment facilities in 1976 and 1978, respectively. Since then, new permit requirements (under National Pollutant Discharge Elimination System [NPDES]) have been issued for each WWTP, which call for further capital improvements that have been implemented and/or in progress to meet more-stringent discharge limits for total nitrogen, total phosphorous, and various metals.

By 1969, the Blackstone Valley Sewer District, which is now known as the Narragansett Bay Commission, had installed a 42-inch reinforced concrete interceptor sewer main (located within OU2 and running adjacent and parallel to the P&W railroad right-of-way) to collect and treat discharges that had previously flowed into leach fields or piped to the Blackstone River. The collected wastewater is treated at the Bucklin Point WWTP in East Providence and then released onto the Seekonk River (a tidal extension of the Blackstone River).

At the time of the OU1 Baseline Risk Assessment in 1993, the Blackstone River was rated by the State as Class C under the federal Clean Water Act (CWA) (suitable for fish and wildlife habitat, recreational boating, and industrial process supply, but not suitable for bathing, agricultural uses, or potable water supply). Since then, the river water quality has generally improved and is currently classified as a Class B1 surface water

body that has an established goal of “fishable and swimmable.” The State of Rhode Island has an overall objective to “restore impaired sections of the Blackstone River and its tributaries,” which includes restoring the river segment that flows through the OU2 site (RIDEM, 2001).

Current surface water quality is discussed in more detail in Section 2.4.

The Rhode Island Rivers and Classification Policy was amended in 2004 by the Rhode Island Rivers Council. The policy is intended to provide guidance for the management and protection of Rhode Island's river and estuarine watershed resources at the state and local levels. Its broad objectives are to protect drinking water supplies and pristine rivers, to encourage recreational use of rivers, to foster the creation of greenways, and to provide for the cleanup of rivers. The policy classifies freshwater into four classes: Pristine Waters, Waters Supplies, Open Space Waters, and Recreational Waters. The Blackstone River near the site (from Manville Dam to the Valley Falls Marsh) is classified as non-contact recreational. Recreational waters include “water bodies, rivers, or river segments that are readily accessible, that may have some development along their shorelines, and may have undergone some impoundment or diversion in the past. These shall include sections of rivers along mill villages, but shall not include sections where development may be characterized as urban. These waters are typically situated in suburban areas and are generally suitable for canoeing and other non-contact recreational activities. They may function as open space corridors or greenways.”

In 1986, the Blackstone River Valley Heritage Corridor (corridor) was created by Congress to protect the resources of the Blackstone Valley, such as the Blackstone River, the canal, and heritage sites and natural areas found throughout the corridor. OU2 falls within the boundaries of this corridor. The Blackstone and Woonasquatucket River systems have also been designated as American Heritage Rivers. National Parks Service and the U.S. Fish and Wildlife Service share responsibilities under the Department of the Interior as a Federal Natural Resources Trustee.

Groundwater in the area was first developed as a public water supply by the Town of Cumberland when the Martin Street well was installed in 1950; the Lenox Street well was added in 1964. Both water supplies had problems with taste, odor, and objectionable levels of inorganics, such as manganese. By 1979, the Martin Street well had been abandoned and the Lenox Street well provided approximately 4% of the Town of Cumberland’s water supply. The Town of Lincoln first developed the Quinnville Well Field in 1957, and it added the last supply well in 1975. The Quinnville Well Field provided approximately 45% of Lincoln’s public water supply. During a routine state-wide testing program for municipal wells in October 1979 by the Rhode Island Department of Health, the volatile organic compounds (VOCs) 1,1,1-trichloroethane, trichloroethene (TCE), and tetrachloroethene (PCE; also known as perchloroethylene) were reported in the Lenox Street and Quinnville Well Field wells. In subsequent testing, trans-1,2-dichloroethene, 1,1-dichloroethene, 1,1-dichloroethane, and trichlorofluoromethane were also reported in the Quinnville wells. Except for occasional

short-term use of the Quinnville Well Field by the Town of Lincoln until 1981, neither the Lenox Street well nor the Quinnville Well Field has been used for public water supply since 1979.

The Town of Cumberland currently receives a portion of its drinking water from surface reservoirs north of OU2. The Town also purchases water from the Pawtucket Water Supply Board. In addition, the Town continues to operate municipal drinking water wells on the Blackstone River in Manville, Rhode Island (approximately 5 miles upriver from the site) and from the Abbott Run aquifer east of the site. Currently, Cumberland seeks to increase its well water production and is actively pursuing improvements at Manville and other test sites. The Town of Lincoln currently receives its drinking water from the Providence Water Authority, utilizing the Scituate Reservoir west of Providence. It also maintains a well in the Lonsdale area south of OU2 for a backup supply.

Among the findings discussed in the 1993 OU1 Record of Decision (ROD), the Blackstone River and the Quinnville Well Field were primary receptors of contaminated groundwater migrating from OU1. Due to the geography of the site, the Blackstone River, the Quinnville Well Field, and the Lenox Street municipal well are all identified as potential receptors for contamination emanating from OU2.

Until 2009, it was believed that no public or private groundwater supply wells were operating within or adjacent to OU2, and that the entire area was served by public water systems. However, in 2009, following a citizen inquiry concerning the site, the EPA became aware of a home on Wildwood Street (immediately east of the site boundary and south of Lenox Street) using groundwater for consumption. Upon further investigation, the EPA learned of two additional homes located on Dixon Street (north of Wildwood Street) that are also using well water. Figure 2-3 presents the approximate locations of these residential wells. In November 2009, sampling of the three private use (residential) wells was conducted by EPA. While minimal traces of groundwater contaminants were detected in two of the three wells, concentrations in the potable water from each residential well were found to meet protective groundwater standards at the time. The affected residents were advised to continue to monitor their household water periodically. Aside from these instances, no other groundwater use has been identified on, or in the immediate vicinity of, the site. The EPA believes that all other residents located within the site or near the site are receiving municipal drinking water.

The town of Cumberland's loss of the Lenox St. well has not been resolved. Negotiations for investigations at OU2 commenced in 1998 calling for the Respondent to complete the terms of the 1987 Site-wide RI/FS AOC and to pay past costs pursuant to the terms of a CERCLA Section 122(h) settlement agreement. The Respondent and its former parent company, Bestfoods, now known as Unilever, entered into an amended 1987 AOC to conduct and finance the RI/FS for OU 2 in the summer of 2001. Unilever was later joined by Waste Management, Inc. and together completed the RI with EPA oversight in 2012.

Groundwater within OU2 is designated under the federal groundwater classification as Class 2B (future drinking water resource). The State of Rhode Island is designated as a natural resource trustee for groundwater; however, the State has elected not to participate in the EPA-endorsed Comprehensive State Ground Water Protection Program. Thus, the federal classification for groundwater applies.

2.2.2 History of Operable Unit 2

Based on a review of aerial photographs (EPA, 1987b), New Pond was flooded above Pratt Dam until the early 1950s. By 1956, the Blackstone River above Pratt Dam was drained, and the canal running parallel to the tracks was filled. All drainage from the area, with the exception of the wetlands immediately east of the J.M. Mills Landfill, was then routed to Pratt Dam. As a result of the draining and filling activities, substantial new tracts of land had opened up in areas of the current J.M. Mills Landfill and the Unnamed Island by the early 1950s. These areas were owned and operated by Joseph and Linda Marszalkowski through their business of J.M. Mills, Inc., during the time of disposal from approximately 1954 to 1986.

Solid waste and industrial wastes including hazardous substances were disposed of at the J.M. Mills Landfill from approximately 1954 to 1986. As described by Unilever Bestfoods and CCL Custom Manufacturing, Inc. in a civil action for recovery of costs submitted to the United States District Court of Rhode Island, "hazardous substances," as defined in Section 101(14) of CERCLA, were disposed at the J.M. Mills Landfill and have come to be located at the site. These hazardous substances include, but are not limited to, 1,1,1-trichloroethane, trichloroethene, methylenechloride, toluene, solvent mixtures, ink, metals, waste oils, absorbents (Speedy-Dry), chlorinated solvents, methyl ethyl ketone, solvents, solid chemical waste (ignitable dust), cyanide, drums, solids and sludges, fly ash, RCRA metals, loose ink, glue waste, hydraulic and lubricating oils, acetone, tetrachloroethene, xylenes, chemical waste, copper hydroxide, plating waste, PCBs, creosote telephone poles, laboratory waste chemicals, formaldehyde, bag house waste, latex sludges, mercury batteries, recycled oils and solvents, plating cyanide solution, hazardous lime sludge with copper and nickel, automotive waste, batteries, assorted hazardous wastes, drums with labels removed, powdered metals, sulfuric acid, caustics, machine oils, wastewater treatment sludge, inorganics, heavy metals, hydroxide sludge, still bottoms, filters, leather trimmings and wax plant wastes.[1] Based on aerial photos, the most active period of filling and regrading (including movement of the Blackstone River channel from the center to the southwest wall of the Blackstone River Valley) occurred in the mid- to late 1960s. The filling and creation of new land appears to have taken place first in the area known as the Nunes Parcel (mid 1950s), also owned and operated by Linda and Joseph Marszalkowski through their business, J.M. Mills, Inc. during the time of disposal from approximately 1954 to 1986. By 1956, a land bridge is visible at the

[1] *Unilever Bestfoods and CCL Custom Manufacturing, Inc. v. American Steel & Aluminum Corp. et al C.A. No. 01-496L*, 2001 Complaint and 2002 First Amended Complaint.

Pratt Dam extending to the Unnamed Island. Extensive stockpiling, excavation, filling, and apparent waste disposal activities on the Nunes Parcel, J.M. Mills Landfill, and the Unnamed Island are evident in the aerial photographs from 1970 through to the mid-to-late1980s. The Nunes Parcel, the J.M. Mills Landfill, and the Unnamed Island are shown on Figure 2-3.

Based on a review of the aerial photographs, disposal activities on the Unnamed Island appear to have ended at the same time. Subsequently, the bridge to the Unnamed Island deteriorated. A large excavator apparently stalled on the Unnamed Island, remaining there until its removal by the RIDEM in the summer of 2003.

Bulky wastes, including large concrete slabs, demolition debris, and drums were disposed during, and subsequent to, the J.M. Mills Landfill operation along the northern access road and the railroad between the J.M. Mills Landfill and Martin Street. The northernmost area consists primarily of broken concrete pieces, asphalt, and soil. Observations and historical information provided by the EPA suggest that a portion of this material originated from the demolition of former gasoline stations. The southeastern area consists of large concrete slabs, railroad ties, and two areas containing drums. Other bulky wastes, concrete, and tanks were found on the floodplain at the southwest portion of the J.M. Mills Landfill.

In 1987, Mrs. Marszalkowski sold an approximately 10-acre portion of the site (now known as the Nunes Parcel) to Michael John Realty, Inc. (Michael and John Nunes) who continued to operate a waste disposal company (Nunes Disposal, Inc.) from these premises until approximately 2003. Prior to the sale, this southern portion of OU2 maintained the gate where landfill operations were accessed from Mendon Road. Under Marszalkowski's ownership, the Nunes Parcel consisted of several lots and was a former privately owned waste transfer station, disposal area, and truck maintenance yard where, during the time of the most extensive landfilling operations, mixed industrial, commercial (including some hazardous) wastes, with a mix of municipal trash, entered the Facility through the Nunes Parcel for disposal throughout the Facility. Later investigations identified waste disposal both above and below grade on this parcel. This parcel includes an inlet and a buried power canal (partially underlying the transfer station building) perpendicular to, and connecting with, the river's edge. Bulky wastes remained stockpiled on the Nunes Parcel after disposal activities at the J.M. Mills Landfill ended. Today, the Nunes Parcel transfer station area is inactive and contains several structures and shacks, including a cement foundation and metal-sided building with wood framed office extensions facing east where the office and controlling operations for the landfill occurred.

Immediately southwest and across the river channel from the J.M. Mills Landfill is the 28-acre Unnamed Island located in the Blackstone River, that was also used for Facility operations. EPA discovered solid wastes disposed on this island and believes that the island's soils were quarried, well below the water table in some cases, and used to provide daily cover materials for landfill operations within the Facility, as well as for other purposes. Some of the borrow pits were also used as additional disposal locations during the time in which the Facility was operating. Portions of these pits remained open, forming ponds. The resulting

ponds are subject to flooding at times of high flow and are functioning as aquatic habitat. Down river from the Unnamed Island is the Pratt Dam, which provides an access point to the island. Collectively, the J.M. Mills Landfill, the Nunes Parcel, and portions of the Unnamed Island are identified as principal sources for OU2 receptors (including groundwater, floodplain soils, and surface water and sediments in site ponds).

After the initial RI was complete and the EPA divided the site into separate OUs in 1990, additional response actions in OU2 were limited. Under a removal action in 1991, EPA contractors constructed a fence to restrict access to the J.M. Mills Landfill. In addition, drums were removed from the base of the J.M. Mills Landfill. In November 1997, a second removal action was taken to address the disposed asbestos-containing wastes found outside the fenced area. This material was taken offsite for disposal. The security fence was extended to limit further uncontrolled dumping and to maintain access restrictions at this portion of OU2.

In October 2003, Owens Corning, under EPA oversight, removed 55.9 tons of fiberglass-containing waste and construction material from the Unnamed Island. The construction material consisted of road-building material used to access the Unnamed Island for the response action. The response action occurred on the Unnamed Island between Pond A and the back channel of the Blackstone River (Owens Corning, 2004). During this time, RIDEM, acting upon citizen complaints, elected to use a temporary constructed access road to dismantle and remove the disabled excavator from the Unnamed Island.

As a component of the construction of the Blackstone River Bikeway in 2004, the Rhode Island Department of Transportation (RIDOT) (under the direction of RIDEM) completed a removal action at the southeast corner of the Nunes Parcel near the Pratt Dam (VHB, 2004). Levels of lead, arsenic, dieldrin, petroleum hydrocarbons, and several semivolatile organic compounds (SVOCs) exceeded relevant State direct exposure criteria for soil, and approximately 11,600 tons of soil were removed and appropriately disposed at permitted offsite locations. The area is used as floodplain compensation and flood storage while some portions were backfilled with clean fill and asphalted to complete the bikeway section. This area encroaches upon the southern boundary of the OU2 portion of the site and is considered an extension of buried wastes deposited within the Nunes parcel. The State completed the removal (off-site) of soil containing lead (failing TCLP), solid wastes, and other soil from the southern boundary of OU2.

Refer to the RI Report (ARCADIS, 2012) for further historical information on the OU2 site.

2.3 Physical Setting

This section, summarized from the RI Report (ARCADIS, 2012), presents information on the physical setting of OU2, based on investigations at OU2 and supplemented, where necessary, with other information for the area.

2.3.1 Surface Features and Land Use

2.3.1.1 Surface Topography

The topography in the area of OU2 is characterized by rolling hills that have been incised by the valley of the Blackstone River, which flows northwest to southeast. Features formed by pre-glacial stream erosion have been modified by glacial and post-glacial erosion. As a result, the hilltops are rounded and the Blackstone River Valley has been deepened and filled with glaciofluvial sediments.

Historical maps and aerial photographs show that, from at least 1870 to 1951, the Blackstone River Valley area, currently occupied by the J.M. Mills Landfill, as well as the wetlands area northeast of the railroad, was flooded to an elevation of approximately 64 feet National Geodetic Vertical Datum of 1929 (NGVD29) in a reservoir referred to as New Pond. By 1956, the area of New Pond was shown as drained, although the wetlands retained standing water behind the railroad levee. After draining of New Pond, the Blackstone River channel flowed almost through the middle of the valley. By 1970, the Blackstone River channel had been rerouted around the north side of the J.M. Mills Landfill and moved close to the Blackstone River Valley wall on the southwest. Additionally, a new backwater channel was created on the southwest side of the Unnamed Island.

Overall, the ground surface along the Blackstone River floodplain slopes gently downstream (to the southeast) at a gradient of approximately 10 feet per mile along the full length of the Blackstone River. Along the 1 mile length of OU2, the Blackstone River drops approximately 3 feet, from a base-flow elevation of approximately 56.5 feet at the upstream boundary to approximately 53.5 feet NGVD29 just above Pratt Dam. The floodplain is contained by Blackstone River Valley walls that rise relatively steeply (especially on the southwest side of the valley) to the surrounding hills, which reach elevations of 250 feet NGVD29.

The Blackstone Canal, built in the early 19th century, runs parallel to the Blackstone River along the southwestern valley edge. This section of the Blackstone Canal originates upstream of OU2 at Ashton Dam, and currently rejoins the Blackstone River just downstream of OU2 at Lonsdale. Historically, the Blackstone Canal carried water out of the Blackstone River Valley and into the Moshassuck watershed via Scott Pond south of Lonsdale. The Blackstone Canal is clay-lined and has a water-level elevation of approximately 73 feet NGVD29 (16 to 20 feet higher than the Blackstone River in OU2).

The J.M. Mills Landfill, located on the northern bank of the Blackstone River, slopes up steeply from the floodplain level to a maximum elevation of approximately 145 feet NGVD29 (approximately 85 feet above the base topographic elevation). The slope of the J.M. Mills Landfill is steepest on the northeast (railroad) side, and is somewhat shallower on the southwest side facing the Blackstone River.

2.3.1.2 Surface Water Bodies and Wetlands

OU2 is located entirely within the Blackstone River drainage basin. The Blackstone River is the main surface water body at OU2. The Blackstone River flows to the southeast from Worcester, Massachusetts through Woonsocket, Rhode Island (at the state border) to the Seekonk River south of Central Falls and Pawtucket, Rhode Island, and from there into Providence Harbor at the head of Narragansett Bay.

Several ponds are also located within the boundaries of OU2 and are shown on Figure 2-3. Ponds A, B, C, F, N, and I are flooded during periods of high water. However, they are not hydraulically connected to the Blackstone River under normal flow conditions and retain water during base-flow conditions. Other ponds and pools where waste and water are captured after flooding or precipitation are identified on Figure 2-3, and these dry to varying degrees depending on the season and water-table level. These include several ponds (E, D, and P) on the Unnamed Island. The hydraulic connection between the Blackstone River, groundwater, and the ponds on the Unnamed Island appears to vary seasonally and with Blackstone River water levels.

Additionally, there is an area of wetlands, designated A through D, located to the north of the Blackstone River between the railroad tracks and the uplands. Based on groundwater elevations measured in piezometers adjacent to the wetlands, they are in hydraulic connection with the groundwater system (see discussion in Section 2.3.3). Surface water also flows into the wetlands from uplands to the north and east. The wetlands are depicted on Figure 2-3.

2.3.1.3 Land Use and Zoning

OU2 is located primarily in the Town of Cumberland, with a small segment lying within the town boundaries of Lincoln. Both towns are in the eastern side of Providence County, which spans the northernmost section of the State of Rhode Island. The entire Blackstone River Valley, including Cumberland, Lincoln and six other communities, lies within the area designated in state-wide land use planning documents as substrate growth area No. 1 (SGA-1). The three most urbanized communities within SGA-1 (Central Falls, Pawtucket, and Woonsocket) decreased in population from 1985 to 1995. However, SGA-1 as a whole, including Cumberland and Lincoln, gained, and is expected to continue gaining, population through 2020.

The Towns of Cumberland and Lincoln were both classified as suburban, with a population density of 500 to 2,499 persons per square mile (Rhode Island Department of Administration, Statewide Planning Program, 2000). Rhode Island conducted major land use/land cover surveys in 1961, 1970, 1988, and 1995. The results of these studies show that land development in the state increased at a rate nine times that of the population and is primarily residential in nature (residential development was growing faster than the population due to the decreasing household size; a trend seen since the mid-1950s). Development of

residential land increased by more than 20% between 1970 and 1995, while industrial land use increased by only 1.2% during this same period.

The area surrounding OU2 consists of a mix of commercial, industrial, residential, and recreational uses. Land use planning for the area is delineated in the *Cultural Heritage and Land Management Plan for the Blackstone River Valley National Heritage Corridor* (Corridor Management Plan). The Corridor Management Plan was prepared by the Blackstone River Valley National Heritage Corridor Commission. The Corridor Management Plan contains numerous objectives for preservation and management of the corridor, including:

- preservation of green space within the corridor
- prevention of filling of wetlands adjacent to the Blackstone River or its tributaries
- restoration of disturbed or degraded sites, such as landfills, gravel pits, and abandoned lots

The Corridor Management Plan also contains detailed recommendations and guidelines for development of property along the Blackstone River, as well as in nearby town centers.

In the summer of 2002, and following EPA's Preliminary Re-use Plan, the Towns of Cumberland and Lincoln, Rhode Island were granted funds from the EPA under the Superfund Redevelopment Initiative (SRI) Pilot Grant to perform an analysis of the Ashton-Pratt Corridor. This analysis included evaluating existing land uses within the site, determining the potential future land uses based on the needs and recommendations of the towns, citizens, property owners, and users. The purpose of this activity was to identify public interest in reuse planning opportunities within the Ashton-Pratt Corridor. Specifically for OU2 of the site, Section 4.3 of the Ashton-Pratt Redevelopment Plan (Crossman Engineering, Inc., 2004) provides identified principal recommended actions and improvements as an outcome of this planning activity. Based on project objectives, these findings included:

- Improve Support Services for Users of the Bikeway and River
- Improve Parking Facilities for Users of the Bikeway and River
- Potential Redevelopment of the Transfer Station Parcel
- Aesthetic Improvements
- Recreational Use of the Unnamed Island

- Cleanup of the Landfill

Since 2005, recreational use on, and along, the river has increased significantly. The regional bike path has been completed which follows the Lincoln side of the river and canal before crossing the Pratt Dam onto the Cumberland side (and entering onto the western tip of the Nunes Parcel) on the south end of the site. The path then follows the eastern side of the river into Lonsdale. With increased recreation in the vicinity of the site, reasonably anticipated future land use for the site would largely include recreational and open space considerations; including water sports. In that light, the Valley Falls Fire District has requested that access to the Pratt Dam be maintained and site design considerations be made for continued vehicular access to town property leading to the dam and for an adequate staging and portage area just north of the dam (Cumberland side) for first responder life-saving efforts on the river.

2.3.2 Geology

2.3.2.1 Regional Geology

As mapped by Hermes et al. (1994), bedrock in the region consists of late Proterozoic or older (Precambrian) metamorphic rocks of the Blackstone Group. These rocks range in type from quartzite and schists derived from sedimentary rocks to greenstone, amphibolites, and serpentinite derived from volcanic rocks. Fernald (1983) studied the Blackstone Group in some detail, including the road-cut exposures along Highway I-295 in the Blackstone River Valley, approximately 1.5 miles north of OU2. Fernald found that the rocks comprising these exposures consisted of 67% quartzite, 9% micaceous quartzite, and 24% phyllite. Fernald described the quartzite beds as homogeneous, massive, and interbedded with phyllite (in some cases, green colored) and micaceous quartzite.

Structurally, the Blackstone River Valley follows the axis of a northwest-trending overturned antiform. This structure is truncated between Lonsdale and Valley Falls by a north-trending normal fault system marking the border of the Narragansett Basin, a rift valley of Triassic to Jurassic age. Schistosity dips moderately at 40 degrees to 60 degrees to the northeast.

Regionally, the bedrock is overlain by a thin mantle of till, which is primarily described locally as poorly sorted sand, silt, gravel, cobbles, and boulders, ranging from very dense sandy silt to comparatively loose silty sand (C-EE, 1990). In the river valleys, thick sand and gravel deposits overlie the till. The surficial Blackstone River Valley deposits were mapped by Chute (1949) as floodplain alluvium, river terrace alluvium, and kame terraces (along the valley walls). The deeper sand deposits within the OU2 study area have been generally characterized by Shield Environmental Associates, Inc. (Shield; 2004) as undifferentiated glaciofluvial deposits.

2.3.2.2 Study Area Geology

2.3.2.2.1 Unconsolidated Deposits

The unconsolidated materials in the OU2 study area have been defined by soil borings completed at 41 locations over the last several years by Blasland, Bouck & Lee, Inc. (BBL) and other consultants. Six cross-sections were constructed by Shield (2004) to represent the geology of the unconsolidated deposits at OU2. Figure 2-4 is the cross-section locator map for those cross-sections, some of which have been augmented through soil borings and monitoring wells installed by BBL. Updated cross-sections A-A', F-F', and D-D' are presented as Figures 2-5, 2-6, and 2-7, respectively.

The cross-sections generally verify the regional geology as described above, although the till (Shield Unit TL) appears to be more limited in areal extent to the base of the bedrock valley. Till was absent in a number of borings located along the bedrock valley walls. The actual thickness of the buried till is not well defined. Many of the deep borings in the valley were drilled to refusal, which may indicate that either the top of the till (i.e., a boulder within the till) or bedrock was encountered. The till is generally classified as an SW soil in the Unified Soil Classification System (USCS).

The undifferentiated glaciofluvial deposits overlying the till are extensive throughout the study area, as demonstrated by the cross-sections. These deposits range from poorly to well-graded sands and gravels (USCS classifications of SM, SW, GM, and GW), based upon 26 samples for grain size distribution analysis from nine monitoring well soil borings installed at OU2 by Shield. These coarse-grained deposits are found everywhere in the bedrock valley, with the exception of cross-section D-D' (Figure 2-7), where a relatively thick (15-foot) lens of laminated silt and clay is indicated by the boring log for MW-109.

The glaciofluvial deposits are overlain by alluvial deposits in approximately the upper 20 feet, which generally exhibit similar physical properties. The alluvial deposits contain a greater percentage of organic matter and thin silt layers. This interlayering of silt and organic layers is expected in a meandering river environment.

Significant reworking and mixing of natural surficial deposits has occurred in the recent past. This reworking/mixing has been caused by draining of the pond and scouring of the Blackstone River bottom by subsequent spring floods, by filling and sand and gravel extraction, and by the regrading of the Blackstone River Valley in the area of the J.M. Mills Landfill and Unnamed Island. Wetlands have become established in some of the formerly flooded and/or excavated areas, trapping organic and fine sediments in a thin deposit over the coarser glaciofluvial deposits. In the area of the former New Pond and wetlands, where a man-made lake flooded the Blackstone River floodplain, a thin layer of finer sediments (primarily silt) can be expected from sediment settling behind the dam.

2.3.2.2.2 Blackstone River Sediments

Shield (2004) characterized the physical nature of sediments in the Blackstone River, Ponds A through F, the Blackstone River inlet near the transfer station (referred to as Nunes Inlet), and the wetland areas. Samples of sediments from these areas were analyzed for grain size. The following table summarizes Shield's findings.

Physical Nature of Blackstone River Sediments

Location	# of Samples	Sediment Description
Blackstone River	13	Fine to coarse sand with varying amounts of gravel.[1]
Pond A	5	Near shore: coarse sand, some gravel, little to no fines. Middle of pond: silt.
Pond B	1	Silt and silty clay.
Pond C	1	Sand and silt.
Pond D	1	Sand, some silt.
Pond E	1	Sand, some silt.
Pond F	1	Variably sandy and silty.
Pond N	1	Sand and silt.
Nunes Inlet	1	Sand and silt.
Wetlands	10	Ranged from silty clay to sand and gravel, with varying amounts of organic matter.

Notes:

[1]One sample, collected behind Ashton Dam, contained a considerable fraction of silt (44% by weight).

2.3.2.2.3 Bedrock

Bedrock beneath OU2 is mapped as quartzite (north of the Blackstone River) and as epidote-and-biotite schist (south of the Blackstone River) (Hermes, 1994). In 1987, Camp, Dresser & McKee installed well borings and cored into bedrock at the OU2 site, two (MW-106 and MW-107) were logged as "green schist" and five (MW-108, MW-109, MW-110, MW-111, and MW-112) were logged as "orthoquartzite." These observations were fairly consistent with the studies done by Hermes (1994) and Fernald (1983).

Aerial photographs and field investigations of fracture patterns in the study area during the site-wide RI yielded inconsistent results (C-EE, 1990). However, both studies appeared to indicate that the dominant fracture directions trend north-northeast, with a more minor component to the northwest.

The configuration of the bedrock surface beneath the valley was mapped in the *Remedial Investigation Report for the Peterson/Puritan Site* (C-EE, 1990) based on bedrock elevations in the literature, test boring logs, and seismic refraction survey results. Shield (2004) revised that map using bedrock surface.

During Phase 1B, BBL performed a geophysical survey and drilling to further refine the definition of the bedrock surface. Boring GNP-705B was located at the north end of the Nunes Parcel and extended to the

bedrock surface. This information, in conjunction with the geophysical survey, was used to reconstruct cross-section F-F' (Figure 2-6) and the bedrock elevation contour map (Figure 2-8). These figures indicate that there is no evidence of a deeper bedrock trough (elevations below -100 feet NGVD29) to the south running parallel to the Blackstone River, as indicated on the Shield map. The more recent data indicates that bedrock elevations there are much shallower (between -50 and -75 feet NGVD29), and that there is a closed depression in the bedrock surface north of boring GNP-705B (Figure 2-8). However, this reinterpretation of the bedrock surface has no appreciable effect on the groundwater flow or the overall geologic model of OU2.

2.3.3 Groundwater Hydrology

2.3.3.1 Regional Groundwater Hydrology

The hydrogeology of the region is dominated by the Blackstone River, which is the major groundwater discharge zone in the region. Groundwater in the Blackstone River Valley is derived chiefly from precipitation that falls on and infiltrates into the uplands and the valley floor, some of it in the form of snowmelt. Another source of groundwater is the infiltration of Blackstone River water during flood stages or behind dams. This groundwater is expected to discharge back to the Blackstone River following floods or shortly below dams. Groundwater is stored in the glacial unconsolidated material that blankets the uplands (till) and fills the bedrock valley (till and glaciofluvial sediments) and also in the bedrock. Groundwater generally moves from the till upland toward the Blackstone River.

Like the Blackstone River Valley, river valleys in the region represent localized zones of abundant water resources in a terrain that is dominated by relatively low-permeability crystalline bedrock mantled by till of low- to moderate-permeability. The USGS has recently performed numerical groundwater flow modeling of the Lincoln and Cumberland well fields, located approximately 4 miles upriver from OU2 (Friesz, 2004). These well fields draw water from the glaciofluvial deposits above bedrock. The modeling showed that the size of the areas contributing recharge to the well fields increased as pumping rates at the well fields were increased, and that induced infiltration from the Blackstone River accounts for a significant portion of the water pumped by the well fields. No groundwater pumping is occurring in OU2; therefore, groundwater is expected to discharge to the Blackstone River under base-flow conditions, which is consistent with past U.S. Army Corps of Engineers modeling studies.

2.3.3.2 Site Groundwater Hydrology

OU2 hydrogeology has been studied for more than 17 years through a series of investigations. This section summarizes the groundwater hydrology based on the findings of the RI Report (ARCADIS, 2012), including previous investigations, and presents conclusions of the implications of the groundwater flow conditions to contaminant migration.

2.3.3.2.1 Hydrostratigraphic Units

Based on the available information, four hydrostratigraphic units are identified within OU2: Upper Glaciofluvial Unit, Lower Glaciofluvial Unit, Till, and Bedrock. Shield (BBL, 2006a) developed a "formation code" that was used to describe the zones and identify the zones in which individual OU2 monitoring wells were screened. Table 2-1 summarizes well construction information and identifies the formation code for each OU2 well. These hydrostratigraphic units and the Shield formation codes are presented below:

- *Upper Glaciofluvial – SH:* Wells screened in glaciofluvial sediments; the screen mid-point elevation is above 35 feet NGVD29.
- *Upper Glaciofluvial – IN:* Wells screened in glaciofluvial sediments; the screen mid-point elevation is between -10 and 35 feet NGVD29.
- *Lower Glaciofluvial – DP:* Wells screened in glaciofluvial sediments; the screen mid-point elevation is below -10 feet NGVD29.
- *Till – TL:* Wells screened in till just above bedrock.
- *Bedrock – BR:* Wells screened in bedrock.

The hydraulic conductivity values reported for these units, as determined by a variety of testing methods, are presented in Table 2-2. The hydraulic conductivity of the Upper Glaciofluvial Unit is, in general, an order of magnitude greater than the Lower Glaciofluvial Unit and the underlying Till Unit. This difference in hydraulic conductivity has significant implications for contaminant migration, as based on the higher hydraulic conductivity of the Upper Glaciofluvial Unit, contaminants are more likely to be confined to the upper 30 feet of the aquifer rather than migrate deeper in the aquifer. Hydraulic gradients also support the finding of contaminants being limited to the shallow aquifer.

2.3.3.2.2 Groundwater Movement

Figure 2-9 presents groundwater contours based upon the November 2005 water-level data, which is representative of previous rounds measured in 2005 and 2006.

Groundwater Elevations and Depth to Water

Depths to water and groundwater elevations for the above-referenced synoptic water-level measurement events are presented in Table 2-3. The depth to water across OU2 varies depending on the proximity of the measuring point to the Blackstone River and the season that the measurement was taken. The greatest

depths to water are at edges of the valley wall, as represented by monitoring wells MW-EA-1 and MW-107A (north and south valley walls, respectively). Groundwater depths there range from approximately 20 feet below ground surface (bgs) to 28 feet bgs for MW-EA-1 to 16 to 20 feet bgs for MW-107A. Groundwater depths rapidly decrease approaching the Blackstone River to 0 feet bgs. Water levels measured in piezometers and monitoring wells installed along the Blackstone River actually show water levels above the ground surface (Table 2-4), indicating that there is an upward vertical gradient, and that the groundwater is discharging to the Blackstone River. This is discussed in more detail below.

Horizontal Movement

The groundwater flow patterns, as represented on Figure 2-9, consistently demonstrate that groundwater generally moves horizontally toward the Blackstone River. The following bullets summarize important information obtained from the prepared water-table maps:

- Where the Blackstone River floodplain is broad (i.e., the Quinnville Well Field and the J.M. Mills Landfill), horizontal hydraulic gradients are slight (approximately 0.005 feet per foot).

- Water in the Blackstone Canal is perched above the regional water table because of the historic lining of the Blackstone Canal and, therefore, has no appreciable effect upon groundwater movement.

- The groundwater elevation data suggest that mounding beneath the J.M. Mills Landfill is minimal or non-existent. All of the groundwater contour maps consistently show groundwater flow to the south and west from the Wetland B and C areas toward the J.M. Mills Landfill and the Blackstone River. If mounding were occurring, groundwater would be expected to flow toward the wetland from the J.M. Mills Landfill, at least at certain times of the year. Based upon the groundwater elevation data, piezometer PZ-12, which is on the north (wetland) side of the railroad tracks, exhibits a consistently higher head than piezometer PZ-19, which is on the south (J.M. Mills Landfill) side of the railroad tracks. While the MW-108 well cluster does exhibit a slight downward vertical groundwater gradient, this is not related to mounding of groundwater beneath the J.M. Mills Landfill, as discussed below. Furthermore, the slight amount of groundwater head build up beneath the J.M. Mills Landfill is unlikely to have any significant effect on contaminant migration, because the high hydraulic conductivity of the Glaciofluvial Unit beneath the J.M. Mills Landfill (see discussion below on Hydraulic Conductivity and Groundwater Flow Rate), coupled with the expected anisotropy that would favor lateral movement of groundwater, would tend to mitigate downward movement of affected groundwater.

- Groundwater generally discharges to the wetlands north of the J.M. Mills Landfill from the valley wall along the northern edges of the wetlands. Based upon historically measured groundwater levels, the base of the wetlands are periodically in hydraulic connection with the groundwater table. During higher water conditions, water from Wetland C flows to Wetland B and finally to Wetland A. Surface water from

Wetland B flows into Wetland A during medium and high water conditions through the berm that separates the two wetlands. During lower water conditions, these wetlands appear to act independently with no visible surface flow from one to the other. In Wetland A, the surface water is captured by a 10-foot by 10-foot concrete basin before traveling southeast adjacent to the railroad tracks before discharging into the Blackstone River south of Route 122.

- During base-flow (non-storm event) conditions, groundwater is not mounded appreciably beneath the Unnamed Island. As a result, groundwater generally moves eastward across the Unnamed Island, with some Blackstone River water recharging Unnamed Island groundwater along the "upriver" (western) portion of the Unnamed Island, and Unnamed Island groundwater discharging back to the Blackstone River along the Unnamed Island's eastern flank.

- During and for brief periods following significant storm events, the Blackstone River near the Unnamed Island acts as a losing reach and likely loses water to the Unnamed Island as bank storage. This statement is based on Shield's most recent water-level measurement round in September 20, 2004, which was collected 2 days after a 2.3-inch rainfall event, and represents a fairly comprehensive dataset collected soon after a sizable rainfall. This condition is not surprising and is expected to be temporary. Blackstone River levels typically drop more quickly than groundwater levels; therefore, within several days of the rainfall event, groundwater flow directions on the Unnamed Island are expected to reverse (i.e., bank storage discharges to the Blackstone River in the eastern portion of the Unnamed Island).

- The reach of the Blackstone River that separates the Unnamed Island from the solid waste transfer station property appears to perennially lose water to that property. The groundwater beneath the transfer station property likely discharges back into the Blackstone River below Pratt Dam.

- Based on existing vertical hydraulic gradient information (discussed below), down-valley movement of deeper groundwater is possible, although insignificant with respect to contaminant migration.

Hydraulic Conductivity and Groundwater Flow Rate

The upper glaciofluvial aquifer, particularly the SH unit, exhibits high hydraulic conductivity. Table 2-2 summarizes the hydraulic conductivities of the hydrostratigraphic units. The individual specific-capacity tests also indicate that there is a high degree of spatial variability in hydraulic conductivity, particularly in the SH (shallow) unit, which is not unusual for glaciofluvial deposits. Based upon Shield's calculations, hydraulic conductivity values vary by 3 to 4 orders of magnitude (8 to 4,500 feet per day). The SH unit beneath the J.M. Mills Landfill exhibits the highest hydraulic conductivities over the entire study area. Shield calculated hydraulic conductivities for monitoring wells SEA-601, SEA-602A, SEA-603, SEA-605, MW-108AA, and P-8, which are located adjacent to the J.M. Mills Landfill and are screened in the SH unit, ranged from approximately 10^{-1} to 10^{0} centimeters per second (cm/sec) or 600 to 4,500 feet per day. In general, shallow

monitoring wells located within the main channel of the Blackstone River exhibited higher hydraulic conductivities than those closer to the valley walls, such as MW-109AA, MW-110A, and MW-111A, which are 1 to 2 orders of magnitude less.

ARCADIS BBL recalculated the Shield hydraulic conductivities using the raw data generated by Shield but a different methodology, resulting in a mean hydraulic conductivity of the SH unit wells adjacent to the J.M. Mills Landfill of approximately 3.1×10^{-2} cm/sec or 88 feet per day. This estimate is believed to be a more realistic estimate for this estimate than the Shield estimate. However, given the variability in the aquifer materials, the actual hydraulic conductivity may be higher.

Groundwater flow rates in the SH unit have been calculated for the J.M. Mills Landfill area, which is the major upland contaminant source. Shallow groundwater flows roughly northeast to southwest across the J.M. Mills Landfill and discharges to the Blackstone River. Using the hydraulic gradient (i) calculated based upon the November 2005 data (0.0049 feet per foot) and the range of hydraulic conductivities (k) (as calculated by ARCADIS BBL) for the shallow wells located in the vicinity of the J.M. Mills Landfill and an effective porosity (n_e) of 0.20 (Todd, 1967), the average estimated groundwater flow velocity ($v = ki/n_e$) is approximately 2 feet per day or 750 feet per year. As discussed above, because of the variability in the aquifer materials and the documented range of hydraulic conductivities for this hydrostratigraphic unit, the groundwater flow velocity in some locations is likely to be even higher.

Because hydraulic conductivities in the aquifer generally decrease with depth, corresponding groundwater flow rates also decrease with depth, likely by 1 to 2 orders of magnitude.

Vertical Movement

Groundwater elevation data for clustered wells (wells screened at different depths at the same location) were used to examine the vertical component of groundwater movement by evaluating the direction and strength of vertical gradients at such locations. These gradients are summarized in Table 2-4, which includes data from Shield (BBL, 2006a).

The available OU2 data indicate that, away from the Blackstone River, there is a downward vertical gradient of groundwater. This is demonstrated by well clusters MW-107 and MW-108. Near the Blackstone River, at least in SH unit, the vertical gradients are upward. This is demonstrated by well clusters GLF-706, MW-106, MW-109, MW-112, MW-B1/B2, and MW-C1/C2. The piezometer elevation data also show a strong upward groundwater flow component adjacent to the Blackstone River. The groundwater elevation data (Table 2-3) indicate that most of the piezometers exhibit water levels higher than the ground surface. These conditions help to limit contaminant migration as discussed in the next section.

Upward gradients over time near the Blackstone River are also demonstrated by hydrographs constructed by Shield based upon water levels measured in 2004 and hydrographs constructed by BBL from data from 2003.

Near Pratt Dam, there is likely a measurable downward component of movement, as groundwater locally moves around and beneath the Pratt Dam before discharging back into the Blackstone River below the Pratt Dam. Data for the deeper units are limited and an evaluation cannot be made at this time.

2.3.3.2.3 Implications for Groundwater Contaminant Migration

Based on measured hydraulic conductivities and horizontal gradients, groundwater beneath OU2 is migrating at a relatively rapid rate, particularly in the SH unit. Furthermore, the Blackstone River is a major discharge zone across OU2, except just upstream of the Pratt Dam. Therefore, contaminant migration, if present, is expected to be controlled hydraulically. First, groundwater flow rates, particularly beneath the primary source, the J.M. Mills Landfill, are rapid, and thus, provide considerable dilution/attenuation capacity for contaminants migrating from beneath the J.M. Mills Landfill. Second, the rapid horizontal flow rates within the SH unit act to inhibit downward migration into the deeper parts of the valley aquifer. Finally, groundwater migrating from these contaminant sources is most likely to discharge to the Blackstone River. Additional information regarding groundwater contaminant migration is presented in the RI Report (ARCADIS, 2012).

2.3.4 Surface Water Hydrology

2.3.4.1 Blackstone River

The 48-mile-long Blackstone River flows to the southeast from Worcester, Massachusetts through Woonsocket, Rhode Island (at the state border) to the Seekonk River south of Central Falls and Pawtucket, Rhode Island, and from there into Providence Harbor at the head of Narragansett Bay. It drains an area of 540 square miles, including 105 square miles in Rhode Island and the balance in Massachusetts. The Blackstone River drops 438 feet from its headwaters to sea level, corresponding to an average gradient of approximately 10 feet per mile. The gradient flattens as the Blackstone River flows closer to the ocean, and the Blackstone River becomes tidal downstream of OU2 in Pawtucket at the Main Street Dam.

The annual mean stream flow for the Blackstone River at Woonsocket (USGS Gauging Station 01112500) ranged from 334 to 1,322 cubic feet per second (cfs) between 1930 and 2001, and averaged 778 cfs, equivalent to 6 million cubic feet per day, or 330,000 gallons per minute. Peak stream flow typically has exceeded 10,000 cfs at least once per decade. High-flow water quality sampling was conducted at both the Pratt Dam and the upstream Ashton Dam by the Group in cooperation with the USGS and the EPA. The USGS estimate of flow during the chemical sampling on April 4, 2005 was reported as 5,530 cfs. Final flow rates will be published with the USGS Rhode Island Annual Report.

C-EE (1990) reported the 7-day, 10-year low flow (7Q10) at Woonsocket as 101 cfs. The RIDEM considers the 7Q10 at Woonsocket to be 102.25 cfs based upon flow data through Water Year 1993, according to *7Q10 Statistics for Rhode Island Gauging Stations*, a table currently included in permit application packages under the Rhode Island Pollutant Discharge Elimination System.

2.3.4.2 Drainage Patterns

The course of the Blackstone River in OU2, between Martin Street and Pratt Dam, has been substantially modified over the last 2 centuries. The Blackstone Canal was built early in the 19th century, and it exchanged water with the Blackstone River, carrying some of its flow into a different watershed. The first dam in the area of Pratt Dam may have been constructed contemporaneously with the Blackstone Canal, and the Blackstone River and wetlands were flooded in the New Pond area for at least 80 years by the end of the 19th century and through the first half of the 20th century. The New Pond was drained in the 1950s. Subsequent filling in the area of the J.M. Mills Landfill, Nunes Parcel, as well as excavation and filling activities on the Unnamed Island, led to additional alterations to the flow channel.

Based upon measurements made during the near-base-flow conditions in August and September 2003, the Blackstone River channel width in OU2 varies from approximately 60 to 125 feet, and the depth of the water varies from approximately 1 foot to more than 6 feet, with 2 to 4 feet being typical under base-flow conditions. The narrowest, deepest segment (approximately 60 feet wide and 6 feet deep) runs along the southwest shore of the J.M. Mills Landfill, between the J.M. Mills Landfill and the bank of the Blackstone Canal. In the main channel along the Unnamed Island and upstream of Pratt Dam, the Blackstone River is somewhat wider and shallower (approximately 60 to 90 feet wide and 4 feet deep). Upstream of the J.M. Mills Landfill is a shallow section (less than 1 foot deep) with a steeper gradient in the vicinity the Unnamed Island near MW-106 and the outfall at the culvert headwall (HW-01). Above that, from the Unnamed Island upstream to the shallows just below Martin Street, the Blackstone River has a typical section approximately 125 feet wide and 2 to 4 feet deep.

Surface water in OU2 ultimately drains to the Blackstone River. Surface water runoff from the west-southwest valley wall, including a stream flowing from the area of Dexter Rock Road, is carried into the Blackstone Canal, and from there drains to the Blackstone River downstream of Pratt Dam. On the northeast bank of the Blackstone River, surface water runoff originating west of the railroad tracks (near the J.M. Mills Landfill, Nunes Parcel, and Unnamed Island) drains directly or via ditches into the Blackstone River within OU2.

The sand and gravel pit (currently the Fleet Construction Co. property) northeast of the railroad tracks, located between the wetlands and Martin Street, appears to intersect the water table on its northeastern flank, at an elevation of 86 to 88 feet NGVD29. Seeps emerging from this flank and surface water runoff into the pit are drained via a ditch running southwest across the pit bottom and combine with Wetland D. From

there, the slightly turbid surface water drains under the railroad via a culvert near the MW-106 well cluster (the upstream headwall on this culvert is referred to as HW-01 and the discharge as the HW-01 outfall). This water eventually discharges to the Blackstone River north of the J.M. Mills Landfill. This inlet is a former intake trench, which historically fed water via a pump and pipeline to the former Mackland sand gravel operation (McNulty Property).

The southern section of wetlands drains to a ditch running to the southeast, parallel to the railroad tracks on their northeastern side, when there is sufficient water for surface water overflow. A culvert or drain pipe emerges at a headwall (HW-02) into this ditch just southeast of the Lenox Street well. This ditch continues parallel to the tracks and flows under Mendon Road, and it then crosses under the railroad tracks, draining into what appears to be a remnant of the former large canal that ran to the eastern Lonsdale Mill.

Surface water flows into the wetlands from uplands to the north and east. The principal drainage into the wetlands is Monastery Brook, which originates in high wetlands at an elevation of approximately 210 feet NGVD29, approximately 7,000 feet north of the New Pond wetlands near a former Cistercian monastery (now the Cumberland Public Library). Monastery Brook drains an area that is primarily residential and wooded, picks up storm drainage near Mendon Road, and flows into the Wetland C. An unnamed intermittent stream flows into the same wetlands section, approximately 250 feet to the west, near the location of combination staff gauge/piezometer PZ-13. This stream originates in a quarried area approximately 600 feet due north of its discharge point in the wetlands, and it drains a combination residential and commercial watershed. A third inflow to the wetlands, referred to for the purpose of this FS as the Panda Culvert, discharges to the northern side of Wetland B. This inflow is fed from a small intermittent stream that originates a couple hundred feet northeast of Mendon Road, and it also picks up storm drainage from the parking lot of the Panda Garden Restaurant. It also receives additional flow from the storm drain system along Mendon Road and from Marshall Avenue. A 12-inch polyvinyl chloride pipe also flows into Wetland B on the Panda Garden property in the vicinity of the Panda Culvert.

Reportedly, other storm drainage from Mendon Road flows into the wetlands between the Panda Culvert and Monastery Brook, but no hard pipes were located during the reconnaissance performed by Shield in May 2002 or during the Phase 1A activities. Some of the gullies draining surface water runoff from the McNulty properties into the wetlands were in the process of being filled and regraded as part of the residential construction in progress on those properties during the summer and fall of 2003.

A Final Total Maximum Daily Load (TMDL) Analysis for Blackstone River Watershed prepared by the RIDEM and dated February 2013 documents the lead and cadmium loading and sources within the Rhode Island portion of the Blackstone River. Recent data collected by the U.S. Geological Survey found in the TMDL report notes that the lead impairment persists in both the lower (Rhode Island) and upper reaches (Massachusetts) of the Blackstone River main stem.

There is no apparent surface drainage connection under base-flow conditions between the northeastern section of Wetland C and Wetland D, which drains to the Blackstone River north of the J.M. Mills Landfill, although the area is heavily vegetated and could not be completely inspected. Aerial photographs show a former siltation pond for the sand and gravel operations on the northern portion of the McNulty properties when active extraction activities were occurring in the 1960s or 1970s. Most of the flow entering the wetlands apparently drains out by downward seepage into the groundwater flow system or as surface flow (during precipitation events) from Wetland C through Wetland B and then Wetland A, which eventually drains into the southeast flowing ditch to the culvert headwall HW-02 (northwest of the Lenox Street Municipal Well) (Figure 2-3). The surface water that drains from this culvert flows along the ditch north of the railroad track and discharges into the Blackstone River below the Pratt Dam (in the vicinity of the Ann and Hope Mill).

2.3.4.3 Hydraulic Connection between J.M. Mills Landfill and Wetland Areas

Based upon OU2 topography, surface water runoff from the J.M. Mills Landfill does not appear to be or to have been a significant source of contamination to the wetland areas, with the exception of one small area adjacent to the P&W railroad tracks. The wetland areas and the J.M. Mills Landfill are separated by the P&W railroad tracks, which provide a topographic barrier between the two areas under normal conditions. Furthermore, since the construction of the railroad preceded the J.M. Mills Landfill by over 100 years, it is unlikely that landfill runoff ever flowed directly into the wetlands, except at times of severe flooding when the river overtops the railroad levee, flows into and out of the eastern wetland complex, and flows on both sides of the landfill during peak floods as observed in the major floods of 2008 and 2010. The wetlands are primarily fed by surface water drainage from upland streams to the north and east. However, during flood events on the Blackstone River, river water overtops the railroad tracks north of the J.M. Mills Landfill and enters the wetlands. Until recently, there were no culverts or drainage connections between the wetlands and the J.M. Mills Landfill site, and none were known to have existed historically. However, as an apparent component of a track and ballast repair that was noted in November 2006, a drain line was observed to have been recently installed (flow direction – north to south) beneath the P&W railroad tracks near the Lenox Street well. The presumed purpose for the drain is to allow ponded floodwater on the north side of the tracks to drain to that level and prevent failure of the railroad embankment; during a severe flood in October 2005, the rail bed was severely eroded both north and south of the J.M. Mills Landfill. In the absence of floodwaters that would flow out of the wetlands through this drain, the only discharge points in the wetlands are at the southern end of Wetland A and the northern end of Wetland D, as discussed in the previous section.

The chemical evidence supports this model of surface water transport. Sediment samples collected from the wetlands exhibit chemical impacts similar to those found in the Blackstone River sediments upstream of OU2. Impacts to the sediment in the wetland are well distributed suggesting sediment-laden water has historically migrated during river flooding and backed up into and across the wetlands. It is likely that impacts

from the J.M. Mills Landfill on concentrations of PAHs or PCBs in the wetland soils or sediments are minimal.

2.3.4.4 Surface Water Classification and Use

The Blackstone River, from the Rhode Island/Massachusetts border to approximately 1.5 miles downstream of OU2, is classified by the RIDEM under the federal CWA as Class B1 (i.e., suitable for primary and secondary contact recreation and fish and wildlife habitat, recognizing the potential for impacts due to approved wastewater discharges and combined sewer overflows). It is listed on the RIDEM 2012 List of Impaired Waters under Section 303(d) of the CWA based on dissolved oxygen, phosphorus, biodiversity impacts, pathogens, as well as mercury, and polychlorinated biphenyls (PCBs) in fish tissue. As required under that section, a draft study to determine the TMDLs from point and non-point sources has been completed.

Blackstone River Listing
State of Rhode Island 2012 List of Impaired Waters

Use Description	Use Attainment Status	Cause/Impairment
Fish and Wildlife Habitat	Not Supporting	Benthic-Macroinvertebrate Bioassessments Cadmium Eurasian Water Milfoil, Myriophyllum Spicatum Lead Non-Native Aquatic Plats Dissolved Oxygen Phosphorus (total)
Fish Consumption	Not Supporting	Mercury in Fish Tissue PCBs in Fish Tissue
Primary Contact Recreation	Not Supporting	Enterococcus Fecal Coliform
Secondary Contact Recreation	Not Supporting	Enterococcus Fecal Coliform

2.3.5 Wetlands and Floodplains

In the Flood Insurance Rate Maps compiled by the Federal Emergency Management Agency (1982 and 1992), most of OU2, including the wetlands, the areas surrounding the J.M. Mills Landfill, the Unnamed Island, the low portions of the Nunes Parcel, and the Quinnville Well Field, are mapped within the 100-year flood zone. The Blackstone Canal and the highest part of the Nunes Parcel lie between the 100-year and 500-year flood zones.

In OU2, the Blackstone River floodplain has a width of 1,000 to 2,000 feet and an elevation of approximately 60 feet NGVD29. A subdued alluvial terrace is present at an elevation of approximately 70 feet NGVD29 in OU1 and is absent in most of OU2. The wetlands north of the J.M. Mills Landfill, which has a bottom elevation of 57 to 60 feet NGVD29, abut a sharp escarpment to the northeast that rises to an elevation of approximately 90 feet. Sand and gravel extraction, as well as bedrock removal, has occurred in the sand and gravel pit northwest of the wetlands and on the McNulty properties. The wetlands area is shown on historical maps to be flooded as early as 1870. The area most likely represents a meander of the Blackstone River that was cut off by construction of the railroad levee in the middle of the 19th century.

At periods of high river stage, the Unnamed Island and other low-lying areas of OU2 are flooded with water from the Blackstone River. As the water level recedes, water continues to flow through the large Ponds A and F before dropping to the point where it has formed ponds with no surface connection to the Blackstone River. Pond N may be connected by a small stream to the Blackstone River during periods of higher water. Ponds C and B appear to be man-made excavations along the toe of the J.M. Mills Landfill that are flooded with river water at high stages and become disconnected from the Blackstone River at lower water levels. Similarly, the upstream end of Pond I (Nunes Inlet) near the Nunes Parcel has been observed to become isolated from the Blackstone River during periods of low flow but the downstream end remains connected to the flow in the Blackstone River when this occurs. Additional information regarding the wetlands and floodplain within the site can be found in the Technical Memorandum: Delineation of Wetland Boundaries and Waterways, Peterson/Puritan, Inc. Superfund Site – Operable Unit 2, Cumberland and Lincoln, Rhode Island, the draft of which is included as Appendix G to this FS. As this document has not yet been finalized, Appendix G also includes the comments provided by EPA on December 22, 2011. Also included in Appendix G is a depiction of the 100-year flood zone.

2.3.6 Climate and Meteorology

New England has a continental climate dominated by westerly winds. Its climate is modified on its coastal margins by the influence of cold marine currents on the eastern shore and warm currents on the southern shore. According to the *Remedial Investigation Report for the Peterson/Puritan Site* (C-EE, 1990), the prevailing wind direction in Rhode Island is from the south-southwest from April through September and from the north-northwest between October and March.

Climate data for Providence were obtained online from the National Oceanic and Atmospheric Administration National Climatic Data Center for the 30-year period from 1971 through 2000. The temperature in Providence varies from a mean daily minimum of 19.1 degrees Fahrenheit (ºF) in January to a mean daily maximum of 82.1°F in July. The mean annual precipitation in Providence is 45.53 inches, with the mean monthly precipitation varying from 3.18 inches in July to 4.43 inches in November. The mean annual precipitation in Woonsocket, Rhode Island, which is approximately 7 miles northwest of the OU2 site,

is 47.85 inches. Annual pan evaporation is estimated to be approximately 35 inches a year, and the annual lake evaporation is approximately 27 inches a year (U.S. Department of Commerce, 1968).

2.4 Conceptual Site Model

This section presents a Conceptual Site Model (CSM) for the OU2 site. This CSM describes the primary sources of contamination, fate and transport mechanisms (primary and secondary), nature and extent of contamination, and principal and low-level threat wastes and potential human health and ecological receptors and exposure pathways based on the previous site investigation activities summarized in Table 2-5.

2.4.1 Primary Sources of Contamination

Based on the findings of the Phase 1A and 1B investigations, the following source areas are distinguished within OU2: 1) the J.M. Mills Landfill; 2) the Unnamed Island (buried and surface waste); 3) the Nunes Parcel (buried and surface waste); and 4) Debris Fields ("DF"), including DF-1 through DF-3 between the northwestern end of the J.M. Mills Landfill and Martin Street and DF-4 on the southeastern flank of the J.M. Mills Landfill.

The primary sources of contamination that have been identified at the site are waste deposits and debris materials that have either been deposited as landfill materials or present in surface debris areas around OU2. The largest volume of source material is the more than 2.2 million cubic yards (cy) of waste estimated to occupy the property referred to as the J.M. Mills Landfill. Additionally, subsurface waste has also been delineated at the Unnamed Island and the Nunes Parcel. The Nunes Parcel was also operated as a transfer station both during the primary landfill era and after. Collectively, the areas today known as the J.M. Mills Landfill, the Nunes Parcel, and the Unnamed Island were owned and operated by Joseph and Linda Marszalkowski through their business of J.M. Mills, Inc., during the time of disposal from approximately 1954 to 1986 and together are defined as the principal source of contamination found at OU2.

The subsurface waste deposits vary in content, based on a review of the test pits completed around their perimeter to determine extent. The J.M. Mills landfill received industrial, commercial, and municipal waste. In addition to buried waste materials, surface DFs and other waste products have also been confirmed at the J.M. Mills landfill area, along the access road to the landfill, and widely distributed on the Nunes Parcel. The waste materials currently observed on the Unnamed Island, the Nunes Parcel, and the DFs appear to be more general industrial refuse in nature, consisting of wood, fiberglass, hosing, rubber parts, tires, scrap metal, mixed with some household waste, and other industrial byproducts. Surface runoff, erosion, and leaching from these source area deposits are mechanisms by which contaminants mobilize, mix with, and impact site soils and sediments.

Surface water features containing sediment and debris build up from stormwater runoff. Areas of the site include the Wetlands A through D to the north of the site and general overland surface flow throughout the site. With the exception of a single culvert that runs under the railroad tracks north of the J.M. Mills Landfill and connects flow from an unnamed brook and Wetland D to the river, there are no surface water piping connections between the wetlands and the J.M. Mills Landfill, nor is any believed to have existed historically. Because Wetlands A though D are considered hydraulically isolated from site-related sources, except for high river stages where the Blackstone River may flow through the culvert or top the railroad tracks in the northern areas, this source is not considered further in this study.

The dominant topographic feature of the mixed urban, suburban, and rural drainage system comprises the Blackstone River Valley. The Blackstone River is a heavily industrialized river that has an extensive history of impacts from urban stormwater runoff and industrial discharges and is considered an impaired waterway by the RIDEM. It has an extensive history, which extends throughout the Industrial Revolution. The Massachusetts Department of Environmental Protection (MassDEP) has issued fish advisories for the Blackstone River below Worcester, Massachusetts to the Rhode Island state line (approximately nine river miles upstream of the site). In studies of resident fish tissue conducted for the site, the study found that people who catch and eat the fish may be at risk from contaminants found in the fish tissues of some native, bottom dwelling and predatory species. Similar findings were documented in fish from both within the boundary of OU 2 as well as in the comparative reference areas upstream. This result, among other factors, indicates that the potential cause for the associated risk in eating fish may be due to many sources within the Blackstone River watershed. More recently, in part as a response to this study, the Rhode Island Department of Health (RIDOH) also posted a fish consumption advisory on their website stating that, “with the exception of stocked trout, fish should not be eaten from the Blackstone River.” However, “catch-and-release” sport fishing can still be enjoyed in this waterway, as in other urban rivers and ponds within the State. RIDOH is currently working with local stakeholders to further educate the public along the Rhode Island segment of the river.

The Blackstone River has the potential to carry elevated levels of contaminants in both surface water and on entrained particulate matter in the water column. These materials may be deposited and redeposited across the Blackstone River channel bottom and within low-lying floodplain soils and standing water bodies (e.g., the ponds and vernal pools located on the Unnamed Island and the ponds at other areas along the banks of the Blackstone River). Due to the dynamic nature of the flows in the Blackstone River, the exchange of sediment and dissolved materials tends to be highly variable depending on whether a zone is depositional in nature or not.

Landfill materials are likely undergoing some degree of active biodegradation processes and, as a result, are creating gases, some of which are currently vented from the J.M. Mills Landfill via a series of five small vent pipes. Only one of these vents (i.e., Vent #5) had appreciable levels of contaminants (i.e., carbon dioxide and methane – these constituents tend to displace nitrogen and oxygen in natural gas resulting from

biodegradation processes at municipal landfills), possibly because of the age and degradation of the landfill materials.

In addition to the generation of gases, the active biodegradation within the landfill cause reducing conditions in the groundwater, which in turn promote the mobilization of naturally occurring arsenic present in the native soils. This situation has been well documented at numerous sites in the New England area.

The Lenox Street Well Field was reported to be contaminated in 1979 and was no longer used as a public water source. Recent investigations 25 years later show no residual contamination. Therefore, no apparent source can be confirmed.

2.4.2 Release and Transport Mechanisms

This section focuses principally on the major fate and transport mechanisms believed to be active at this site, as well as the fate and transport properties of constituent groups.

2.4.2.1 Fate and Transport Properties of Constituents

For those constituents that are typically bound to soil and sediment (i.e., PAHs), the most important mechanism of fate and transport can be understood by examining erosion and deposition processes for soil and sediment at the site. Sediment particles may also be mixed within the sediment column or released to surface water through disturbance by benthic organisms, fish, turtles, or terrestrial organisms.

In addition to sediment transport, surface water transport, and dissolution, other mechanisms may be responsible for the relocation of soils and sediments. These mechanisms include the direct disposal of materials or the relocation of existing sediment or floodplain soils. For other constituents that are not hydrophylic in nature (i.e., “water loving” or dissolve readily in water like most inorganics), surface water may be the primary fate and transport medium.

Inorganic Constituents

Metals are chemical elements and cannot be destroyed by normal biophysical processes. Therefore, their fate includes cycling and chemical transformation, rather than degradation to simpler substances. For metals released into aquatic ecosystems, sediments may act as a sink, at least temporarily. This is because biotic and abiotic processes can cause sediment-bound metals to re-enter the water column and the food chain. The partitioning of metals between sediments and ecological compartments (i.e., water column and biota) is influenced by numerous physicochemical variables and the concentration and nature of ligands in the ambient water. In turn, the partitioning of metals determines the bioavailability of the chemical to aquatic organisms.

Some forms of metals (e.g., arsenic) exhibit the potential for trophic transfer via uptake from food, but quantities are insufficient to result in biomagnification (Suedel et al., 1994). Arsenic transforms rapidly to organic forms in aquatic food chains, and this transformation affects the accumulation of these metals among aquatic organisms (Bryan and Langston, 1992; Suedel et al., 1994). Other factors that may affect the biological availability of metals to organisms include temperature, salinity, hydrogen ion concentration, oxygen-reduction potential, and complexation. In addition, bioaccumulation may also depend on sediment properties, such as the presence and concentration of iron oxides, sulfides, and organic matter (Campbell et al., 1988).

Arsenic in groundwater occurs either as a release and/or as a result of reducing conditions that occur in groundwater beneath and near buried waste, which can cause oxidation-reduction-sensitive metals, such as arsenic, to become mobile in groundwater and is a well-documented occurrence at numerous sites in New England.

Semivolatile Organic Compounds

SVOCs, especially those containing chlorine atoms and/or two or more fused benzene rings, are relatively persistent in the environment. In air, soil, and water, the half-lives of chlorinated SVOCs are typically measured in hours. In groundwater and sediment, they are measured in days. The higher the number of chlorine atoms, the more likely the SVOC will be persistent and more difficult to degrade, and consequently, prone to long-range transport away from sources. Moreover, the chlorine-substituted molecules are more likely to be present in the ionic form in the environment. This is important because the degree of ionization controls the fate and transport of SVOCs according to the pH of the receiving medium. In the normal range of pH, chlorinated SVOCs exist as ionic species. This leads to increased water solubility and mobility (and subsequent transport) in the aqueous phase as a result of reduced sorption potential. With decreased sorption, there is also increased potential for volatilization and transport via air. In the neutral form, chlorinated SVOCs tend to have low water solubility and increased capacity for sorption. Some SVOCs (including methylphenols) may enter the food chain and accumulate in biota. However, the magnitude of this bioaccumulation is low due to metabolic degradation in biota. In the environment, the main degradation processes for SVOCs are photolysis and biodegradation.

A special subgroup of SVOCs includes PAHs, which are chemical compounds that contain two or more fused benzene rings. Examples of PAHs include naphthalene, acenaphthylene, fluorene and pyrene. Once in an aquatic system, PAHs do not usually exist in the dissolved form because they are hydrophobic. PAHs are either removed from the water column via photodegradation, are taken up by aquatic organisms (and subsequently metabolized), or they rapidly become associated with particles and are deposited in bottom sediments (McElroy, 1985; McElroy et al., 1989). Due to their hydrophobicity and strong affinity for organic matter, accumulation in sediments and bioaccumulation in fish and shellfish tend to be the primary fate of PAHs in the environment (Herbes and Schwall, 1978). Studies have shown that any PAH bioaccumulation

by aquatic organisms is correlated with physical/chemical properties of the given PAH, such as molecular weight and octanol/water partition coefficients (McElroy et al., 1989). However, given their affinity for sediments, PAHs are characterized as only moderately bioavailable, particularly in environments with high organic carbon content.

Volatile Organic Compounds

This group of chemicals is characterized by extreme volatility. For example, acetone will evaporate from water in less than 24 hours. As a result, air plays the main role in the environmental transport and degradation of VOCs released into the environment. Once in the atmosphere, VOCs tend to degrade rapidly due to their strong absorptive affinity for ultraviolet rays. The typical half-life of acetone in air is 30 days. Although VOCs have moderate solubility in water, they are rarely found in ambient water samples due to their high volatility. However, they sometimes can be detected in groundwater, where the potential for volatilization is limited. In addition to volatilization, VOCs are generally degraded or attenuated in the environment. Chlorinated VOCs tend to degrade less rapidly than other VOCs. In general, concentrations of VOCs in soil, sediment, or water are usually very low unless there is an active groundwater recharge zone and continued source load. VOCs do not bioaccumulate due to their short-lived nature in the environment.

Pesticides

This group of chemicals encompasses a wide variety of compounds whose specific function is to kill insects and other pests. Many of the older formulations (such as dichlorodiphenyltrichloroethane [DDT]) were specifically designed to be resistant to biochemical degradation, and have been formally banned by the EPA in 1973. This is particularly true for organochlorine pesticides (pesticides with a molecular structure containing one or more chlorine atoms) (Howard, 1991). Exposure media at the site included several pesticides, which included DDT metabolites, chlordane, dieldrin, endrin, endosulfan, and toxaphene. The most likely fate of these pesticides is metabolic degradation/transformation and accumulation in sediments and biological tissues (Howard, 1991).

Polychlorinated Biphenyls

PCBs are entirely of anthropogenic origin and are typically resistant (by design) to any type of biological or physical degradation (Howard, 1991). Moreover, they have a high affinity for biological tissues (especially fats) and sediment particles. Therefore, the fate of PCBs in the environment includes bioaccumulation in biota and cycling between various ecological compartments (i.e., biological tissues, prey, sediment, and soil) (Howard, 1991).

2.4.2.2 Secondary Fate and Transport Mechanisms

A listing of the secondary mechanisms believed active at the site by media is summarized below.

Groundwater

Chemicals may come in contact with groundwater through migration of contaminants from impacted soil media (i.e., leaching), direct contact with sources (e.g., buried landfill material), or from infiltration from river or other surface water sources. Almost all of the shallow site groundwater flows towards the river, the primary hydraulic discharge boundary in the river valley system. This is partially reversed for a relatively short time period during flood events where the Blackstone River stages rise and cause a reversal of localized gradients. Once groundwater commingles with the river, it becomes mixed with surface water flows and also can interact with sediment media. Due to the large recharge that the river experiences in this reach of the river, increased levels of dilution of constituents contained within groundwater is expected.

Groundwater gradients in the low-lying areas of the site (i.e., Nunes Parcel, Unnamed Island, Quinnville Well Field, and the floodplain areas at the toe of the landfill) are relatively flat. Groundwater gradients within the landfill are relatively steep due to the topographic elevation changes that are dramatic in this area (increase of 80 feet from river stage elevation). Groundwater in all areas of the site moves in a relatively rapid manner due to the elevated permeability of the sand and gravels located along the river and flow gradients present.

Due to the relatively low levels of impacts observed in sampling of monitoring wells distributed throughout the site, groundwater fate and transport mechanisms are considered to be minor at this site relative to increasing the mobility and/or redistribution of contaminants. Arsenic in groundwater may be associated with disposal activities and/or a result of reducing conditions that occur in groundwater beneath and near buried waste, which can cause oxidation-reduction-sensitive metals, such as arsenic, to become mobile in groundwater.

Soil

Impacts to soils can occur due to migration of shallow groundwater, impacts from surface infiltration, direct disposal, or commingling with source materials (e.g., buried landfill materials) either from spills and/or redistribution of surface soils, dust accumulation, or stormwater runoff. Migration of contaminants can also occur in the reverse of the pathways described above.

Sediment

Sediment in the vicinity of the site is subjected to a dynamic physical environment due to the stormwater runoff that occurs in the floodplain areas, potentially increasing the sediment loads and flows from the

Blackstone River that may deposit and scour sediment depending on the hydraulic profile of the river at any given cross section and the level of flow. Many chemicals bind to sediment and, therefore, have the potential to be redistributed, sometimes distant from the original source of impact, or become trapped in isolated areas at the site (e.g., in the ponds on the Unnamed Island).

Surface Water

Surface water impacts can arise from migration of groundwater to the Blackstone River, impacts from upstream locations within the river, stormwater runoff, direct contact with source materials (e.g., waste debris located along the riverbank), and dust migration. Surface water does not appear to be a significant source of flux of contaminants at the site, and the predominant influences in the areas in the river and floodplain areas are expected to be from upstream sources.

Fish Tissue

A wide variety of fish species has been observed within the Blackstone River. Some species tend to be very mobile, while others restrict their habitat to a relatively small area. Fish containing elevated chemical concentrations were observed at all study locations (including upstream reference locations). Fish uptake chemicals through a combination of eating other organisms (e.g., other fish), contact with water, and sediment and through the gills. Fish can then be consumed by anglers and also by other animals and provide a source for accumulation in the food chain. Chemical uptake in fish is considered a complete pathway at the site, but fish body burdens are not necessarily attributable to the site. Based on the statistical evaluation conducted for fish tissue PCB data, concentrations in fish from upstream portions of the Blackstone River are not significantly different from concentrations found in fish from OU2. Therefore, body burdens are more reflective of regional conditions.

Air

Air sources for relatively volatile compounds (e.g., VOCs) include the volatilization from impacted soils and groundwater, direct discharges of landfill gases produced by natural biodegradation processes, potential volatilization from surface water, and migration from offsite airborne sources. Air pathways are not considered significant pathways unless they come in direct contact with breathing zones of humans, and this is typically restricted at the site due to limited access.

Leachate

Active leachate or seeps have been observed at the site, but not during any major field investigation phases. Despite observations by agency personnel of seeps at the toe of the J.M. Mills Landfill (Pond C) and at the Nunes inlet (Pond I), the fact that these seeps were not observed during any field investigations indicates

that these seeps are likely ephemeral in nature. It should be noted that migration of contamination from waste sources to groundwater (and ultimately to the Blackstone River) is likely occurring, but not always visible.

Waste

Waste materials in landfill areas can relocate or change forms due to changes in the soil structure, surficial erosion, subsidence, and the amount of water in contact with the materials. Given the large volume of subsurface municipal and industrial waste that is present, the timeframe that it has been there, and the amount of subsidence that has already occurred, the waste materials that are not in immediate contact with groundwater or surface water are not expected to contribute significantly to the existing contamination in other media at the site.

2.4.3 Nature and Extent of Contamination

Collectively, the J.M. Mills Landfill, the Nunes Parcel, and the Unnamed Island represent a single landfilling and disposal operation over the time period of the majority of site disposal from approximately 1954 to 1986 and together are defined as the principal source of contamination found at OU2. Numerous investigations have been completed at the site since initial environmental investigation activities began at OU2 in 1980.

The majority of the investigative work for OU2 has been completed since 2003. The RI Report (ARCADIS, 2012) relied on this most current RI data set as a means to define the nature and extent of contamination. The following has been completed at OU2 since 2003:

- Ground surveys to provide for horizontal and vertical control of sampling locations and other key features.
- Bathymetric survey of the Blackstone River, its back channel, and Pond A in 2004 to aid in determining the hydraulic profile, and physical characteristics of the Blackstone River.
- Electromagnetic induction surveys were completed in 2003 to map out potential subsurface sources.
- Electrical conductivity/membrane interference probe survey was completed in 2003 to further evaluate levels of VOCs located downgradient and along the toe of the J.M. Mills Landfill.
- A geophysical survey (seismic refraction and microgravity profiling) was completed in 2005 to evaluate underground features and to help refine the shape and direction of the floor of the bedrock valley below OU2.

- Soil investigations were completed from 2003 through 2006 which included an extensive number of test trenches and soil borings with collection of both surface and subsurface soil samples.

- Geotechnical soil samples were completed in 2003 to provide for a baseline for general geotechnical characteristics.

- Several phases of groundwater investigations were completed from 2003 to 2007, including installation of numerous monitoring wells and piezometers, permeability testing, water-level monitoring to assess groundwater flow gradients and direction, and comprehensive groundwater sampling and analysis.

- Sediments were sampled through a series of investigations from 2003 and 2005, including a sediment quality triad (SQT) study of aquatic habitats and sediment probing completed in 2005. The SQT consisted of sediment sampling, benthic community sampling, and laboratory toxicity testing. A total of 80 sediment samples were collected at 80 locations, including 15 locations upstream of OU2.

- Surface water samples were collected both in the Blackstone River and throughout some of the more significant water bodies within OU2.

- Ecological community sampling was completed, including a fish community survey, fish tissue sampling, a benthic community survey, a habitat delineation and assessment, a wildlife survey, and a threatened/endangered species and critical habitats survey.

- Air samples were collected from the existing air vents located at the top of the J.M. Mills Landfill in Phase 1A.

- Waste contact delineation and extent sampling was completed within test pits completed around the Nunes Parcel to supplement the existing dataset to permit for risk evaluations for potential subsurface exposures in 2007.

- Additional soil and groundwater data collection at the Unnamed Island in the vicinity and contact with buried wastes in 2009 also for risk assessment purposes and waste volume estimate refinement.

- In 2012, additional limited sampling of groundwater, soil, and earthworms for potential Preliminary Remediation Goal (PRG) refinement and improved knowledge of current groundwater contaminant concentrations in support of this FS on the J.M. Mills Landfill floodplain and upstream reference areas.

2.4.3.1 Groundwater

Groundwater impacts related to the site appear to be relatively limited in extent and adequately defined. The Phase 1B groundwater investigation in 2005 completed the delineation of chemical constituents detected in the shallow and deep aquifer. The shallow aquifer contains low levels of organic chemicals typical of municipal landfills. However, there is evidence of attenuation of site-related constituents at depth. Groundwater impacts are confined to the upper 30 feet of the glaciofluvial aquifer beneath OU2 and limited to the area immediately downgradient of the west side of the J.M. Mills Landfill along the Blackstone River, and to a lesser extent, the area immediately downgradient at the south end of the J.M. Mills Landfill. There were a few detections on the Unnamed Island and at the north end of the Nunes Parcel. The most prevalent VOCs observed in groundwater above the site screening criteria, known as project action levels (PALs), were benzene, chlorobenzene, and 1,4-dichlorobenzene primarily in shallow wells, most notably in wells downgradient of the J.M. Mills Landfill. PALs are not regulatory standards but are used by investigators to determine nature and extent. Low concentration PAHs above screening criteria were also observed in some shallow monitoring wells. PCBs and pesticides were observed in groundwater at very low levels with only one (out of 95) groundwater sample at GNP-705 exceeding the screening criterion for Aroclor-1254.

EPA Regional Screening Levels (RSLs) were used as screening criteria in the human health risk assessment (HHRA). Several metals exceeded screening criteria. In addition, inorganic concentrations in some upgradient or reference groundwater also exceeded screening criteria. Reducing conditions that occur in groundwater beneath and near-buried waste tend to solubilize metals; therefore, some of the inorganics levels (most notably arsenic) at the site may be a result of this condition.

The concentrations of most detected constituents have historically been below regulatory criteria, which are the federal maximum contaminant levels (MCLs)/maximum contaminant level goals (MCLGs), federal risk-based standards, or more stringent Rhode Island groundwater standards. A subset (eight) of the site wells was sampled in 2012 for a limited list of analytes (benzene, Aroclor-1254, cadmium, and lead at various wells). Concentrations of the analyzed parameters were typically below historical detections at these wells, leading to the conclusion that groundwater concentrations of these contaminants at the site have been steadily declining.

The primary fate of constituents currently found in groundwater is to ultimately discharge to the Blackstone River, which hydrogeologically serves as a hydraulic discharge boundary in the Blackstone River Valley. The aquifer exhibits strong upward vertical hydraulic gradients toward the Blackstone River, which limits downward migration of contaminants. Furthermore, the aquifer exhibits variable but generally moderate to high hydraulic conductivity values (i.e., ranging from 8 to 4,300 feet per day at monitoring wells adjacent to the J.M. Mills Landfill), which result in moderate to relatively rapid groundwater flow rates and promote dilution and fairly rapid discharge to the Blackstone River.

2.4.3.2 Soil

A number of constituents, including PAHs (as well as with a few other SVOCs), PCBs, pesticides, and metals were observed in several locations across the site at mostly relatively low concentrations; however, a number of the contaminants did exceed the PALs, as well as RIDEM regulatory standards. In addition, PAHs and inorganics were observed at Mackland Farm, in an area originally considered potentially to be a "reference area" where a manufactured gas plant structure potentially containing coal tar was located near the Ashton Dam. The RIDEM TMDL Study in February 2013 and more recent data collected by ARCADIS in November/ December 2012 further documents these inorganics and PAHs upstream of the site. VOCs were generally not detected in soil samples and none were observed at significant levels in samples collected near the J.M. Mills Landfill or the Unnamed Island. Concentrations of dioxins/furans were above their respective screening levels for residential soil and were identified as a risk driver for the Nunes Parcel in the HHRA.

There are a number of locations in floodplain areas that contain concentrations of PCBs, PAHs, pesticides, and some metals; however, in some areas, these constituents may be the result of historical deposition of contaminated material from upstream areas of the Blackstone River. For example, this occurrence is observed in the Quinnville Well Field surface soil samples (where there is no evidence of land disposal activity).

There is evidence of elevated levels of lead on the Nunes Parcel and RIDEM Soil Removal Area.

2.4.3.3 Sediment

A broad range of sediment samples were collected from several areas, including within the Blackstone River proper, as well as upstream of the Ashton Dam. A number of detections of a broad suite of constituents, including several VOCs, SVOCs, PCBs, pesticides, and metals, were observed in these samples. These detections included elevated concentrations that were also found in upstream sample locations, as well as within the defined site boundary that may indicate contributions from basin-wide sources (historically occurring industrial pollution and stormwater runoff), in addition to those contributions more indicative of disposal practices throughout the site.

Similar distributions of constituents were observed on the Unnamed Island. Elevated levels of contaminants in sediment in ponds throughout OU2 were also found. Some of these levels are above reference conditions, as shown in the ecological risk assessment. Some of the ponds on the Unnamed Island become connected with the river flow at times as the Blackstone River rises and falls. All are submerged during significant rainfall events (i.e., generally yearly peak flooding events), more than one of which have occurred in the last few years. Therefore, the Unnamed Island ponds, as well as the vernal pools, may serve as

"sinks" for particulate matter entrained in the Blackstone River while waste deposits in close proximity to the ponds may also be a contributor.

2.4.3.4 Surface Water

Generally, VOCs, SVOCs, PAHs, PCBs, pesticides, and metals were rarely detected in surface water samples in the Blackstone River. The surface water data do not suggest ongoing or widespread potential impacts are occurring from OU2 to adjacent surface water in the Blackstone River or to Wetlands A through D across the railroad tracks to the northeast of the J.M. Mills Landfill. Elevated levels of contaminants, however, were found in surface water in ponds throughout OU2, with some contribution due to site source areas. These contaminants include aluminum, barium, cadmium, copper, manganese, and lead. Multiple metals exceeded EPA's National Ambient Water Quality Criteria (NAWQC) in site ponds at levels greater than exceedances noted upstream, suggesting possible contributions from site source areas.

Chemical concentrations present upstream in the Blackstone River may have the potential to contaminate the areas adjacent to the J.M. Mills Landfill and the Unnamed Island with low concentrations of lead, PAHs, PCBs, and other constituents until such time as the overall water quality of upstream reaches of the Blackstone River improve further. A recent TMDL Study by the RIDEM was released in February 2013, which described upgradient sources of certain metals. However, overall water quality of the Blackstone River is shown to be improving over time, and surface water does not appear to be a significant source for the flux of contaminants at the site.

2.4.3.5 Fish Tissue

Fish tissue samples were collected from six distinct areas: Blackstone River Area 1 (beginning approximately 1.25 miles upstream of the Ashton Dam and extending for approximately 0.5 mile downstream); Blackstone River Area 2 (beginning at the Ashton Dam and extending approximately 0.65 mile downstream); Blackstone River Area 3 (located within the boundaries of OU2); Pond A (P-1) (located on the Unnamed Island); Pond F (P-2) (located at the southeastern extent of OU2); and P-6, used as a reference pond (located approximately 1.6 miles north west of the Ashton Dam and not near the Blackstone River).

Due to the widespread distribution of constituents in all of the subareas, the fish tissue data are discussed in this FS by five classes of constituents: PAHs, SVOCs other than PAHs, PCB homologs, pesticides, and metals. In addition, a discussion of the distribution of constituents is also segregated between whole body and fillets, as well as some discussions of the variability of data among different species of fish. In total, there were over 220 discrete fish tissue samples evaluated.

In general, fish throughout the portions of the Blackstone River studied, including portions of the Blackstone River upstream of OU2, exhibit elevated levels of constituents, including the five classes identified above with PCBs, pesticides, and metals, the most common constituents identified above screening criteria. There was no evident pattern of "hot spots" within the Blackstone River.

2.4.3.6 Air

Several VOCs were observed in samples collected from the five air vents at the J.M. Mills Landfill. Most exhibited low levels of certain VOCs, carbon dioxide, and methane; however, higher levels of these constituents were observed in Vent #5, with a concentration of 59% by weight of methane, which is more typical of gases resulting from active biological degradation of materials in a municipal landfill. The vents at the J.M. Mills Landfill are not considered representative of ambient air samples at the site; therefore, ambient air concentrations were modeled in the HHRA to assess that specific exposure pathway. The HHRA determined that risk associated with exposure of receptors to ambient air at the J.M. Mills Landfill is negligible. During predesign studies, additional investigations will be conducted to ascertain whether landfill gases require remediation.

2.4.3.7 Leachate

A number of grab samples of water were collected from test trenches near the J.M. Mills Landfill as part of a previous investigation. However, all of the analyses were completed on non-filtered samples from a non-decontaminated backhoe. This technique is not consistent with *Quality Assurance Project Plan Addendum* (BBL, 2005) protocols and was not considered representative of leachate. It was later determined through quality assurance/quality control methodology that those samples do not accurately represent seep leachate conditions because the samples were not collected consistent with methods prescribed by the EPA. While some seeps have been reported by the EPA, these seeps were not present when field work was conducted. Therefore, they could not be sampled by the field crews during the RI.

2.4.3.8 Waste

Based on the delineation of waste deposits through the use of intrusive test pitting operations, the volumes of waste for the J.M. Mills Landfill and the Unnamed Island are projected at 2,200,000 cy and 40,000 cy, respectively. Additionally, there are approximately 21,000 cy of waste covering a broad area of 5.6 acres in the three DFs (DF-1, DF-2, and DF-3) located adjacent to the J.M. Mills Landfill. The estimated volume of waste material at the Nunes Parcel (transfer station) is approximately 56,000 cy.

At the J.M. Mills Landfill, the waste deposits extend into the floodplain along the Blackstone River, as well as somewhat to the north between the Blackstone River and the railroad tracks. While much of the surface cover material at the J.M. Mills Landfill is sparse and thin, the east side of the J.M. Mills Landfill is currently

fenced and the west side (including the floodplain area) is bounded by the river. At the Unnamed Island, waste was encountered in two general areas: (1) in the area surrounding Pond E (a smaller waste deposit, including several hundred tires situated between Pond D and the southern and western bank of Pond A) and (2) in an elongated area on the west side of the Unnamed Island, parallel to the back channel of the Blackstone River (a larger waste deposit between the back channel and Ponds A and D).

2.4.4 Principal Threat Wastes

The concept of principal threat waste, as developed by the EPA in the NCP is to be applied on a site-specific basis when characterizing source material. “Source material” is defined as that material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or act as a source for direct exposure.

Subsurface waste deposits are a primary source of contaminants at the site on land areas and are present at the J.M. Mills Landfill, the Unnamed Island, and the Nunes Parcel. The projected volume of wastes is greatest at the J.M. Mills Landfill, followed by the Unnamed Island, and then the Nunes Parcel.

Principal threat wastes are those source materials considered to be highly toxic or extremely mobile and cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. There is no evidence of principal threat waste at OU2 based on previous investigations and sampling results.

2.4.5 Low-Level Threat Wastes

Piles and pockets of surface debris that were left from the waste disposal operations are sporadically distributed at locations within the J.M. Mills Landfill, the Unnamed Island, and the Nunes Parcel. This debris has not been fully characterized, but is likely comparable to the debris present in the landfills.

Groundwater impacts appear to be modest and well defined. Relatively low concentrations of a limited number of VOCs (primarily benzene) have been observed at monitoring wells located at the toe of the J.M. Mills Landfill, primarily limited to its western end adjacent to the Blackstone River. Groundwater was not impacted at depths greater than approximately 30 feet below the water table. Limited groundwater sampling in 2012 have shown most of the wells that previously had the most significant benzene concentrations have attenuated to below detection limits.

Impacts to soil are variable, with soil contamination (primarily metals) identified along the floodplain at the base of the J.M. Landfill, within areas of the Unnamed Island, and adjacent to the Nunes Parcel. These floodplain area soil samples may be indicative of contributions from overland flow and deposition during high river stages, such as after a significant storm.

With the exception of occasional major flooding events, the adjacent wetlands (A through D) do not appear to be hydraulically connected via urban stormwater pathways nor influenced by groundwater transport from OU2 site source areas, although evidence of stormwater impacts attributable to other offsite sources has been observed and referred by the EPA to the RIDEM.

2.4.6 Potential Human Exposure

The following table summarizes the receptors and exposure pathways that were evaluated as part of the HHRA for each subarea.

Potential Exposure Media	Receptors of Interest	Exposure Areas
Surface Soil	Trespassers Recreational users	J.M. Mills Landfill Quinnville Well Field Southern Bank DFs Wetlands A, B, C, D Nunes Parcel Unnamed Island
	Commercial workers	Nunes Parcel Quinnville Well Field
	Construction workers	Nunes Parcel Quinnville Well Field Southern Bank Unnamed Island
	Residents	Nunes Parcel
Subsurface Soil	Recreational users Construction workers Commercial workers Residents	Nunes Parcel
	Recreational users Construction workers	Unnamed Island
Sediment	Trespassers Recreational users	Blackstone River Ponds A, B, C, D, E, F, P Excavator Pond Wetlands A, B, C, D
Surface Water	Trespassers Recreational users	Blackstone River Ponds A, B, C, D, E, F, P Excavator Pond Wetlands A, B, C, D
Groundwater	Residents	Site-wide groundwater
Shallow Groundwater	Construction workers	Site-wide groundwater Unnamed Island
Leachate	Trespassers	J.M. Mills Landfill
	Trespassers Recreational users Construction workers	Unnamed Island
Ambient Air	Trespassers Recreational users Site workers	J.M. Mills Landfill

Potential Exposure Media	Receptors of Interest	Exposure Areas
Outdoor (Trench) Air	Construction workers	Nunes Parcel Unnamed Island
Fish Tissue	Recreational users	Blackstone River OU2 Ponds
Indoor Air	Commercial workers Residents	Nunes Parcel

Exposure routes that were evaluated in the HHRA included ingestion, dermal contact, and inhalation. Section 3.1 of this FS summarizes the results of the HHRA and identifies those exposure pathways and receptor scenarios that had risks and/or hazards above EPA targets.

2.4.7 Potential Ecological Exposure

Potential ecological receptors evaluated in the BERA were selected using a feeding guild approach, as described in the *Ecological Risk Assessment Work Plan* (BBL, 2006b), and subsequent meetings and discussions with the EPA. The selected feeding guilds and representative species are listed below:

- benthic macroinvertebrates (e.g., midges, mayflies)
- amphibians (e.g., frogs, newts)
- fish (e.g., largemouth bass, golden shiner)
- omnivorous birds (e.g., American robin, American woodcock)
- piscivorous birds (e.g., great blue heron, belted kingfisher)
- omnivorous mammals (e.g., short-tailed shrew, red fox)
- piscivorous mammals (e.g., mink, river otter)

The EPA, the trustee agencies, and the Group determined that terrestrial plants and soil invertebrates would not be quantitatively addressed in the BERA due to a paucity of soil benchmarks.

Typical exposure routes for aquatic and terrestrial receptors are inhalation, ingestion, and dermal absorption. Ingestion routes can include ingestion of soil while foraging, consumption of contaminated water, or ingestion of contaminated food. These ingestion routes were considered the primary exposure routes in the ecological risk assessments. Inhalation and dermal absorption tend to be less important for terrestrial receptors because constituents of potential environmental concern (COPEC) concentrations in air are usually low and skin/fur/feathers often form an effective barrier. Furthermore, ambient air sampling at the site

did not indicate elevated levels of any constituents. Therefore, these routes are considered secondary and were not examined for terrestrial receptors.

3. Basis for Site Remediation

3.1 Risk Evaluation

This section summarizes the results from the HHRA and BERA that were conducted for OU2, as well as any supplemental risk evaluations. This section also discusses the subsequent risk refinements for the HHRA and BERA and the development of human health-based and ecological-based PRGs/Performance Standards.

3.1.1 Summary of OU2 Human Health Risk Assessment

The following is a general timeline of for the OU2 HHRA activities:

- June 2007: ARCADIS provided first draft of HHRA to EPA
- November 2007: ARCADIS revised HHRA based on EPA comments
- September 2008: ARCADIS revised HHRA based on additional EPA comments
- April 2009: EPA updates HHRA document
- July 2010: EPA develops *Supplemental Human Health Risk Assessment for Unnamed Island*
- May 11, 2011: EPA memorandum with corrections to the cancer slope factor (CSF) for dioxin
- April 19, 2012: EPA memorandum regarding determination of PRGs in support of the FS
- February 21, 2013: EPA memorandum regarding updates on dioxin toxicity values and their implication on the baseline HHRA (BHHRA).

The HHRA (as supplemented) concluded that carcinogenic risks and non-carcinogenic hazards for soil, sediment, surface water, leachate, and/or ambient air for trespassers and recreational users, and soil, shallow groundwater, and outdoor (trench) air for construction workers were generally less than or within

EPA target levels (i.e., risk range of 10^{-4} to 10^{-6} and hazard index [HI] of 1). Non-carcinogenic hazards and carcinogenic risks are discussed separately for each exposure area below.

3.1.1.1 Non-Carcinogenic Hazards

J.M. Mills Landfill

Non-cancer hazards from limited available floodplain soil data were equal to or below the EPA target HI of 1. Under the presumptive approach it is presumed that the landfill debris within the J.M. Mills Landfill poses a human health risk.

Debris Fields

Non-cancer hazards were less than the EPA target HI of 1. However, these debris fields are understood to be extensions of the land filling operations and will be handled presumptively. Additional sampling may be conducted as part of the remedial design to further characterize the debris, if required.

Quinnville Well Field

Non-cancer hazards were less than or equal to the EPA target HI of 1. No action is required for this area of the OU2 RI Study Area to address human health risks.

Southern Bank

Non-cancer hazards were less than or equal to the EPA target HI of 1. No action is required for this area of the OU2 RI Study Area to address human health risks.

Nunes Parcel/RIDEM Soil Removal Area

Non-cancer hazards for a hypothetical residential scenario were above the EPA target HI of 1. Under the presumptive approach it is presumed that the landfill debris within the Nunes Parcel poses a human health risk.

Wetlands A-D

Non-cancer hazards were less than the EPA target HI of 1. No action is required for these areas within the OU2 RI Study Area outside of the OU2 boundary to address human health risks.

Groundwater

Non-cancer hazards for potable use of OU2 groundwater are above the EPA target HI of 1. Therefore, future use of groundwater presents a potential human health risk.

Fish Tissue

Non-cancer hazards to recreational receptors eating resident fish from OU2, BR-1, and BR-2 were greater than the EPA target HI of 1. However, eating fish from the background/reference area pond (P-6) also posed target organ hazard index greater than 1 for recreational receptors, which places site risks into a more regional perspective. Based on the statistical evaluation conducted for fish tissue PCB data, concentrations in fish from upstream portions of the Blackstone River are not significantly different from concentrations found in fish from OU2. Further, consumption of fish from the background/reference area pond (P-6) at the same rates as those used in the OU2 calculations resulted in hazards above the EPA target of 1. Therefore, based on this study and other watershed-wide findings, the potential cause(s) for associated risks in consuming fish from the river may be likely due to known sources and conditions observed throughout the watershed and no site-specific action under CERCLA is required to address human health risks associated with consumption of fish. Actions that may be taken to reduce contamination at the site may have indirect impacts on the river by reducing contaminant contributions from the site. Measures will be considered to conduct public outreach, monitoring, and/or other actions related to fish consumption.

Unnamed Island

See Section 3.1.2.

3.1.1.2 Carcinogenic Risks

J.M. Mills Landfill

Cancer risks from limited available floodplain soil data were within or less than the EPA's target risk range of 10^{-4} to 10^{-6}. Exposure scenarios that exceeded a risk level of 1×10^{-6} included:

- Current exposure of trespassers to surface soil, sediment, surface water, leachate, and ambient air;
- Future exposure of recreational users while wading to surface soil, sediment, surface water, leachate, and ambient air; and

- Future exposure of recreational users while swimming to surface soil, sediment, surface water, leachate, and ambient air.

Under the presumptive approach it is presumed that the landfill debris within the J.M. Mills Landfill poses a human health risk.

Debris Fields

Cancer risks were within or less than the EPA's target risk range of 10^{-4} to 10^{-6}. Exposure scenarios that exceeded a risk level of 1 x 10^{-6} included:

- Current exposure of trespassers to surface soil, sediment, and surface water; and
- Future exposure of recreational users while wading and swimming to surface soil, sediment, and surface water.

Asbestos (predominantly observed on the site in the form of transite pipe and shingles), in particular, may present significant health risks due to its status as a Class A (known human) carcinogen if fibers are released into the air and inhaled. These debris fields are understood to be extensions of the land filling operations and will be handled presumptively. Additional sampling may be conducted as part of remedial design to further characterize the debris, if required.

Quinnville Well Field

Contamination in this area is not linked to releases from OU2 (see Section 3.3). Cancer risks were within or less than the EPA's target risk range of 10^{-4} to 10^{-6}. Exposure scenarios that exceeded a risk level of 1 x 10^{-6} included:

- Current exposure of commercial workers to surface soil;
- Current exposure of trespassers to surface soil, sediment, and surface water;
- Future exposure of recreational users while wading and swimming to surface soil, sediment, and surface water; and
- Future exposure of commercial workers to surface soil.

No action is required for this area of the OU2 RI Study Area to address human health risks.

Southern Bank

Contamination in this area is not linked to releases from OU2 (see Section 3.3). Cancer risks were within or less than the EPA's target risk range of 10^{-4} to 10^{-6}. Exposure scenarios that exceeded a risk level of 1×10^{-6} included:

- Current and future exposure of recreational users while wading and swimming to surface soil, sediment, and surface water;
- Current exposure of trespassers to sediment; and
- Future exposure of construction workers to surface soil, including fugitive dust, and shallow groundwater.

No action is required for this area of the OU2 RI Study Area to address human health risks.

Nunes Parcel/RIDEM Soil Removal Area

Cancer risks were within or less than the EPA's target risk range of 10^{-4} to 10^{-6}, except for future hypothetical residents and future commercial workers exposed to surface and subsurface soils and indoor air. Risk to a future commercial worker exposed to soil and indoor air at the Nunes Parcel exceeded 1×10^{-4} due primarily to benzene in indoor air. Major contributors to risk are carcinogenic PAHs, bis(2-ethylhexyl)phthalate, dieldrin, dioxins, and/or arsenic in soil and benzene, naphthalene, and/or tetrachloroethene in indoor air. In addition, risk to a future resident exposed to soil and indoor air at the Nunes Parcel exceeded a cancer risk of 1×10^{-4}. The exceedance is primarily due to benzene, naphthalene, 1,4-dichlorobenzene, ethylbenzene, tetrachloroethene, and/or vinyl chloride in indoor air and carcinogenic PAHs, PCBs, dieldrin, dioxins, bis(2-ethylhexyl)phthalate, and/or arsenic in soil.

Under the presumptive approach it is presumed that the landfill debris within the Nunes Parcel poses a human health risk.

Wetlands A-D

Cancer risks were within the EPA's target risk range of 10^{-4} to 10^{-6}. Exposure scenarios that exceeded a risk level of 1×10^{-6} included:

- Current exposure of trespassers to surface soil, sediment, and surface water; and

- Future exposure of recreational users while wading and swimming to surface soil, sediment, and surface water.

No action is required for these areas within the OU2 RI Study Area outside of the OU2 boundary to address human health risks.

Groundwater

Cancer risks for potable use of OU2 groundwater are above the EPA's target risk range of 10^{-4} to 10^{-6}. Therefore, future use of groundwater within OU2 presents a potential human health risk. Risks to hypothetical future residential receptors from ingestion, dermal contact, and inhalation due to potable use of groundwater were greater than 1 x 10^{-4}, even though some contaminants contributing to elevated risks were generally present at concentrations less than their respective drinking water MCLs (e.g., benzene). The major contributors to the groundwater risk are arsenic, carcinogenic PAHs, 1,4-dioxane, 4-chloroaniline, atrazine, bis(2-ethylhexyl)phthalate, naphthalene, 1,4-dichlorobenzene, chloroform, ethylbenzene, methyl tert-butyl ether, PCE, TCE, vinyl chloride, aldrin, dieldrin, PCBs, and benzene.

Fish Tissue

Cancer risks to recreational receptors eating resident fish from OU2, BR-1, and BR-2 were greater than 1 x 10^{-4}. However, the background/reference area pond (P-6) had risks in the range of 10^{-5}, which places site risks into a more regional perspective. Based on the statistical evaluation conducted for fish tissue PCB data, concentrations in fish from upstream portions of the Blackstone River are not significantly different from concentrations found in fish from OU2. Therefore, no site-specific action is required under CERCLA to address human health risks associated with consumption of fish. Actions that may be taken to reduce contamination at the site may have indirect impacts on the River by reducing contaminant contributions from the site. Measures will be considered to conduct public outreach, monitoring, and/or other actions related to fish consumption. As an example, in 2012, a Technical Fact Sheet was published to recognize the findings and recommended against taking resident fish for consumption from the water bodies identified in the fish study.

Physical Hazards

In addition to the quantified risks and hazards mentioned above, physical hazards, such as metal debris, tires, dilapidated buildings, and broken glass at the site may also present some risks. These physical hazards are considered in this FS.

Unnamed Island

See Section 3.1.2.

3.1.1.3 Lead Evaluation

The lead evaluation initially identified the following scenarios within the OU2 RI Study Area as having potential lead risks above the current EPA target level of no more than 5% of the receptor population having blood lead level exceeding 10 micrograms per deciliter (µg/dL):

- Exposure of commercial workers to soils within the RIDEM Soil Removal Area within OU2;
- Exposure of construction workers to soils at the Nunes Parcel and RIDEM Soil Removal Area within OU2; and
- Exposure of hypothetical young child residents to soil and groundwater from the RIDEM Soil Removal Area within OU2.

In addition, outside of OU2, within the OU2 RI Study Area there were potential lead risks identified for:

- Exposure of construction workers to soils at the Quinnville Well Field and Southern Bank outside of OU2 (from non-OU2-related sources).

However, the evaluation of lead risks for the construction worker used an upper-bound soil ingestion rate of 330 milligrams per day (mg/day) as presented in the 2009 Agency Review BHHRA. EPA has subsequently approved a soil ingestion rate of 100 mg/day for this receptor to be used with the lead model as recommended by the lead Technical Review Workgroup (Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil, December 1996), and this is outlined in the Human Health Risk Refinement (Section 3.1.3).

3.1.2 Summary of Human Health Risk Assessment for Unnamed Island

The Supplemental HHRA for the Unnamed Island was conducted in July 2010 by EPA subcontractors Metcalf & Eddy and AECOM.

Results of the Supplemental HHRA for the Unnamed Island indicated that risks and hazards for soil, sediment, surface water, and leachate for trespassers and recreational users, and soil, shallow groundwater, and outdoor (trench) air for construction workers at the Unnamed Island were within the EPA's target levels

(i.e., risk range of 10^{-4} to 10^{-6} and a HI of 1). Non-carcinogenic hazards and carcinogenic risks are discussed separately for each exposure area below.

3.1.2.1 Non-Carcinogenic Hazards

Current Adolescent Trespasser

Non-cancer hazards for the current adolescent trespasser exposed to surface soil, leachate, surface water, and sediment were less than the EPA target HI of 1. No action is required for the Unnamed Island to address human health risks for this receptor of concern.

Future Recreational User

Non-cancer hazards for the future older child and adult recreational user exposed to surface and subsurface soil, leachate, surface water, and sediment were less than the EPA target HI of 1. No action is required for the Unnamed Island to address human health risks for this receptor of concern.

Future Construction Worker

Non-cancer hazards for the future construction worker exposed to surface and subsurface soil, shallow groundwater, leachate, and outdoor (trench) air were less than the EPA target HI of 1. No action is required for the Unnamed Island to address human health risks for this receptor of concern.

3.1.2.2 Carcinogenic Risks

Current Adolescent Trespasser

Cancer risks for the adolescent trespasser exposed to surface soil, leachate, surface water, and sediment were within the EPA target risk range of 10^{-4} to 10^{-6}. No action is required for the Unnamed Island to address human health risks for this receptor of concern.

Future Recreational User

Cancer risks for the future older child and adult recreational user exposed to surface and subsurface soil, leachate, surface water, and sediment were within the EPA target risk range of 10^{-4} to 10^{-6}. No action is required for the Unnamed Island to address human health risks for this receptor of concern.

Future Construction Worker

Cancer risks for the construction worker exposed to surface and subsurface soil, leachate, shallow groundwater, and outdoor (trench) air were within the EPA target risk range of 10^{-4} to 10^{-6}. No action is required for the Unnamed Island to address human health risks for this receptor of concern.

Physical Hazards

In addition to lead, physical hazards, such as metal debris, tires, and broken glass, at the Unnamed Island may also present some risks. These physical hazards are considered in this FS.

3.1.2.3 Lead Evaluation

Estimated lead risks for future recreational users and current trespassers at the Unnamed Island were below the EPA target level of no more than 5% of the receptor population having blood lead level exceeding 10 µg/dL. The lead evaluation for the Unnamed Island initially identified construction workers as having estimated lead risks above the EPA target. However, this evaluation used an upper-bound soil ingestion rate of 330 mg/day for the construction worker and the EPA has subsequently recommended a soil ingestion rate of 100 mg/day for this receptor to be used with the lead model as recommended by the lead Technical Review Workgroup (EPA, 1996). Section 3.1.3 describes the human health risk refinement for evaluation of lead risks for construction workers at the Unnamed Island.

3.1.3 Human Health Risk Refinement

The human health risk refinement applies to both the OU2 HHRA and the Supplemental HHRA for the Unnamed Island. The refinement addresses the soil ingestion rate used for construction workers in the lead evaluations and also addresses the change in toxicity values for dioxins, tetrachloroethene (PCE), and trichloroethene (TCE). The following sections discuss the effects of these changes on the HHRAs.

3.1.3.1 Lead Modeling

Previously, an upper-bound soil ingestion rate of 330 mg/day was used to evaluate potential lead risks for construction workers. The EPA has subsequently approved a soil ingestion rate of 100 mg/day to be used with the lead model as recommended by the lead Technical Review Workgroup (EPA, 1996) for purposes of the lead evaluation for a construction worker. Appendix C.1 presents the revised lead modeling for OU2 and Appendix C.2 presents the revised lead modeling for the Unnamed Island.

In summary, the following exposure scenarios are the only ones that have estimated lead risks above the EPA target level of no more than 5% of the receptor population having blood lead level exceeding 10 µg/dL:

- Exposure of construction workers to soils at the RIDEM Soil Removal Area;

- Exposure of commercial workers to soils within the RIDEM Soil Removal Area and
- Exposure of hypothetical young child residents to soil and groundwater from the RIDEM Soil Removal Area.

3.1.3.2 Toxicity Values

Toxicity values (i.e., oral CSFs and oral reference doses [RfDs]) have changed for dioxins, PCE, and TCE since the completion of the baseline HHRA. PCE was originally shown to be a risk driver in the baseline HHRA. To assess and document the impact of these changes, the following briefly discusses the changes in toxicity values and resulting impacts on the contribution of these contaminants to overall risk and hazard estimates for receptors of concern.

Dioxins

The following tables present the dioxin toxicity values that were used in the baseline HHRAs for OU2 and the Unnamed Island, as well as the current approach recommended by EPA Region 1.

Exhibit 1
Cancer Toxicity Data for Dioxin – Oral/Dermal and Inhalation

Source	Oral/Dermal CSF[(1)]	Unit	Source	Inhalation Unit Risk	Unit	Source
2009 Updated BHHRA	1.3E+05	$(mg/kg\text{-}day)^{-1}$	CalEPA	3.8E+01	$(\mu g/m^3)^{-1}$	CalEPA
2010 Supp. HHRA	1.56E+05	$(mg/kg\text{-}day)^{-1}$	EPA OHEA	3.8E+01	$(\mu g/m^3)^{-1}$	CalEPA
Current approach	1.56E+05	$(mg/kg\text{-}day)^{-1}$	EPA OHEA	3.8E+01	$(\mu g/m^3)^{-1}$	CalEPA

Exhibit 2
Non-Cancer Toxicity Data for Dioxin – Oral/Dermal and Inhalation

Source	Oral/Dermal RfD[(1)]	Unit	Source	Inhalation Reference Concentration	Unit	Source
2009 Updated BHHRA	N/A	N/A	N/A	N/A	N/A	N/A
2010 Supp. HHRA	1E-09	mg/kg-day	ATSDR	4E-05	$\mu g/m^3$	CalEPA
Current approach	7E-10	mg/kg-day	IRIS	4E-05	$\mu g/m^3$	CalEPA

Notes:
CalEPA = California Environmental Protection Agency
OHEA = EPA's Office of Health and Environmental Assessment
ATSDR = Agency for Toxic Substances and Disease Registry
IRIS = EPA's Integrated Risk Information System

EPA Region 1 prepared a technical memorandum (presented as Appendix C.3 to this FS) that discusses the change in toxicity values for dioxins. Briefly, the CSF used in the 2009 Baseline HHRA for OU2 (1.3E+05 $[mg/kg/d]^{-1}$ from CalEPA) was replaced with a CSF of 1.56E+05 $(mg/kg/d)^{-1}$ from the EPA's OHEA. This change in CSF resulted in a slight increase of cancer risks, but the EPA deemed that the changes are minimal and revised risks and hazards are within the EPA's acceptable risk range (see Appendix C.3).

Non-cancer toxicity data were not available for dioxins when the baseline HHRA was prepared for OU2. However, following the EPA's finalization of its *Reanalysis of Key Issues Related to Dioxin Toxicity and Response to NAS Comments, Volume 1* in February 2012, an RfD and inhalation reference concentration (RfC) were used in the Supplemental HHRA for the Unnamed Island. Similar to the change in cancer toxicity values, the use of these new non-cancer toxicity values did not significantly change the results of the Baseline HHRA (see Appendix C.3).

PCE

The following tables present the PCE toxicity values that were used in the baseline HHRAs for OU2 and the Unnamed Island, as well as the current approach recommended by the EPA.

Exhibit 3
Cancer Toxicity Data for PCE – Oral/Dermal and Inhalation

Source	Oral/Dermal CSF(1)	Unit	Source	Inhalation Unit Risk	Unit	Source
2009 Updated BHHRA	5.4E-01	$(mg/kg\text{-}day)^{-1}$	CalEPA	5.9E-06	$(\mu g/m^3)^{-1}$	CalEPA
2010 Supp. HHRA	5.4E-01	$(mg/kg\text{-}day)^{-1}$	CalEPA	5.9E-06	$(\mu g/m^3)^{-1}$	CalEPA
Current approach	2.1E-03	$(mg/kg\text{-}day)^{-1}$	IRIS	2.6E-07	$(\mu g/m^3)^{-1}$	IRIS

Exhibit 4
Non-Cancer Toxicity Data for PCE – Oral/Dermal and Inhalation

Source	Oral/Dermal RfD(1)	Unit	Source	Inhalation Reference Concentration	Unit	Source
2009 Updated BHHRA	1.0E-01	mg/kg-day	IRIS	2.7E+02	$\mu g/m^3$	ATSDR
2010 Supp. HHRA	N/A	N/A	N/A	N/A	N/A	N/A
Current approach	4.0E-02	mg/kg-day	IRIS	6.0E-03	$\mu g/m^3$	IRIS

Notes:
(1) There are no dermal toxicity values for PCE. Because the oral absorption efficiency to dermal for PCE exceeds 50%, no adjustment of the oral toxicity values is necessary.
N/A = not applicable/not available

Appendix C.4 to this FS discusses the change in toxicity values for PCE. Briefly, both the cancer and non-cancer toxicity values changed for PCE. Specifically, the cancer values became less stringent (i.e., indicate PCE is less potent) and the non-cancer values became more conservative (i.e., indicate PCE is more toxic). This change in CSF would result in a decrease of PCE cancer risks by approximately 250-fold for oral risks and by approximately 20-fold for inhalation risks. The change in RfDs and RfCs would result in an increase in PCE non-cancer hazards by approximately 2-fold for oral hazards and 7-fold for inhalation hazards. However, these changes in PCE toxicity values resulted in the EPA screening value changes, which when taken into consideration, indicate PCE is only identified as a risk-based contaminant of concern (COC) for Nunes Parcel indoor and outdoor air. Because the Nunes Parcel will be addressed as part of a presumptive containment approach, no further evaluation of PCE is warranted for the baseline HHRA.

TCE

The following tables present the TCE toxicity values that were used in the baseline HHRAs for OU2 and the Unnamed Island, as well as the current approach recommended by the EPA.

Exhibit 5
Cancer Toxicity Data for TCE – Oral/Dermal and Inhalation

Source	Oral/Dermal CSF(1)	Unit	Source	Inhalation Unit Risk	Unit	Source
2009 Updated BHHRA	1.3E-02	$(mg/kg\text{-}day)^{-1}$	CalEPA	2.0E-06	$(\mu g/m^3)^{-1}$	CalEPA
2010 Supp. HHRA	N/A	NA	NA	2.0E-06	$(\mu g/m^3)^{-1}$	CalEPA
Current approach	4.6E-02	$(mg/kg\text{-}day)^{-1}$	IRIS	4.1E-06	$(\mu g/m^3)^{-1}$	IRIS

Exhibit 6
Non-Cancer Toxicity Data for TCE – Oral/Dermal and Inhalation

Source	Oral/Dermal RfD(1)	Unit	Source	Inhalation Reference Concentration	Unit	Source
2009 Updated BHHRA	N/A	N/A	N/A	10	$\mu g/m^3$	NYSDOH
2010 Supp. HHRA	N/A	N/A	N/A	10	$\mu g/m^3$	NYSDOH
Current approach	5.0E-04	mg/kg-day	IRIS	2	$\mu g/m^3$	IRIS

Notes:
(1) There are no dermal toxicity values for TCE. Since the oral absorption efficiency to dermal for TCE exceeds 50%, no adjustment of the oral toxicity values is necessary.

N/A = not applicable/not available

Appendix C.5 to this FS discusses the change in toxicity values for TCE. Briefly, both the cancer and non-cancer toxicity values changed for TCE. Specifically, both the cancer values and non-cancer values became more conservative. This change in CSF would result in an increase of TCE cancer risks by approximately 8-

fold for oral risks and by approximately 2-fold for inhalation risks. The change in RfCs would result in an increase in TCE non-cancer hazards by approximately 2-fold for inhalation hazards. (There were no previous RfDs for TCE for the oral pathway.) TCE was identified as a risk driver for site-wide groundwater. However, using the revised toxicity values, risks and hazards for TCE would still be within EPA targets and, therefore, would not significantly change the results of the baseline HHRA.

3.1.3.3 Exposure Factor Updates

Note that the HHRA was completed in 2009/2010. In February 2014, EPA finalized a Directive to update standard default exposure factors and frequently asked questions associated with these updates (located online at http://www.epa.gov/oswer/riskassessment/superfund_hh_exposure.htm; items # 22 and #23 of this web link). Applying these updated standard default exposure factors to the risk assessment would possibly result in a slight decrease of the risk estimates; however, it would not change the conclusions regarding unacceptable risks at the site. These revisions will be reviewed further during ROD development with respect to risk-based performance standards.

3.1.4 Summary of Baseline Ecological Risk Assessment

The following is a general timeline of for the OU2 BERA activities:

- February 2007: ARCADIS provided a Screening-Level Ecological Risk Assessment (SLERA) to the EPA
- September 2008: ARCADIS submitted the final revised BERA to the EPA
- May 2009: the EPA provides a revised BERA
- July 27, 2010: AECOM develops Supplemental Ecological Risk Assessment for Unnamed Island
- August 12, 2010: AECOM submits Technical Memorandum – Ecological Risk Summary (see Appendix D.1)
- April 11, 2012: EPA memorandum regarding sediment COC refinement and PRG development (see Appendix D.2)
- April 12, 2012: EPA memorandum regarding additional refinements to terrestrial ecological risk calculations (see Appendix D.3)
- April 19, 2012: EPA letter regarding EPA's determination of PRGs in support of the FS (see Appendix D.4)

- June 21, 2013: EPA memorandum reviewing the PRP group's technical memorandum titled: *Background Screening Levels for Sediment and Soil Supplemental Data Collection Efforts* (see Appendix D.5)

- November 18, 2013: EPA memorandum reviewing the PRP group's technical memorandum titled: *Small Omnivorous Bird Risks at the J.M. Mills Landfill; Supplemental Data Collection Efforts* (see Appendix D.6)

The BERA (as supplemented) used a weight-of-evidence (WOE) approach to evaluate risks for several representative receptors for each subarea of the site. The potential receptors that were identified in the problem formulation (and subsequently evaluated in the BERA) are benthic macroinvertebrates, fish, amphibians, birds, and mammals.

In terms of terrestrial risks, the risk refinement conducted by the EPA (April 12, 2012) concluded the following:

- The hazard quotients (HQs) and evaluation of risk above background levels suggest potential risk from lead and bis(2-ethylhexyl)phthalate (BEHP) to small omnivorous birds feeding at the Unnamed Island with low (BEHP) and moderate (lead) confidence in the risk estimates.

- The evaluation also suggests potential risk from cadmium to small omnivorous birds feeding at the J.M. Mills Landfill, with moderate confidence in the risk estimates.

- Lead, cadmium, and BEHP pose a low potential risk site-wide, but with lower confidence than observed for the Unnamed Island and J.M. Mills Landfill.

In response to these risk estimates, additional sampling was conducted in November 2012 to further refine the risk estimate for small omnivorous birds in the vicinity of the J.M. Mills Landfill. The sampling included the collection and analysis of co-located earthworm and soil samples from adjacent to and upstream of the site. Collectively, the data indicate that risks to birds from ingestion of earthworms are relatively similar between upstream reference areas and areas adjacent to the J.M. Mills Landfill. However, these data are still being evaluated further.

The following table presents a summary of aquatic ecological risks.

Exhibit 7
Sediment Ecological Primary Contaminants by Exposure Area[1]

Area	Primary Contaminants
Unnamed Islands (Ponds A, D, and E)	Cd, Cr, Cu, Pb, Zn, total PAHs
Ponds Adjacent to the Blackstone River (Pond I)	Cd, Cr, Cu, total PAHs
Ponds Adjacent to the Blackstone River (Pond N)	Cd

[1] From EPA April 11, 2012 memo: Sediment COC refinement and PRG development.

3.2 Applicable or Relevant and Appropriate Requirements

This section presents a summary of the regulatory requirements for developing remedial alternatives for the site. The Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA") of 1980, as amended, and the National Contingency Plan ("NCP") require that potential ARARs be identified during the RI/FS process. ARARs are federal and state human health and environmental requirements and guidelines that will be used to: (1) evaluate the appropriate extent of the site cleanup; (2) define and formulate remedial action alternatives; and (3) govern implementation and operation of the selected action. ARARs are classified as follows:

- *Chemical-specific* requirements are usually health- or risk-based numerical values or methods that, when applied to site-specific conditions, result in the establishment of numerical values for the acceptable loading or concentration of a hazardous substance that may be found in, or discharged to, the environment.

- *Location-specific* requirements are restrictions placed on the conduct of activities solely because they occur in specific locations.

- *Action- (or remedy-) specific* are usually technology- or activity-based and may include requirements for actions taken with respect to hazardous constituents.

3.2.1 Definition of ARAR Categories

To properly consider ARARs and to clarify their function in the RI/FS and remedial response processed, the NCP defines two ARAR components: (1) "applicable requirements" and (2) "relevant and appropriate requirements." Requirements under federal or state law may be either applicable or relevant and appropriate to CERCLA cleanup actions. In addition, while not mentioned in CERCLA, *EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under* CERCLA provides that other information not meeting the definition of an ARAR, may also be considered. Such other information is referred to as "TBC" or "to be considered." The definitions of these types of requirements are as follows:

- Applicable requirements are "cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, removal action, location, or other circumstance found at a CERCLA site" (40 CFR 300.5). These include federal requirements that are directly applicable, as well as those incorporated by a federally authorized state program. Only those state standards identified by the state in a timely manner that are more stringent than federal requirements may be applicable.

- Relevant and appropriate requirements are "cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, removal action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (40 CFR 300.5). There is more discretion in this determination in that it is possible for only part of a requirement to be considered relevant and appropriate, the rest being dismissed if judged not to be relevant and appropriate in a given case. Only those state standards identified by the state in a timely manner that are more stringent than the applicable federal standard may be relevant and appropriate.

- TBCs are other "available information [that] is not an ARAR (e.g., advisories, criteria, and guidance)." Such TBCs "may be considered in the analysis if it helps to ensure protectiveness or is otherwise appropriate for use in a specific alternative." Two categories of TBC information are: (1) technical information on how to perform or evaluate remedial or response actions; and (2) regulatory policy or proposed regulations (USEPA 1988).

Development of a comprehensive inventory of ARARs and TBCs involves a two-tiered analysis: establishing the applicability of an environmental regulation; and evaluating relevancy and appropriateness if the regulation is not applicable. A requirement may be either "applicable" or "relevant and appropriate" but not both.

CERCLA onsite remedial response actions must only comply with the substantive requirements of an ARAR and not the administrative requirements to obtain federal, state, or local permits [CERCLA §121(e)]. The NCP defines onsite as "the aerial extent of contamination and all areas in very close proximity to the contamination necessary for implementation of the response action." Offsite actions need only comply with applicable requirements, not relevant and appropriate requirements. However, offsite actions must comply fully with both substantive and administrative requirements (USEPA, 1988).

3.2.2 Identification of ARARs

3.2.2.1 Chemical-Specific ARARs

Chemical-specific requirements generally involve health or risk based numerical values or methodologies that establish site-specific acceptable chemical concentrations or amounts of a chemical that may be found in, or discharged to, the environment. Chemical-specific ARARs have been organized by relevant media for OU2. Table 3-1 summarizes potential chemical-specific ARARs and TBCs for OU2. Of particular importance are RIDEM Direct Exposure Criteria and/or Leachability Criteria for soil. For groundwater at OU2, all of the groundwater is within the designated waste management area for the OU and so there is no anticipated future use for any purpose. For soil, the anticipated future use is recreational. Under RIDEM regulations, properties used for recreational purposes are required to meet state requirements for residential use.

3.2.2.2 Location-Specific ARARs

Location-specific ARARs are those that generally restrict certain activities because of geographical or land use concerns (e.g., wetlands, waterbodies, floodplains, sensitive ecosystems). Table 3-2 summarizes potential location-specific ARARs for OU2. The primary location-specific ARARs for OU2 are related to the location of portions of OU2 within the floodplain of the Blackstone River and areas that have been designated as wetlands.

3.2.2.3 Action-Specific ARARs

Action-specific ARARs are those that may place requirements on the conduct of remediation activities or the use of certain technologies. Of particular importance are RCRA Subtitle C closure requirements and their applicability (for the J.M. Mills Landfill, Nunes Parcel, and Unnamed Island). Per the discussion above, for the Subtitle C closure requirements to be applicable (USEPA, 1989), it is necessary to establish that the waste disposed of at the site is RCRA hazardous waste and either: 1) the waste was initially treated, stored, or disposed of after the effective date (November 19, 1980), or 2) subsequent activity at the site constitutes treatment, storage, or disposal as defined by RCRA. While the record shows that hazardous waste was delivered to the site, it is not clear whether RCRA hazardous waste was delivered after November 19, 1980 or prior to this date. Therefore, RCRA Subtitle C requirements are relevant and appropriate and not applicable. The determination of relevance and appropriateness of certain RCRA requirements are subsequently evaluated in consideration of specific site conditions, taking into account factors, such as the mobility or immobility of waste, and physical restrictions present (size and location of the landfill relative to the river and railroad tracks).

Action-specific ARARs for the OU2 site are presented as appropriate for each alternative in Appendix I, with further discussion in the detailed analysis of alternatives (Section 7).

3.2.2.4 Potential Waivers to ARARs

CERCLA Section 121(d)(4) establishes six waivers to ARARs for onsite actions. Waivers for specific ARARs are as follows:

- *Interim Measure* – May be used for temporary measures that are part of final action, provided that the final remedy will, within a reasonable time, attain all ARARs.

- *Greater Risk to Human Health and the Environment* – May be used when compliance with the requirement will result in greater risk to human health and the environment than non-compliance.

- *Technical Impracticability* – May be used if it is technically impracticable from an engineering standpoint, based on the feasibility, reliability, and cost of the engineering methods required.

- *Equivalent Standard of Performance* – May be used if an alternative design or method of operation can produce equivalent or superior results, in terms of the degree of protection afforded. TBC equivalent, the alternative must achieve the same degree of protection, the same level of performance, and the same future reliability.

- *Inconsistent Application of State Requirements* – May be used if evidence exists that the requirement has not been applied to other sites (NPL or non-NPL) or has been applied variably or inconsistently.

- *Fund Balancing* – May be used if compliance would be costly relative to the degree of protection or risk reduction likely to be attached and the expenditure would jeopardize remedial actions at other sites.

Once the remedial alternatives for OU2 are more fully developed in subsequent chapters of this FS, the potential for ARAR waivers will be revisited.

3.3 Conclusions Based on Remedial Investigation Report, Risk Assessments, and ARARs Review

Based on a review of the available data collected during the RI, the following conclusions based on OU2 characterization, risk assessments, and ARARs review have been reached:

- *J.M. Mills Landfill* – Conditions identified at the J.M. Mills Landfill support a presumptive containment approach. The presumptive approach is appropriate when waste is present in large volumes and is a heterogeneous mixture of industrial, commercial, and municipal waste.

The general principals of the presumptive approach relates primarily to containment (i.e., capping) of the landfill mass and collection and/or treatment of landfill gas. In addition, measures to control landfill leachate, affected groundwater at the perimeter of the landfill, and/or upgradient groundwater that is causing saturation of the landfill mass may be implemented as part of the presumptive approach. The presumptive containment approach does not address exposure pathways outside the source area (except for consolidating adjacent debris under the landfill cap), nor does it include the long-term groundwater response action. The presumptive containment approach also eliminates the requirement for sampling in the area where the cap will be placed, although sampling may occur, if deemed necessary.

Site conditions, as well as other information, including testimony, transactional documents, and other information, indicate that large volumes of heterogeneous mixtures of industrial, commercial, and some municipal waste have been disposed at the J.M. Mills Landfill. Subsurface waste deposits are a principal source of contamination at the J.M. Mills Landfill. The estimated volume of waste in the main area of the J.M. Mills Landfill is approximately 2 million cy. The areal extent of the waste deposits is fairly defined and has been generally mapped based on available data (Figure 3-1). Soil with elevated levels of cadmium that present an unacceptable ecological risk should be included as part of the presumptive containment approach. Soil with exceedances of PRGs should also be included as part of the presumptive approach.

Piles of surface debris are sporadically distributed at locations adjacent to the J.M. Mills Landfill. All debris piles are considered to be an extension of the waste disposal activities at the site. Surface soil samples were collected from locations close to or in direct contact with the surface debris. Concentrations of contaminants in the surficial soil samples did not result in an exceedance of EPA's risk criteria, but do exceed RIDEM's Remediation Regulations standards for recreational exposure. Soil exceeding PRGs developed to be protective of recreational users are included as part of the presumptive approach and will be consolidated under the landfill cap. Data collected from air emissions at the vents at the J.M. Mills Landfill suggest that there is some evidence of landfill gas generation.

While some seeps have been reported by the EPA and RIDEM personnel in the vicinity of the J.M. Mills Landfill (at Pond C), this seep was not present when field work was conducted. It should be noted that migration of contamination from waste sources to groundwater (and ultimately to the Blackstone River) is likely occurring, but not always visible.

As discussed in Section 3.2.2.3, RCRA closure requirements are relevant and appropriate at the site, taking into consideration the site conditions . At the J.M. Mills Landfill, conditions include the presence of contamination posing a direct contact threat, but that potentially also exceed leachability standards for the protection of groundwater.

- *Nunes Parcel* – Conditions and risk identified at the Nunes Parcel also support a presumptive containment approach. Site conditions, as well as other information, indicate that large volumes of heterogeneous industrial, commercial, and some municipal waste have been stored and disposed of at the Nunes Parcel. Subsurface waste deposits are a principal source of contamination at the Nunes Parcel. The projected volume of buried waste is estimated to be approximately 56,000 cy. The areal extent of the waste deposits is fairly defined and has been generally mapped based on available data (see Figure 3-2). Soil sampling has indicated there are also high levels of lead and other contaminants in surface soil that present an unacceptable human health risk, which will be included as part of the presumptive containment approach. Similarly, soil with exceedances of RIDEM's Direct Exposure Criteria and Leachability Criteria will also be included as part of the presumptive approach. RIDEM's Remediation Regulations are applicable at the site and soil exceeding PRGs developed to be protective of recreational users will also be included as part of the presumptive approach.

  Piles of surface debris are sporadically distributed at locations within the Nunes Parcel, but were not analyzed. All debris piles are considered to be an extension of the waste disposal activities at the site. Some materials inventoried on the Nunes Parcel (i.e., motor capacitors and roofing shingles and liquids in 55-gallon drums and tanks) may require further testing during the remedial design stage to more accurately determine appropriate handling and disposal procedures. Finally, modeling was used in determining that there is the potential for elevated levels of some contaminants to occur in indoor air on the property. This would need to be accounted for with any remedy proposed at the site.

  While some seeps have been reported by EPA and RIDEM personnel in the vicinity of the Nunes Parcel (inlet along the western edge of the parcel), these seeps were not present when field work was conducted. It should be noted that migration of contamination from waste sources to groundwater (and ultimately to the Blackstone River) is likely occurring, but not always visible.

  As discussed in Section 3.2.2.3, RCRA closure requirements are relevant and appropriate, taking into consideration the site conditions. At the Nunes Parcel, these conditions include the presence of contamination posing a direct contact threat, but that potentially also exceed leachability standards for the protection of groundwater.

- *Nunes Parcel (RIDEM Soil Removal Area)* – Soil remaining near this area contains elevated levels of lead that present an unacceptable human health risk. Similarly, soil that exceeds PRGs developed based on RIDEM's Direct Exposure Criteria and Leachability Criteria will be included as part of the presumptive containment approach for the Nunes Parcel.

- *Unnamed Island* – Unique characteristics of this area and site conditions identified at the Unnamed Island do not support a presumptive approach. Although waste material disposed in this area is similar to that in the J.M. Mills Landfill and Nunes Parcel, the continual flooding of this area make it unsuited for

a presumptive containment approach. Subsurface waste deposits are located on the Unnamed Island. The estimated volume of subsurface waste is approximately 40,000 cy. The areal extent of the waste deposits is fairly defined and has been generally mapped based on available data (Figure 3-3). Waste deposits are the likely source of contaminated sediment in ponds located on the Unnamed Island. Piles of surface debris are also sporadically distributed at locations on the Unnamed Island. Sampling has indicated that there are elevated levels of BEHP and lead in soil that present an unacceptable ecological risk. In addition, soil with exceedances of RIDEM's Leachability Criteria will be addressed. RIDEM's Remediation Regulations are applicable at the site and soil exceeding PRGs developed to be protective of recreational users will also be addressed.

- Collectively, the J.M. Mills Landfill, the Nunes Parcel, and the Unnamed Island represent a single landfilling and disposal operation over the time period of primary site disposal from 1954 through 1986, with additional operations and/or disposal activities occurring periodically after 1986, and together are defined as the principal source of contamination found at OU2.

- *Ponds* – Sediment and/or surface water contaminant concentrations are elevated in a number of ponds. These contaminants consisted of the following: aluminum, barium, cadmium, copper, lead, and manganese in surface water and PAHs, cadmium, chromium, copper, lead, and zinc in sediments. Of particular significance is the ecosystem located on the Unnamed Island, composed of a series of vernal pools and ponds. These ponds may serve as "sinks" for both particulate matter entrained in the Blackstone River and site-related contaminants.

- *Groundwater* – Groundwater impacts have historically appeared across the site, although recent groundwater sampling was conducted at eight site wells on the J.M. Mills Landfill and the Nunes Parcel, where previous sampling had indicated concentrations exceeding the MCLs for benzene, PCBs, cadmium, and lead. The results indicated declining concentrations of these parameters when compared to earlier sampling events, with only one organic compound (benzene) in one well exceeding the MCL. That well is located within the Nunes Parcel waste disposal area which will be subject to the presumptive containment approach. Historically, concentrations of a limited number of VOCs (primarily benzene) with most detections below applicable MCLs and arsenic have been observed at monitoring wells located at the toe of the J.M. Mills Landfill, primarily limited to its western end adjacent to the Blackstone River, and on the Unnamed Island and Nunes Parcel. Arsenic in area soils is suspected to be natural occurring and further exacerbated by elevated carbon sources from known disposal practices as noted in nearby OU1 studies and other facilities in the New England region. Historically, PCBs/pesticides and SVOCs (primarily PAHs) were detected at various locations across the site and metals were detected at elevated levels at many site wells. Groundwater was not impacted at depths greater than approximately 30 feet below the water table. Furthermore, strong upward hydraulic gradients cause groundwater to preferentially discharge to the Blackstone River. There is no evidence of chlorinated VOC sources that have been observed in groundwater at OU1 that have contributed to the

conditions within the landfilled areas at OU2 in recent sampling events. However, while groundwater contaminants have been detected at concentrations resulting in an unacceptable human health risk, as well as at levels exceeding federal and state drinking water requirements, recent sampling indicates that with the exception of arsenic, concentrations of contaminants on the J.M. Mills Landfill and the Nunes Parcel have declined and with one exception are below MCLs. Further sampling will be required to confirm this trend. Arsenic is present in downgradient of areas of known waste. This presence is consistent with arsenic being mobilized from area soils (naturally occurring) by the reducing conditions present below the waste, although it is also possibly leaching from waste. In addition, historical detections of other contaminants will require further monitoring to determine if similar concentration declines are occurring.

No OU2-related contaminants were identified in groundwater adjacent to OU2 that posed a human health risk. Recent groundwater monitoring conducted at OU2 has shown no current groundwater impacts at the Lenox Street well. Chlorinated VOCs were historically identified at the Lenox Street well in 1979, but the source of chlorinated VOCs in the well was not identified during the RI. Groundwater impacts for chlorinated VOCs to the Quinnville Well Field have attenuated, as shown by sampling data from 2003, 2004, and 2005.

Other Adjacent Areas Investigated as part of the OU2 RI Study Area

- *Blackstone River* – Although investigations of the Blackstone River indicate that contamination in both sediment and surface water is present in the Blackstone River and that consumption of fish from the Blackstone River presents health risks, these issues occur throughout a larger portion of the Blackstone River and are not significantly different within the boundaries of OU2. As a result, there does not appear to be a significant site-related component to these problems and specific alternatives will not be developed to directly address the Blackstone River (sediment, surface water, and biota), although actions that may be taken at the J.M. Mills Landfill, Nunes Parcel, and Unnamed Island may have indirect effects on the river by reducing contaminant contributions from the site. Measures will be considered to conduct public outreach, monitoring, and/or other actions related to fish consumption.

- *Quinnville Well Field and Southern Bank/Pratt Dam* – The human health and ecological risk refinements performed (see Sections 3.1.1 to 3.1.3) concluded no current exceedance of risk criteria or unacceptable risk from OU2 contamination which would drive a remedial action. Based on their locations relative to the site source areas and lack of a clear contaminant migration pathway, contaminants detected at these two areas are considered to be not significantly site-related. No action is necessary in these areas as part of the OU2 remedial action.

- *Wetlands A-D* – The wetlands adjacent to the J.M. Mills Landfill (labeled A through D) are influenced by the Blackstone River during floods, although they do not appear to be influenced by groundwater

transport from OU2 source areas. Based upon sampling data, these wetlands appear to be minimally impacted from OU2 activities, and based on the EPA's ecological risk assessment refinement memoranda, no action is necessary as part of the OU2 remedial action.

Site Boundary

Based on the information presented above, the site boundary has been adjusted to include only areas impacted by OU2 waste. Figure 3-7 presents this revised site boundary. Note that other figures in this document typically present the RI Site Study Area boundary.

3.4 Development of Remedial Action Objectives

CERCLA Section 121(d)(2)(A) requires that remedial actions meet any federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate. CERCLA Section 121(d)(2)(A)(ii) requires state ARARs to be met if they are more stringent than federal requirements. In addition, the NCP, published in 40 CFR Part 300, requires that un-promulgated criteria, advisories, or guidance that do not meet the definition of ARARs but that may assist in the development of remedial objectives be listed as TBC. The key potential ARARs for OU2 are presented in Section 3.2.

Section 300.430(a)(iii)(B) of the NCP contains the expectation that engineering controls, such as containment, will be used for waste that poses a relatively low long-term threat where treatment is impracticable. The preamble to the NCP identifies municipal landfills as a type of site where treatment of the waste may be impracticable because of the size and heterogeneity of the contents (55 FR 8704). Waste at CERCLA landfill sites usually is present in large volumes and consists of a heterogeneous mixture of municipal waste frequently co-disposed with industrial waste.

Based on the information provided above, the EPA has determined that general principals of the presumptive approach, in this case "containment," is applicable to the J.M. Mills Landfill and the Nunes Parcel. The general principals of the presumptive approach relates primarily to containment of the landfill mass and collection and/or treatment of landfill gas. Other measures, such as control of landfill leachate and groundwater at the perimeter of the landfill may also be warranted. Based on a review of OU2 characterization data, the conclusions of the HHRA and BERA, the applicable ARARs, and the consideration of the presumptive approach, the following RAOs for each area are proposed for OU2:

Groundwater:

- Prevent potential exposure from ingestion/dermal contact/inhalation by a current or future resident to concentrations of contaminants in excess of ARAR and risk-based standards within the compliance boundary for the waste management area.

- Prevent migration of site contaminants in groundwater from beyond the edge of the compliance boundary of the waste management area[2].

- Prevent contaminant migration from the source areas to the Blackstone River via groundwater.

J.M. Mills Landfill:

- Prevent direct contact with landfill contents.

- Prevent direct human contact/ingestion/inhalation with contaminated soils that exceed ARAR standards.

- Prevent exposure to ecological receptors from soil contaminants that present an unacceptable ecological risk.

- Prevent soil leaching and landfill cover infiltration and resulting contaminant migration to groundwater.

- Control surface water runoff and erosion.

- Prevent infiltration and washout during flooding, up to a 500-year flood event.

- If necessary, collect and treat leachate to prevent further contaminant migration to the Blackstone River, based on federal and State water quality standards and RCRA Subtitle C landfill closure standards.

- Control and, if necessary, treat landfill gas, based on federal and state air pollution control standards and RCRA Subtitle C landfill closure standards.

- Prevent potential future exposure to contaminated indoor air.

- Prevent migration of contaminated soil/debris to pond sediment.

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[2] As per Section 300.430(a)(iii)(F) of the NCP, the EPA expects to return usable groundwater to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site. When restoration of groundwater to beneficial uses is not practicable, the EPA expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction.

Nunes Parcel (including the RIDEM Soil Removal Area):

- Prevent direct contact with landfill contents.
- Prevent direct human contact/ingestion/inhalation with contaminated soils that exceed ARAR and risk-based standards.
- Prevent exposure to ecological receptors from contaminants in soil that present an unacceptable ecological risk.
- Prevent soil leaching and landfill cover infiltration and resulting contaminant migration to groundwater.
- Control surface water runoff and erosion.
- Prevent infiltration and washout during flooding, up to a 500-year flood event.
- If necessary, collect and treat leachate to prevent further contaminant migration to the Blackstone River, based on federal and State water quality standards and RCRA Subtitle C landfill closure standards.
- Control and, if necessary, treat landfill gas, based on federal and state air pollution control standards and landfill closure standards.
- Prevent potential future exposure to contaminated indoor air.
- Prevent migration of contaminated soil/debris to pond sediment.

Unnamed Island:

- Prevent direct contact with waste deposits.
- Prevent direct human contact with contaminated soils that exceed ARAR standards.
- Prevent exposure to ecological receptors from contaminants in soil that present an unacceptable ecological risk.
- Prevent soil leaching and resulting contaminant migration to groundwater.
- Prevent washout of waste/contamination during flooding, up to a 500-year flood event.

- Prevent migration of contaminated soil/debris to pond sediment.

Ponds:

Note that because of the periodic flooding of Ponds A, C, D, E, I, N, and P by the Blackstone River, it is not appropriate to directly address surface water in these locations. Instead, surface water exceedances will be addressed by remediating contaminant sources in sediment and from the landfills, with appropriate monitoring of surface water to ensure RAOs are achieved.

- Prevent exposure to ecological receptors from contaminants in sediment that present an unacceptable ecological risk.

- Minimize migration of contaminants from sediment to surface water that present an unacceptable ecological risk.

- Reduce contamination in surface water from CERCLA sources within OU2 to acceptable ecological risk levels.

- Prevent washout of contaminated sediment during flooding, up to a 500-year flood event.

3.5 Preliminary Remediation Goals

PRGs/Performance Standards have been developed for the site to prevent exposure to groundwater, soils, and sediment with site-related contaminant concentrations that may present human health and/or ecological risks and are presented in Tables 3-3 through 3-6. PRGs/Performance Standards are developed based on an evaluation of risk-based PRGs, background concentrations, practical quantitation limits (PQLs), and other site-specific considerations (e.g., ARARs). If there are established ARARs for chemical-specific concentrations (e.g., federal or state MCLs), these are often selected as PRGs/Performance Standards. In the absence of established ARARs, risk-based PRGs are often developed using EPA guidance in Development of Risk-Based Preliminary Remediation Goals (EPA, 1991), following the consideration of background/reference concentrations and PQLs. One criterion for determination of PRGs/Performance Standards is evaluating background conditions. The RIDEM has recently released (February 2013) the final TMDL analysis for the Blackstone River watershed. The report notes a legacy of pollution from industrial usage of the Blackstone River and many of these pollutants can still be found in the river's sediments and continue to influence the water quality and overall health of the river's ecosystem (RIDEM, 2013). In December 2012, ARCADIS submitted to the EPA and RIDEM the results of supplemental soil and worm testing adjacent to the J.M. Mills Landfill and at 10 areas upstream. The results indicated elevated metals (cadmium and lead) throughout the basin. The reports are found in Appendix E. This information may be

utilized, along with additional investigations, during the pre-design phase of the remedy to better define extent of remedial actions.

3.5.1 Human Health PRGs/Performance Standards

Human health risk-based PRGs were developed using the equations presented in EPA's Risk Assessment Guidance for Superfund, Part B: Preliminary Remediation Goals and the methodology used to develop EPA's Regional Screening Levels. Exposure factors used in the calculation of risk-based PRGs/Performance Standards were the same as those used to estimate risks and hazards in the baseline HHRA, except as noted below.[3]

3.5.1.1 Soil PRGs

Soil PRGs were developed for the following scenarios:

- OU 2 Soil – Recreational User Scenario
- Nunes Parcel/RIDEM Soil Removal Area – Commercial Worker Scenario
- Nunes Parcel/RIDEM Soil Removal Area – Construction Worker Scenario

While the baseline HHRA included calculations for potential future development of the Nunes Parcel as residential property, the EPA determined that the presumptive containment approach would be implemented in this area of the site in addition to the J.M. Mills Landfill proper. Based on the property layout, recreational use is the most likely future exposure scenario. The baseline HHRA did not show a recreational user risk to soil at the site, but the RIDEM Remediation Regulations establish Direct Exposure Criteria (DECs) which apply to the site. While there are no DECs for a recreational user, RIDEM applies the residential DECs when evaluating recreational user exposures. OU 2 soil PRGs developed under the recreational user scenario only include those analytes whose detections exceeded RIDEM's residential DECs and/or

[3] As described in Section 3.1.3.3, the HHRA was completed in 2009/2010. In February 2014, EPA finalized a Directive to update standard default exposure factors and frequently asked questions associated with these updates (located online at http://www.epa.gov/oswer/riskassessment/superfund_hh_exposure.htm; items # 22 and #23 of this web link). Applying these updated standard default exposure factors to the risk assessment would possibly result in a slight decrease of the risk estimates; however, it would not change the conclusions regarding unacceptable risks at the site. These revisions will be reviewed further during ROD development with respect to risk-based performance standards.

leachability criteria. These contaminants include benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, pyrene, chlordane, dieldrin, PCBs, antimony, arsenic, beryllium, lead, manganese, and thallium.

Risk-based PRGs were developed for soil associated with potential future cumulative cancer risks greater than 10^{-4} or target organ HIs greater than 1 considering the ingestion, dermal contact, and inhalation exposure pathways in a commercial worker exposure scenario. For those soils, risk-based PRG development was required for each chemical with an individual cancer risk above 10^{-6} or with an HQ above 1 (see Appendix C.6, Table 1). These contaminants include benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, bis(2-ethylhexyl)phthalate, dibenz(a,h)anthracene, naphthalene, dieldrin, arsenic, lead, and dioxins.

The human health risk-based PRGs provided in Appendix C.6 correspond to target cancer risk levels of 10^{-6}, 10^{-5}, and 10^{-4} and a target non-cancer HQ of 1. For each of the contaminants, risk-based PRGs were calculated using equations and exposure assumptions presented in Appendix C.6, Table 2. Toxicity values used in the calculation of the risk-based PRGs are presented in Appendix C.6, Tables 3 through 6. Appendix C.6, Table 7 presents the dermal worksheet used to develop PRGs for the dermal pathway. The human health risk-based soil PRGs for each contaminant are summarized in Appendix C.6, Table 8. The PRGs are selected by considering the ARARs, risk-based PRGs, quantitation limits, and reference/background data.

Table 10 in Appendix C.6 presents lead PRGs for a construction worker (910 milligrams per kilogram [mg/kg]) and a commercial worker (2,240 mg/kg), which were developed using the EPA's Adult Lead Model (ALM). The same exposure factors were used in the ALM to develop the lead PRG, with the exception of the construction worker soil ingestion rate of 100 mg/day, which was used in the human health risk refinement, as discussed in Section 3.1.3 (resulting in only the Nunes Parcel/RIDEM Soil Removal Area showing an exceedance). It should be noted that these PRGs were developed using a target blood lead level of 10 ug/dL, consistent with current EPA recommendations (USEPA, 2003). However, ongoing discussions in the EPA Technical Review Workgroup for Lead may result in reducing the target blood lead level to 5 ug/dL, which would then reduce the lead PRGs.

PRGs for soil generally correspond to RIDEM DECs, selected as ARARs for the site, except for commercial worker PRGs for benzo(a)pyrene, dioxin, and arsenic, which have been shown to have higher site-specific reference concentration (see Table 8 in Appendix C.6 for reference concentrations). Per CERCLA and the NCP, EPA does not require cleanup to below background or reference levels. Therefore, PRGs for benzo(a)pyrene, dioxin, and arsenic are set at reference levels. PRGs for the remaining contaminants for the commercial worker include benzene, benzo(a)anthracene, benzo(b)fluoranthene, bis(2-ethylhexyl)phthalate, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, naphthalene, dieldrin, beryllium, and lead which are based on a cancer risk level of 1×10^{-6}, RIDEM DECs, or leachability criteria.

3.5.1.2 Groundwater Performance Standards

Groundwater Performance Standards (PSs), rather than PRGs, were developed for site-wide groundwater because all contaminated groundwater within the site is located within the compliance boundary for the site's waste management area. Therefore, no cleanup of the groundwater within the compliance boundary is required and only PSs to establish monitoring standards have been developed. The PSs are based on a residential scenario with potential future cumulative cancer risks greater than 10^{-4} or target organ HIs greater than 1 considering the ingestion, dermal contact, and inhalation exposure pathways. Risk-based PS development was required for each chemical with an individual cancer risk above 10^{-6} or with an HQ above 1 (see Appendix C.7, Table 1).

The human health risk-based PSs[4] provided in Appendix C.7 correspond to target cancer risk levels of 10^{-6}, 10^{-5}, and 10^{-4} and a target non-cancer HQ of 1. For each of the contaminants, risk-based PSs were calculated using equations and exposure assumptions presented in Appendix C.7, Table 2. Note that the BHHRA conservatively used 1.5 L/day as the ingestion rate for a child. However, EPA's default value of 1 L/day has been used in development of the PSs to be consistent with recommended national default standard values. Toxicity values used in the calculation of the risk-based PSs are presented in Appendix C.7, Tables 3 through 6. Appendix C.7, Tables 7 through 10 present intermediate PS calculations, accounting for adult, child, and mutagenic modes of exposure. The human health risk-based PSs for each contaminant are summarized in Appendix C.7, Table 11. The PSs are selected by considering the ARARs, risk-based standards, quantitation limits, and reference/background data.

Table 11 in Appendix C.7 presents the human health groundwater PSs, which include 1,4-dichlorobenzene, benzene, chloroform, ethylbenzene, methyl tert-butyl ether, TCE, vinyl chloride, 1,4-dioxane, 4-chloroaniline, atrazine, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, bis(2-ethylhexyl)phthalate, indeno(1,2,3-cd)pyrene, naphthalene, PCBs, aldrin, dieldrin, aluminum, arsenic, cadmium, cobalt, iron, lead, manganese, and thallium. Many of these PSs represent EPA MCLs, but some are based on a cancer risk level of 1×10^{-6} or an HQ of 1.

3.5.1.3 Uncertainties Associated with Human Health PRGs/PSs

Limitations and uncertainty of predicting human health risks and hazards were discussed in the HHRAs. Much of the uncertainty in these documents also applies to the risk-based PRGs/PSs because PRG/PS development is based on chemicals and exposure scenarios identified in the HHRAs. Also, the PRGs/PSs were developed using the same exposure assumptions and parameters used in the HHRAs, except as

[4] In HHRAs these standards are referred to as PRGs.

noted above. Dose-response uncertainty is common to all hazardous waste risk assessments. There are many uncertainties regarding the amount of contact there will be in the future between potential receptors and the contaminants. A complete discussion of the HHRA uncertainties can be found in the HHRAs.

3.5.1.4 Human Health Residual Risks

EPA requires that risks and hazards associated with the selected PRGs for each medium and receptor population be calculated to ensure that these cumulative residual risks meet EPA acceptable risk range.

Appendix C.6, Table 9 presents calculations for residual human health risks associated with soils at the site. The calculation of residual risks uses the same exposure factors used in the baseline HHRA, except as noted above. If soils in these areas of the site were remediated to reflect an exposure point concentration equal to the selected PRG, the subsequent cumulative residual risks would be:

Human Health Residual Risks

Media/Exposure Area	Receptor of Concern	Residual Risk	Residual Hazard
Soil - Nunes Parcel/RIDEM Soil Removal Area	Commercial worker	2×10^{-5}	0.1
Site-wide Soil	Recreational User	2×10^{-5}	1

If lead concentrations in soil were remediated to the concentrations presented for each scenario, the resulting residual lead risks would meet the EPA benchmark of no more than 5% of the receptor population having a blood lead level exceeding 10 µg/dL.

3.5.2 Ecological PRGs

Ecological risk-based PRGs were provided by the EPA in a letter dated April 19, 2012 (see Appendix D.4). The PRGs include values for soil and sediment.

For soils, the ecological risk-based PRGs were developed for the J.M. Mills Landfill (cadmium) and the Unnamed Island (lead and BEHP). The PRGs are based on risks to small omnivorous birds. However, for cadmium and lead, the risk-based PRGs were below values selected from the existing dataset to represent reference. Therefore, reference values were identified by the EPA as the PRG. In a memorandum from EPA dated November 18, 2013 (see Appendix D.6), the cadmium PRG was refined further based on additional review of toxicity values and site-specific data. Ecological PRGs for soil are presented in Table 3-5.

For sediment, the ecological risk-based PRGs were selected by the EPA based on the reference sample with the highest/best survival in sediment toxicity tests (Sample TO5BL-004). Ecological PRGs for sediment are presented in Table 3-6.

It is important to note that most of the ecological risk-based soil PRGs and all of the ecological risk-based sediment PRGs are based on limited reference datasets. In response to the limited reference data, additional soil and sediment sampling was conducted in November 2012. The sampling included the collection and analysis of soil and sediment samples from areas upstream of the site. Collectively, the reference data indicate that metals and total PAHs are elevated throughout the Blackstone River, including areas upstream of the site. These data may be useful (in part) to consider an adjustment in the soil/sediment cleanup levels if further reference concentration assessments are conducted during the remedial design to increase the statistical strength of the current data set. Appendix D.5 includes an EPA memorandum dated June 21, 2013 which discusses the available reference data.

3.6 General Response Actions

3.6.1 Groundwater

Site-wide groundwater impacts consist of a limited number of historical MCL/PS exceedances of VOCs, SVOCs, PCBs, pesticides, and metals attributed to waste materials and larger scale arsenic exceedances associated with naturally occurring arsenic in soils mobilized by the reducing conditions associated with the waste. Recent sampling shows improvement (decreasing concentrations) to the contaminants analyzed in the locations sampled. Potential general response actions for contaminated groundwater remediation at the OU2 site include one or more of the following:

- No Action (as required by the NCP)
- Institutional Controls (ICs)
- Long-Term Monitoring
- Hydraulic Containment
- Extraction/Removal/Collection/Discharge
- In-Situ Treatment
- Ex-Situ Treatment
- Residuals Management

Groundwater monitoring wells, piezometers, and staff gauges are presented on Figure 3-5. A compliance boundary (see Figure 3-6) encircles the waste management unit at the site, as defined by the waste

deposited in the J.M. Mills Landfill, Nunes Parcel and Unnamed Island. Appendix H presents monitoring wells sampled during site investigations which contained constituent concentrations greater than the PSs presented in Table 3-4, and were considered to be site-related. Further discussion of exceedances is presented in Section 6.1.

3.6.2 Source Area Wastes and Soil

A presumptive containment approach will be used to address waste located in the J.M. Mills Landfill and Nunes Parcel. Locations of buried waste at the J.M. Mills Landfill, the Nunes Parcel, and Unnamed Island are presented on Figures 3-1, 3-2, and 3-3, respectively. Floodplain soil at the base of the J.M. Mills Landfill, as well as the nearby debris fields, will be incorporated into the presumptive approach (placed under the cap). Figure 3-1 presents the extent of soil PRG exceedances and location of debris fields near the J.M. Mills Landfill. Similarly, soil outside of the waste area on the Nunes Parcel which exceeds PRGs and piles of debris adjacent to the area to be capped will be incorporated into the presumptive approach (placed under the cap). Figure 3-2 presents the extent of soil PRG exceedances outside of the waste extent on the Nunes Parcel.

The No Action alternative must be included according to the NCP.

- No Action (as required by the NCP)

Components of the presumptive containment approach at the J.M. Mills Landfill and Nunes Parcel may include one or more of the following:

- Institutional Controls
- Landfill Cap
- Leachate Control and Treatment
- Landfill Gas Collection and Treatment

A presumptive approach was not applied to the soils and waste on the Unnamed Island. Figure 3-3 presents the sample locations exceeding PRGs on the Unnamed Island. Potential general response actions for the soil on the Unnamed Island include one or more of the following:

- No Action
- Institutional Controls

- Containment
- Removal
- In-Situ Treatment
- Ex-Situ Treatment

3.6.3 Sediment

As described above, sediment requiring evaluation in this FS is present in Ponds A, D, and P on the Unnamed Island and Ponds I and N adjacent to the Blackstone River. Figure 3-4 presents the sample locations exceeding remedial goals in the ponds. General response actions that are potentially applicable to sediment at the site include one or more of the following:

- No Action (as required by the NCP)
- Institutional Controls (as potential remedy protection)
- Containment
- Removal
- In-Situ Treatment
- Ex-Situ Treatment

4. Identification and Screening of Applicable Technologies

This section identifies the potentially applicable technology types and process options for each impacted medium at the OU2 site. Potentially applicable technology types and process options were developed for groundwater, soil in areas with buried waste, waste, and sediment. These technologies and options were derived from professional experience with the constituents of concern, technologies identified in other RODs, and the Federal Remediation Technologies Roundtable Remediation Technologies Screening Matrix (www.frtr.gov).

The potential remedial technology types and process options are described in Tables 4-1 through 4-3 for groundwater, soils at the Unnamed Island, and sediment, respectively. The potential remedial technology type is a general category of technologies, while the process options are specific methods within each remedial technology type.

A presumptive containment approach was applied to source areas with buried waste at the J.M. Mills Landfill and the Nunes Parcel, including soil and debris fields next to the source areas. The components of a presumptive containment approach include a landfill cap, waste/debris consolidation under the cap, source area groundwater and leachate control and treatment, landfill gas collection and treatment, and institutional controls. By using the presumptive approach, the technology screening step is eliminated, and the only alternatives considered are the appropriate components of a presumptive containment approach and the required No Action alternative. While there is waste and debris present at the Unnamed Island, a presumptive containment approach has not been applied here due to the flooding that occurs.

All OU2-related contaminated groundwater is located within the compliance boundary for the waste management area, where there is no anticipated future use of the groundwater. However, groundwater treatment technologies were considered in an effort to evaluate the potential for improved contaminant reduction in the waste management area.

An initial screening of the technical implementability of each process option and technology type was performed to reduce the number of technologies potentially applicable to the OU2 site to a manageable number before performing a more rigorous screening process. Remedial technology types and process options that cannot be effectively implemented were eliminated from further consideration.

5. Development of Remedial Alternatives

This section evaluates the potential technologies for remediating groundwater, soil in contact with buried waste, waste, and sediment that were retained from the initial screening. These technologies are evaluated based on effectiveness, implementability, and cost. The remaining technologies are then assembled into remedial alternatives.

5.1 Groundwater

5.1.1 Remedial Alternatives Components

Table 5-1 summarizes and compares groundwater technologies retained in Section 4 (Table 4-1) for secondary screening in this section. Groundwater technologies were compared based on relative

effectiveness, implementability, and cost. Technologies that are retained after this comparison were assembled into remedial alternatives that are discussed in Section 5.1.2.

5.1.1.1 No Action (GW-1)

The No Action technology does not implement measures at the site to correct current site conditions. This technology is included in this FS to provide a baseline for subsequent comparison of the benefits of implementing "action" technologies to address the impacted groundwater at the site.

5.1.1.2 Institutional Controls (GW-2, GW-3, and GW-4)

To address groundwater at the site, institutional controls will be used to restrict use of, and exposure to, groundwater throughout the duration of the remedial action. The controls would exclude installation of private wells within the compliance boundaries. Deed restrictions would be implemented to prevent exposure to groundwater and to protect components of the remedy (monitoring wells) should the property be transferred prior to completion of the remedial action.

5.1.1.3 Groundwater Monitoring (GW-2, GW-3, and GW-4)

While not an "active" technology, monitoring is conducted to document groundwater quality and long-term trends, confirming that PSs are being met outside of the compliance boundaries. Groundwater monitoring would be conducted by utilizing existing wells or completing new wells in locations and conducting routine sampling for contaminants. Monitoring of surface waters will also be conducted to confirm groundwater contamination is not posing a risk to the waterbodies and aquatic receptors on site. Final monitoring locations, frequency, and parameters would be developed during the remedial design phase after the ROD is signed.

5.1.1.4 Phytoremediation (GW-3)

Phytoremediation takes advantage of natural process of plants, including water and chemical uptake and metabolism with the plant to address dissolved contaminants. To address shallow groundwater as present at the site, phreatophytic plant species, such as poplar trees, would be utilized. Implementation would result in: 1) uptake of groundwater (seasonally), reducing cross-site flow outside of the compliance boundary and 2) degradation of contaminants, primarily through rhizodegradation. However, with respect to the contaminants present at the site, the effectiveness of phytoremediation is limited to VOCs and SVOCs and is of limited use for dissolved metals, which are the primary and most widespread contaminants present at the site. Although uptake of dissolved metals can occur, it can lead to bioaccumulation within the plant material. Contaminants within the woody portions of the trees would be retained until the trees are

harvested, while contaminants located in the leaves would and be released to the environment as plant material decays.

5.1.1.5 Chemical Oxidation (GW-4)

In-situ chemical oxidation is a powerful and proven technology that consists of the addition of strong oxidants, such as peroxide, ozone, permanganate, and persulfate, to the subsurface that react chemically with organic contaminants, and, if carried to completion, ultimately results in carbon dioxide and water. Although not as widely implemented, reactive chemical oxidants can also be utilized to immobilize aqueous metals to solid, stable phases that become part of the soil. When used for in-situ treatment, the oxidants are injected directly into the treatment area, as direct contact between the oxidants and contaminant, is required. Depending on the oxidant selected, reaction can occur over a period of days to months, during which contaminants are destroyed (VOCs) or stabilized (metals) where adequate contact is achieved. The short duration of treatment make chemical oxidation most effective in addressing source areas. Where addressing groundwater downgradient of the contaminant source, chemical oxidation may effectively remove contaminants within the treatment zone, but these contaminants can be replenished if the source is not removed.

5.1.2 Remedial Alternatives

Groundwater remedial alternatives are developed based upon those technologies and process options that were carried forward from Section 4 (Table 4-1). In assembling groundwater alternatives, the general response actions and the technologies chosen to represent the various process options for groundwater are combined to form alternatives for site-wide groundwater. The following groundwater alternatives have been assembled and will be discussed further in Section 6.

Remedial Alternatives for Groundwater

Components	GW-1: No Action	GW-2: Limited Action (Monitoring)	GW-3: Active Remediation (Phyto)	GW-4: Active Remediation (Chemox)
No Action	X			
Institutional Controls		X	X	X
Long-Term Monitoring		X	X	X
Phytoremediation			X	
Chemical Oxidation				X

Descriptions of the remedial alternatives are provided in Section 6.1.

5.2 Source Area Wastes and Soil

5.2.1 Remedial Alternatives Components

A presumptive containment approach has been applied to the previously defined waste areas (sources) and neighboring soils/debris fields at the Nunes Parcel and the J.M. Mills Landfill (see Figures 3-1 and 3-2). By using the presumptive approach (i.e., containment/capping), the technology screening step is eliminated and the only alternatives considered are the appropriate components of a presumptive containment approach and the required No Action alternative. These are assembled into remedial alternatives for source control in Section 5.2.2.

A presumptive approach has not been applied to the waste and soil impacts on the Unnamed Island. For these areas, the technologies and process options for waste/soils that were carried forward from the initial screening are screened on the basis of effectiveness, implementability, and cost. The secondary screening is presented in Table 5-2. Process options retained from this secondary screening are assembled into soil remedial alternatives in Section 5.2.2.

5.2.1.1 No Action (JM-SO-1, NP-SO-1, and UI-SO-1)

The No Action technology does not implement measures at the site to correct current site conditions. This technology is included in this FS to provide a baseline for subsequent comparison of the benefits of implementing “action” technologies to address the source area soil and waste at the site.

5.2.1.2 Institutional Controls

5.2.1.2.1 Deed Restrictions (JM-SO-2, JM-SO-3, NP-SO-2, NP-SO-3, and UI-SO-2)

Deed restrictions are a form of institutional control that utilizes legal avenues to control the future land use of portions of the facility. Deed restrictions require cooperation with local government agencies and landowners to provide strict enforcement in order to effectively control future development and access to areas of the site, as well as protect components of the remedy (including landfill caps and monitoring wells). The effectiveness of land use deed restrictions is increased when used in conjunction with physical barriers that limit access to impacted areas.

5.2.1.2.2 Fencing and Signage (JM-SO-2, JM-SO-3, NP-SO-2, and NP-SO-3)

Fencing and signage may be an effective and easily implemented means of providing access restrictions, as required. Fencing would involve the installation of a physical barrier around remedy areas to restrict unauthorized access, if deemed necessary. While cover will be placed over both waste and impacted soils

as a component of the final remedies for the J.M Mills Landfill and the Nunes Parcel, fencing and signage will reduce the potential for onsite activities disturbing cover material and other components of the remedy and leading to exposure of both human and ecological receptors. During the remedial design phase, the need for and, if required, location of the fencing and signage will be evaluated to provide maximum effectiveness in restricting access while minimizing the potential for damage during periodic flooding.

5.2.1.3 Soil Removal from Riverbank and Floodplain with Bank Restoration (JM-SO-2 and JM-SO-3)

To meet the RAOs along the riverbank, it will be necessary that ecological risk-based soil impacts be fully removed to prevent ecological exposure. To meet these requirements, soil removal activities would be completed between the J.M. Mills Landfill and the Blackstone River. This procedure would include removing all existing vegetation, including mature trees, brush, and grass present in the remedy area. Soils within the remedy area will be removed until clean soil is encountered. Excavated soil will be transported to either the J.M. Mills Landfill or Nunes Parcel and placed under the proposed cover. Where necessary to restore altered habitats, clean fill will be used to restore the original grade. At all locations, all soil exceeding PRGs will be removed. However, the final determination as to the amount of fill brought in to restore the altered habitat will be made during the remedial design phase, as final remedy selection may require floodplain compensation.

5.2.1.4 Presumptive Approach – Subtitle D Cap (NP-SO-2)

Remedial alternative NP-SO-2 includes the installation of a Subtitle D soil cap system, which is also compliant with RIDEM solid waste regulations. The proposed cap system consists of the following components in descending order (i.e., from top to bottom):

- 12-inch-thick vegetative soil
- Drainage layer (assumed geocomposite for costing purposes; $k >= 10^{-1}$ cm/sec)
- Barrier layer (assumed 60-mil HDPE geomembrane for costing purposes; $k <= 10^{-12}$ cm/sec)
- 6-inch-thick bedding layer (minimum)

Compliance/equivalency with RIDEM solid waste regulations will be evaluated further during the design phase.

Additional design details, including gas collection/venting components (including potential gas venting layer)/design, perimeter berm/cap termination, and stormwater management features on the final cover system would be included in this alternative and be determined during remedial design efforts. Since the

cap will be located within the floodplain, the cap will need to be designed to prevent any release of contamination during flooding, up to a 500-year flood event.

Note that soils exceeding risk-based standards and RIDEM ARARs outside of the current extent of waste will require excavation and placement under the proposed cap. As discussed further below, sediments in Pond I near Nunes Parcel are anticipated to be removed at the same time as neighboring soils and placed beneath the neighboring cap. It is also anticipated that excavated soil/waste from Unnamed Island and sediment from the island ponds will likely be placed under the proposed Nunes Parcel cap.

5.2.1.5 Presumptive Approach – Full RCRA Subtitle C Cap (JM-SO-2 and NP-SO-3)

Remedial alternative JM SO-2 includes the installation of a RCRA Subtitle C Cap, which consists of a vegetative/protective soil layer, a drainage layer, a two-component low-permeability layer flexible membrane liner (FML or geomembrane) and compacted low-permeability soil or geosynthetic clay liner (GCL) where appropriate), and a gas vent layer overlying the waste. While the design will determine the final cap components based on guidance and cap equivalency, an EPA Region I Alternative Cap (with RCRA Subtitle C equivalency; USEPA, 2001a) has been proposed for costing purposes. The profile of the proposed cover system for a Subtitle C equivalent cap includes the following components, in descending order (i.e., from top to bottom):

- 6-inch-thick vegetative soil layer
- 18-inch-thick cover soil (barrier protection layer)
- Geocomposite drainage layer
- Flexible membrane liner (60-mil thickness)
- Geosynthetic Clay Liner (GCL)
- Grading layer and/or gas venting layer

Under remedial alternative JM-SO-2, the full profile of the Subtitle C equivalent cap would be constructed over the entire waste footprint of the J.M. Mills Landfill. Top portions of the landfill would be graded to a minimum 4% gradient, while the sideslopes of the landfill would be graded to a maximum 33% gradient. Additional design details, including gas collection/venting components/design, perimeter berm/cap termination, and stormwater management features on the final cover system would be included in this alternative and be determined during remedial design efforts. Preliminary analysis of final cover efficiency (defined as the sum of percentage of percolation lost to runoff, evapotranspiration, and lateral drainage) for

remedial alternative JM-SO-2, based on Hydrologic Evaluation of Landfill Performance (HELP) Model output considering the preliminary design parameters detailed above, is 99% efficient (see Appendix J). Design evaluations may determine that maximum sideslopes may be inappropriate for geosynthetic clay liner (GCL), depending on room available for tiers/benching. Compacted clay may be used as a replacement material, but, for FS purposes, GCL has been utilized for costing purposes. Since the cap will be located within the floodplain, the cap will need to be designed to prevent any release of contamination during flooding, up to a 500-year flood event.

Note that under NP-SO-3, soils exceeding risk-based standards and RIDEM ARARs outside of the current extent of waste will require excavation and placement under the proposed cap. For both JM-SO-2 and NP-SO-3, neighboring debris fields will be removed and placed under the proposed cap, as appropriate. As discussed further below, sediments near areas to be managed (Pond N near J.M. Mills Landfill and Pond I near Nunes Parcel) are anticipated to be removed at the same time as neighboring soils/debris and placed beneath the neighboring caps. It is also anticipated that excavated soil/waste from Unnamed Island and sediment from the island ponds will be consolidated under the proposed Nunes Parcel and/or J.M. Mills cap(s).

5.2.1.6 Presumptive Approach – Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (JM-SO-3)

Remedial alternative JM-SO-3 includes the installation of a RCRA Subtitle C Cap (utilizing the final cover components discussed in Section 5.2.1 above) over the top portions of the J.M. Mills Landfill (i.e., areas graded to 4% minimum gradient), as well as the upper portions of the sideslope areas to result in approximately 33% of the landfill surface area being covered with the RCRA Subtitle C Cap. The remaining portions of the J.M. Mills Landfill final cover system (i.e., the portions of the sideslopes extending from the perimeter toe of slope, up to the Subtitle C Cap limits) would be constructed utilizing a soil cap system consisting of the following components in descending order (i.e., from top to bottom):

- 6-inch-thick vegetative soil
- 18-inch-thick barrier layer (k </= 10^{-5} cm/sec)

Preliminary analysis of final cover efficiency (defined as the sum of percentage of percolation lost to runoff, evapotranspiration, and lateral drainage) for remedial alternative JM-SO-3, based on HELP Model output considering the preliminary design parameters detailed above, is 80% efficient (see Appendix J). Since the cap will be located within the floodplain, the cap would need to achieve standards requiring no release of contamination during flooding, up to a 500-year flood event.

Neighboring debris fields will be removed and placed under the proposed cap, as appropriate. As discussed further below, sediments in Pond N are anticipated to be removed at the same time as neighboring

soils/debris and placed beneath the neighboring cap. While it is also anticipated that excavated soil/waste from Unnamed Island and sediment from the island ponds will likely be placed under the proposed Nunes Parcel cap, some may also be placed under the proposed J.M. Mills cap (upper RCRA Subtitle C portion).

5.2.1.7 Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs (UI-SO-2)

To meet the RAOs for ecological risk-based soil exceedances on the Unnamed Island, it will be necessary that soil impacts be fully removed or placed below a minimum of 2 feet of clean fill to prevent ecological exposure. In addition this procedure would include removing all existing vegetation, including mature trees, brush, and grass present in the remedy area. Waste and soils within the remedy area will be removed to a depth of 2 feet or until groundwater, as appropriate. Excavated waste/soil will be transported to the J.M. Mills Landfill and/or Nunes Parcel and placed under the proposed caps(s). Temporary access connecting to the Unnamed Island will be installed to provide vehicle and equipment access to the remedy area. Where waste or soil impacts remain or where necessary to restore vegetation, clean fill will be placed to a minimum depth of 2 feet. Where soil impacts remain along the riverbank, bank restoration will be completed, which will include armoring to prevent erosion of the clean fill. Since the cover will be located within the floodplain, the cover would need to achieve standards requiring no release of contamination during flooding, up to a 500-year flood event.

At all locations, all soil exceeding PRGs will be removed up to a depth of 2 feet, and where PRG exceedances remain, 2 feet of clean fill will be placed to bring the ground surface up to its original grade. However, the final determination as to the amount of fill brought in to the areas where all soils with PRG exceedances are removed will be made during the remedial design phase, as final remedy selection may require floodplain compensation or habitat mitigation.

5.2.1.8 Geotextile with Riprap Cover (UI-SO-2)

Covers are typically used at sites to prevent exposure to underlying impacted media and would be incorporated into the remedy on the Unnamed Island where excavation does not fully remove soil with ecological risk-based PRG exceedances and a 2-foot cover is required to meet RAOs. A cover on the Unnamed Island will require that: 1) it is compatible with the high energy environment present on the Unnamed Island during flood conditions and 2) minimizing height of restoration above the pre-remedy grade requiring floodplain compensation elsewhere on the Unnamed Island or adjacent parcels. To meet these objectives, a geotextile would be placed on the excavated surface to provide a barrier to ecological receptors. Engineered fill would be placed above the geotextile to a depth of 1 foot, which, in turn, would be covered with a minimum of 1 foot of riprap designed to minimize erosion under flood conditions. Since the cover will be located within the floodplain, the cover would need to achieve standards requiring no release of contamination during flooding, up to a 500-year flood event. Habitat mitigation may be required to compensate for the alteration of habitats in the areas to be riprapped.

5.2.1.9 Remove/Consolidate All Waste/Soil Exceeding PRGs (UI-SO-3)

This remedy assumes that all contaminants exceeding PRGs will be removed from the Unnamed Island. Complete removal will eliminate ecological risks from soil. This procedure would include removing all existing vegetation, including mature trees, brush, and grass present in the remedy area. Soils within the remedy area will be excavated until clean soil is encountered. Excavated soil will be transported to the J.M. Mills Landfill and/or Nunes Parcel and placed under the proposed cap(s). A temporary bridge connecting the Nunes Parcel and Unnamed Island will be installed to provide vehicle and equipment access to the remedy area. Although final determination will be made during the remedial design phase, it is not anticipated that clean fill will be brought in to restore the pre-remedy grade unless required for habitat mitigation.

5.2.1.10 Waste Removal (UI-SO-3)

This remedy assumes that all waste present on the Unnamed Island will be removed to comply with landfill closure standards. Complete removal will eliminate waste as a potential contributor to groundwater impacts, and will eliminate the requirement for institutional controls on the Unnamed Island. This procedure would include removing all existing vegetation, including mature trees, brush, and grass present in the remedy area where the waste is located. Waste within the remedy area will be fully excavated. Current site information indicates waste is present to a depth of up to 10 feet below the water table. Thus, removal of the waste will require a combination of dewatering of the waste, stabilization of the excavation, and removal (and potentially treatment) of groundwater from the excavation prior to discharge back to the river. Excavated waste will be transported to the J.M. Mills Landfill and/or Nunes Parcel and placed under the proposed cap(s). Final disposition will be a factor of capacity under the caps. A temporary bridge connecting the Nunes Parcel and Unnamed Island will be installed to provide vehicle and equipment access to the remedy area. Although final determination will be made during the remedial design phase, it is not anticipated that clean fill will be brought in to restore the pre-remedy grade unless required for habitat mitigation.

5.2.2 Remedial Alternatives

The remedial alternatives for source control are developed based upon the presumptive containment approach for the J.M. Mills Landfill and the Nunes Parcel and the technologies and process options that were retained in Table 5-2 for the Unnamed Island. To assemble the remedial alternatives, general response actions and the process options retained are combined. The following alternatives for source control have been assembled and will be discussed in Section 6.

Remedial Alternatives for Source Control – J.M. Mills Landfill

Components	JM-SO-1: No Action	JM-SO-2: Presumptive Approach	JM-SO-3: Presumptive Approach
No Action	X		
Deed Restrictions		X	X
Fencing and Signage		X	X
Soil Removal from Riverbank and Floodplain with Bank Restoration		X	X
Full RCRA Subtitle C Cap		X	
Hybrid Landfill Cap			X

Remedial Alternatives for Source Control – Nunes Parcel

Components	NP-SO-1: No Action	NP-SO-2 Presumptive Approach	NP-SO-3: Presumptive Approach
No Action	X		
Deed Restrictions		X	X
Fencing and Signage		X	X
RCRA Subtitle D Cap (meeting RIDEM Solid Waste ARARs)		X	
RCRA Subtitle C Cap			X

Remedial Alternatives for Source Control – Unnamed Island

Components	UI-SO-1: No Action	UI-SO-2:	UI-SO-3:
No Action	X		
Deed Restrictions		X	
Remove/Consolidate waste/soil (0 to 2 feet) Exceeding PRGs		X	
Geotextile with Riprap		X	
Remove/Consolidate waste/soil Exceeding PRGs			X
Waste Removal			X

Additional information regarding the components of the remedial alternatives for soil/waste is included in Tables 5-3, 5-4, and 5-5 for the Nunes Parcel, J.M. Mills Landfill, and Unnamed Island, respectively.

5.3 Sediment

5.3.1 Remedial Alternatives Components

Table 5-6 summarizes and compares sediment technologies retained in Section 4 (Table 4-3) for secondary screening in this section. Sediment technologies were compared based upon relative effectiveness, implementability, and cost. Technologies that are retained after this comparison were assembled into remedial alternatives that will be discussed further in Section 5.3.2.

As discussed in the soil source area alternative components, sediments near areas to be managed (Pond N near J.M. Mills Landfill and Pond I near Nunes Parcel) are anticipated to be removed at the same time as neighboring soils/debris and placed beneath the neighboring caps. Therefore, the alternatives below focus on the ponds within the Unnamed Island (Ponds A, D, and E).

5.3.1.1 No Action (SE-1)

The No Action technology does not implement measures at the site to correct current site conditions. This technology is included in this FS to provide a baseline for subsequent comparison of the benefits of implementing "action" technologies to address the sediment at the site.

5.3.1.2 Institutional Controls (SE-3 and SE-4)

Deed restrictions are a form of institutional control that utilizes legal avenues to control the future land use of portions of the facility. Deed restrictions require cooperation with local government agencies and, in the case of the Unnamed Island, the land owner to provide strict enforcement in order to effectively control future development and access to areas of the site. In the case of the sediments, deed restrictions would be used to minimize the potential for damage to the subaqueous covers utilized in Alternatives SE-3 and SE-4.

5.3.1.3 Remove/Consolidate Sediment Exceeding PRGs (SE-2)

This remedy assumes that all contaminants exceeding PRGs will be removed from the ponds. Complete removal will eliminate ecological risks from sediment. Sediments within the remedy area will be dredged or excavated until clean sediment is encountered. Dredged/excavated sediment will be transported and placed under the proposed Nunes Parcel and/or J.M Mills cap(s). A temporary bridge will be installed to provide vehicle and equipment access to the remedy area. Although final determination will be made during the remedial design phase, it is not anticipated that clean fill will be brought in to restore the pre-remedy elevation or that any aquatic habitat mitigation will be required. Some fill may be needed to restore shoreline wetland habitat.

5.3.1.4 Partial Removal with Subaqueous Cover (SE-3)

Subaqueous covers are typically used at sites to prevent exposure to underlying impacted media and would be incorporated into the remedy in the ponds where dredging or excavation does not fully remove sediment with PRG exceedances and a 1-foot cover is required to eliminate ecological risks from the remaining sediment. Final determination on the need for geotextile as part of the cover will be made during the remedial design phase, as river currents during flooding could potentially pull up the geotextile and disturb the cover more than if it were not in place. Since the cover will be located within the floodplain, the cover will need to be designed to prevent any release of contamination during flooding, up to a 500-year flood event.

In addition, the use of amendments along with standard cover materials will be evaluated during the remedial design phase, including hydrodynamic studies of the water bodies, to determine if protectiveness (related to future potential erosion) can be improved in a cost-effective manner.

As part of this process, sediments will require further sediment profiling during design to ascertain final dredging depths and volume estimates. It is also important to note that if the difference in dredged volume is relatively small, additional dredging may reduce or potentially eliminate the need for a subaqueous cover and future maintenance of this applied cover.

It is not expected that any aquatic habitat mitigation will be required due to the depth in the ponds where most of the sediment will be covered, but the issue will be addressed in the remedial design. Some fill may be needed to restore shoreline wetland habitat.

5.3.1.5 Subaqueous Cover (SE-4)

Subaqueous covers are typically used at sites to prevent exposure to underlying impacted media. For this alternative, a geotextile would be placed above the impacted sediments to establish the bottom of the clean fill and to minimize exposure of ecological receptors. One foot of clean fill would be placed above the geotextile to provide an appropriate ecological habitat. Final determination on the need for geotextile as part of the cover will be made during the remedial design phase, as river currents during flooding could potentially pull up the geotextile and disturb the cover more than if it were not in place. Since the cover will be located within the floodplain, the cover will need to be designed to prevent any release of contamination during flooding, up to a 500-year flood event.

It may be necessary to compensate elsewhere on site for loss of flood storage capacity due to the cover placement. It is not expected that any aquatic habitat mitigation will be required due to the depth in the ponds where most of the sediment will be covered, but the issue will be addressed in the remedial design. Some fill may be needed to restore shoreline wetland habitat.

In addition, the use of amendments along with standard cover materials will be evaluated during the remedial design phase, including hydrodynamic studies of the water bodies, to determine if protectiveness (related to future potential erosion) can be improved in a cost-effective manner.

As part of this process, sediments will require further sediment profiling during design to ascertain final dredging depths and volume estimates. It is also important to note that if the difference in dredged volume is relatively small, additional dredging may reduce or potentially eliminate the need for a subaqueous cover and future maintenance of this applied cover.

5.3.2 Remedial Alternatives

Sediment remedial alternatives are developed based upon those technologies and process options that were carried forward from Section 4 (Table 4-3). In assembling sediment alternatives, the general response actions and technologies chosen to represent the various process options for sediment are combined to form alternatives. The following sediment alternatives have been assembles and will be discussed further in Section 6.

Remedial Alternatives for Sediment

Components	SE-1: No Action	SE-2: Sediment Removal to PRGs	SE-3: Sediment Removal and Subaqueous Cover	SE-4: Subaqueous Cover
No Action	X			
Deed Restrictions			X	X
Subaqueous Cover			X	X
Sediment Removal to PRGs		X		
Sediment Removal to 1 Foot			X	

6. Alternatives Screening Process

This section screens the entire assembled alternatives on the basis of effectiveness, implementability, and cost. The comparison between alternatives in this screening step is generally made between similar alternatives. The screening criteria are defined as follows.

Effectiveness	Implementability	Cost
Overall protectiveness of human health and the environment	Technical feasibility	Equipment/construction
Compliance with RAOs	Demonstrated performance	Operation and maintenance (O&M)
Reduction of toxicity, mobility, or volume of contaminants through treatment	Availability of equipment, space, and services	
Adverse short- and long-term effects caused by implementation	Administrative feasibility	

Alternative screening for groundwater, soil, sediment, and waste are included below.

6.1 Groundwater Remedial Alternatives

Four alternatives were assembled in Section 5 and are described in detail in the following sections. The four remedial alternatives for groundwater are:

- GW-1: No action
- GW-2: Institutional Controls and Long-Term Monitoring
- GW-3: Active Remediation: Institutional Controls, Long-Term Monitoring, and Phytoremediation
- GW-4: Active Remediation: Institutional Controls, Long-Term Monitoring, and Chemical Oxidation

These alternatives have been developed to meet the screening criteria based on there being no future beneficial use of groundwater within the OU and the current site conditions and the trends in contaminant concentrations observed during previous investigation activities. As described earlier, impacts to groundwater are limited in nature and appear to be trending downward for many of the contaminants. Exceedances of Performance Standards in study area wells are presented in Appendix H. In wells where multiple sampling rounds were performed, impacts appear to typically be trending downward.

As presented in the RI, shallow groundwater flow from the J.M. Mills and the Nunes Parcel discharges to the Blackstone River with little to no evidence of vertical migration. At the Unnamed Island, groundwater discharges to both the Blackstone River and ponds located on the island. In each case, the Blackstone River is a reasonable compliance boundary beyond (downstream) which compliance with groundwater RAOs is appropriate.

The proposed compliance boundary is shown on Figure 3-6.

Four alternatives were assembled in Section 5 and are described in detail in the following sections. The four remedial alternatives for groundwater are as follows.

6.1.1 Alternatives GW-1: No Action

Under this alternative, no action would be taken to address groundwater impacts.

Table 6-1 presents the evaluation of the effectiveness, implementability, and cost associated with no action. The evaluation concludes that the No Action alternative would not be protective of human health or the environment. This alternative is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

6.1.2 Alternative GW-2: Institutional Controls and Long-Term Monitoring

Under this alternative, deed restrictions would prevent the use of groundwater, as well as protect components of the remedy (monitoring wells). Site-wide groundwater and surface water monitoring would be used to confirm that groundwater contamination is not migrating beyond the compliance boundary or into the river at levels that exceed performance standards.

Table 6-2 presents the evaluation of the effectiveness, implementability, and cost associated with the Institutional Controls and Long-term Monitoring alternative. The evaluation concludes that the Institutional Controls and Long-term Monitoring alternative would be effective in preventing exposure to receptors and is retained for detailed analysis.

6.1.3 Alternative GW-3: Active Remediation: Institutional Controls, Long-Term Monitoring, and Phytoremediation

Under this alternative, institutional controls and long-term monitoring would be combined with phytoremediation at targeted locations where PSs for VOCs have been exceeded to reduce the overall time to achieve RAOs. This alternative requires installation of a phytoremediation barrier to recover impacted groundwater and provide a barrier to migration.

Table 6-3 presents the evaluation of the effectiveness, implementability, and cost associated with the Active Remediation alternative. The evaluation concludes that because of the limited areas that this technology would be appropriate, this alternative is not retained for detailed analysis.

6.1.4 Alternative GW-4: Active Remediation: Institutional Controls, Long-Term Monitoring, and Chemical Oxidation

Under this alternative, institutional controls and long-term monitoring would be combined with chemical oxidation at locations where VOC impacts exceed PSs to reduce the overall time to achieve RAOs. This alternative requires injections around impacted wells to address VOC impacts exceeding PSs.

Table 6-4 presents the evaluation of the effectiveness, implementability, and cost associated with the Active Remediation alternative. The evaluation concludes that because of the decline in groundwater concentrations for the contaminants for which this technology would be most appropriate (VOCs), this alternative is not retained for detailed analysis.

6.2 Source Control Remedial Alternatives

The screening of alternatives for source control at the J.M. Mills Landfill, the Nunes Parcel, and the Unnamed Island are included in Sections 6.2.1, 6.2.2, and 6.2.3, respectively.

6.2.1 J.M. Mills Landfill

The three remedial alternatives developed in Section 5 for soils at the J.M. Mills Landfill are:

- Alternative JM-SO-1: No Action
- Alternative JM-SO-2: Presumptive Approach: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls
- Alternative JM-SO-3: Presumptive Approach: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

These three alternatives are described and screened in Sections 6.2.1.1 through 6.2.1.3.

6.2.1.1 Alternative JM-SO-1: No Action

This alternative consists of no remedial activities beyond those that have already been conducted at the site. It is the minimum proposed remedial action for source control at the J.M. Mills Landfill.

Table 6-5 presents the evaluation of the effectiveness, implementability, and cost associated with the No Action alternative at the J.M. Mills Landfill. The evaluation concludes that the No Action alternative would not be protective of human health and the environment. This alternative is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

6.2.1.2 Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

This alternative provides protection to human health by preventing or controlling potential exposures to waste and contaminated soils (including neighboring debris fields) through institutional controls and installation of a full RCRA Subtitle C cap on the J.M. Mills Landfill. Sediment from Pond N would also be removed and placed under the cap. Access would be limited through construction of fencing and a cap over the soils in waste areas. Contaminant mobility and surface water infiltration would also be significantly reduced (see Appendix J). Post-construction monitoring would be performed to determine if any additional actions related to leachate control (beyond limiting infiltration) will be necessary. Consolidation of contamination would be achieved as impacted soils and debris would be removed from the riverbank and floodplain. The effectiveness, implementability, and cost associated with this alternative are evaluated in Table 6-6. The conclusion is that this alternative would be effective in preventing exposure to receptors and is retained for detailed analysis.

6.2.1.3 Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

This alternative provides protection to human health by preventing or controlling potential exposures to waste and contaminated soils (including neighboring debris fields) through institutional controls and installation of a RCRA Subtitle C Cap on the upper one-third of the J.M. Mills Landfill and a perimeter soil cap over the lower two-thirds of the J.M. Mills Landfill. Sediment from Pond N would also be removed and placed under the cap. Access would be limited through construction of fencing and a cap over the soils in waste areas. Contaminant mobility and surface water infiltration would also be reduced (see Appendix J). Post-construction monitoring would be performed to determine if any additional actions related to leachate control (beyond limiting infiltration) will be necessary. Consolidation of contamination would be achieved as impacted soils and debris would be removed from the riverbank and floodplain.

The effectiveness, implementability, and cost associated with this alternative are evaluated in Table 6-7. The conclusion is that this alternative would not be effective in preventing exposure to receptors, but is retained for detailed analysis for comparative purposes.

6.2.2 Nunes Parcel

The three remedial alternatives developed in Section 5 for soils at the Nunes Parcel are:

- Alternative NP-SO-1: No Action
    - Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls
    - Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

These three alternatives are described and screened in Sections 6.2.2.1 through 6.2.2.3, respectively.

6.2.2.1 Alternative NP-SO-1: No Action

This alternative consists of no remedial activities beyond those that have already been conducted at the OU2 site. It is the minimum proposed remedial action for soils at the Nunes Parcel. No monitoring would be done to evaluate changes in contaminant concentrations or risks to human health or the environment.

Table 6-8 presents the evaluation of the effectiveness, implementability, and cost associated with the No Action alternative at the Nunes Parcel. The evaluation concludes that the No Action alternative would not be protective of human health and the environment. This alternative is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

6.2.2.2 Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls

This alternative does not provide treatment but does provide protection to human health by preventing or controlling potential exposures to waste and contaminated soils through institutional controls and capping waste areas. Sediment from Pond I would also be removed and placed under the cap. Access would be limited through construction of fencing and a full RCRA Subtitle D cap (in compliance with State Solid Waste Regulations; see Section 5.2.1.4). Contaminant mobility and surface water infiltration would also be reduced, but not to levels that would meet hazardous waste standards. Post-construction monitoring would be performed to determine if any additional actions related to leachate control (beyond limiting infiltration) will be necessary. Where practical, building demolition debris would be processed for use elsewhere on the OU2 site.

The effectiveness, implementability, and cost associated with this alternative are evaluated in Table 6-9. The conclusion is that this alternative would not be effective in preventing exposure to receptors, but is retained for detailed analysis for comparison purposes.

6.2.2.3 Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

This alternative does not provide treatment but does provide protection to human health by preventing or controlling potential exposures to waste and contaminated soils through institutional controls and capping waste areas. Sediment from Pond I would also be removed and placed under the cap. Access would be limited through construction of fencing and a full RCRA Subtitle C cap over the soils in waste areas. Contaminant mobility and surface water infiltration would also be reduced to meet hazardous waste standards. Post-construction monitoring would be performed to determine if any additional actions related to leachate control (beyond limiting infiltration) will be necessary. Where practical, building demolition debris would be processed for use elsewhere on the site.

The effectiveness, implementability, and cost associated with this alternative are evaluated in Table 6-10. The conclusion is that this alternative would be effective in preventing exposure to receptors and is retained for detailed analysis.

6.2.3 Unnamed Island

The three remedial alternatives developed in Section 5 for soils at the Unnamed Island are:

- Alternative UI-SO-1: No Action
- Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls
- Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

These three alternatives are described and screened in Sections 6.2.3.1 through 6.2.3.3, respectively.

6.2.3.1 Alternative UI-SO-1: No Action

This alternative consists of no remedial activities beyond those that have already been conducted at the OU2 site. It is the minimum proposed remedial action for soils/waste at the Unnamed Island. No monitoring would be done to evaluate changes in soil concentrations or risks to human health or the environment.

Table 6-11 presents the evaluation of the effectiveness, implementability, and cost associated with the No Action alternative at the Unnamed Island. The evaluation concludes that the No Action alternative would not be protective of human health or the environment. This alternative is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

6.2.3.2 Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

This alternative provides some protection through partial removal and covering remaining contaminated soils/waste. Institutional controls in the form of deed restrictions would be implemented to control future development on the Unnamed Island, and signage would be implemented to alert recreational users so as to protect the cover system. Exposure would be limited through construction of a geotextile fabric and overburden stone cover over the soils where contaminants exceeding PRGs extend more than 2 feet bgs. In addition, removal of surface waste (and buried waste down to 2 feet bgs) would also be conducted, including tires and debris in Wetland E. The constructed cover would need to meet flood standards to prevent the release of contaminants, up to a 500-year flood event. It would also need to meet landfill closure standards.

Table 6-12 presents the evaluation of the effectiveness, implementability, and cost associated with this alternative at the Unnamed Island. The evaluation concludes that the alternative would not be protective of receptors by limiting exposure, but is retained for detailed analysis for comparison purposes.

6.2.3.3 Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

This alternative provides protection through removal of all soils where contaminants exceed PRGs (estimated to extend from 0 to 12 feet bgs). In addition, removal of all surface and buried waste and all tires and debris in Wetland E would also be conducted to meet landfill closure standards. No institutional controls, O&M, nor statutory review will be required for this area because all waste and soil which exceed PRGs will be removed.

The effectiveness, implementability, and cost associated with this alternative are evaluated in Table 6-13. The conclusion is that this alternative would be effective in preventing exposure to receptors and is retained for detailed analysis.

6.3 Sediment Remedial Alternatives

Four alternatives to address sediment impacts on the Unnamed Island were assembled in Section 5 and are described in detail in the following sections. The four remedial alternatives for sediment are:

- SE-1: No Action

- SE-2: Remove/Consolidate Sediment Exceeding PRGs
- SE-3: Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls
- SE-4: Subaqueous Cover (No Sediment Removal) with Institutional Controls

These four alternatives are described and screened in Sections 6.3.3.1 through 6.3.3.4, respectively.

6.3.1 Alternative SE-1: No Action

This alternative involves performing no action. Through no action, impacted sediments would remain and the effects of these impacts on the ecological habitat and human receptors would be unabated.

Table 6-14 presents the evaluation of the effectiveness, implementability, and cost associated with the No Action alternative. The evaluation concludes that the No Action alternative would not be protective of the environment. This alternative is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

6.3.2 Alternative SE-2: Remove/Consolidate Sediment Exceeding PRGs

This alternative removes all impacted sediments (estimated at approximately 18,000 cy) and eliminates risks to ecological habitat. Water quality exceedances in the ponds are expected to be addressed by the removal of the contaminated sediments and additional source control measures within the OU. O&M of engineered substrates would not be required because all sediments which exceed PRGs will be removed. Sediments would be disposed of under either the J.M. Mills or Nunes Parcel caps.

Table 6-15 presents the evaluation of the effectiveness, implementability, and cost associated with this alternative. The evaluation concludes that this alternative would be effective in preventing exposure to receptors and is retained for detailed analysis.

6.3.3 Alternative SE-3: Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

This alternative removes sediment with PRG exceedences to 1 foot. Sediments would be disposed of under either the J.M. Mills or Nunes Parcel caps. A subaqueous cover would be utilized in areas where PRG exceedances are not fully removed. Water quality exceedances in the ponds are expected to be addressed by the removal and covering of the contaminated sediments and additional source control measures within the OU. Access to contaminated sediments by aquatic receptors would be limited by placing geotextile and

1 foot of clean fill over the remaining sediments. O&M of engineered substrates with periodic cover monitoring over the long-term would be conducted. Final determination on the need for geotextile as part of the cover will be made during the remedial design phase, as river currents during flooding could potentially pull up the geotextile and disturb the cover more than if it were not in place. The constructed cover would need to meet flood standards to prevent the release of contaminants, up to a 500-year flood event. In addition, the use of amendments along with standard cover materials will be evaluated during the remedial design phase to determine if protectiveness (related to future potential erosion) can be improved in a cost-effective manner.

As part of this alternative, sediments will require further sediment profiling during design to ascertain final dredging depths and volume estimates. It is also important to note that if the difference in dredged volume is relatively small, additional dredging may reduce or potentially eliminate the need for a subaqueous cover and future maintenance of the applied cover.

Table 6-16 presents the evaluation of the effectiveness, implementability, and cost associated with this alternative. The evaluation concludes that this alternative would be effective in preventing exposure to receptors and is retained for detailed analysis.

6.3.4 Alternative SE-4: Subaqueous Cover (No Sediment Removal) with Institutional Controls

This alternative does not provide treatment but provides protection to human health and the environment by preventing or controlling potential exposures to contaminated sediments through institutional controls and covering areas of PRG exceedances. Water quality exceedances in the ponds are expected to be addressed by the covering of the contaminated sediments and additional source control measures within the OU. Access to contaminated sediments by aquatic receptors would be limited through placement of geotextile and clean fill over the sediments. O&M of engineered substrates periodic cover monitoring over the long-term would be conducted. Final determination on the need for geotextile as part of the cover will be made during the remedial design phase, as river currents during flooding could potentially pull up the geotextile and disturb the cover more than if it were not in place. The constructed cover would need to meet flood standards to prevent the release of contaminants, up to a 500-year flood event. It may be necessary to compensate elsewhere on site for loss of flood storage capacity due to the cover placement. In addition, the use of amendments along with standard cover materials will be evaluated during the remedial design phase to determine if protectiveness (related to future potential erosion) can be improved in a cost-effective manner.

Table 6-17 presents the evaluation of the effectiveness, implementability, and cost associated with this alternative. The evaluation concludes that this alternative would be effective in preventing exposure to receptors and is retained for detailed analysis.

7. Detailed Analysis of Alternatives

The purpose of this detailed analysis of alternatives is to allow for comparisons among the groundwater, source area, and sediment remedial alternatives based on the standard criteria specified in the NCP. Nine evaluation criteria were developed by the EPA to serve as the basis for the detailed analysis of alternatives. These criteria are set forth in the NCP, at 40 CFR Part 300.430(e)(9). Further detail is provided in the EPA's *Guidance for Conducting Remedial Alternatives and Feasibility Studies Under CERCLA* (EPA, 1988). The nine criteria are summarized below.

Threshold Criteria

1. Overall protection of human health and the environment: This criterion focuses on whether a specific alternative achieves adequate protection and how site risks for each migration pathway being addressed by the FS are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. Also considered are whether an alternative poses any unacceptable short-term or cross-media impacts.

2. Compliance with ARARs: Assessment against this criterion describes how the remedial alternative complies with chemical-, location-, and action-specific ARARs, or if a waiver is required and how the waiver is justified.

Balancing Criteria

3. Long-term effectiveness and permanence: This criterion pertains to the risks remaining after response objectives have been met. Three factors TBC are the magnitude of the residual risk, the adequacy and reliability of any controls used to manage treatment residuals or untreated wastes that remain at the site, and the permanence of the remedy.

4. Reduction of toxicity, mobility, or volume: This criterion reflects the statutory preference for treatment alternatives that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances. Preferred alternatives destroy toxic contaminants, reduce the total mass of toxic contaminants, irreversibly reduce contaminant mobility, or reduce the total volume of contaminated media.

5. Short-term effectiveness: This criterion refers to the protection an alternative offers to workers and the community during the construction and implementation of a remedy, as well as the time required to reach the response objectives.

6. Implementability: This criterion considers technical feasibility, administrative feasibility, and the availability of required materials and services. *Technical feasibility* is evaluated on the basis of four parameters: ability to construct the alternative, the reliability of the technologies proposed, the ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy. *Administrative feasibility* considers activities needed to coordinate with other agencies, such as permits and rights-of-way.

7. Cost: This criterion evaluates the capital and O&M costs of each alternative.

Modifying Criteria

8. State acceptance: This criterion evaluates the technical and administrative issues and concerns the state may have regarding each alternative. This criterion is not addressed in this FS. It will be addressed in the ROD after comments on this FS and proposed plan have been received.

9. Community acceptance: This criterion evaluates the issues and concerns the public may have regarding each alternative. This criterion is not addressed in this FS. It will be addressed in the ROD after comments on this FS and proposed plan have been received.

The detailed analysis for each alternative includes a detailed description of each remedial alternative followed by a detailed evaluation of each remedial alternative evaluation Criteria 1 through 7. Criteria 1 and 2 are considered to be “threshold factors,” which each alternative must meet in order TBC appropriate for a site. Criteria 3 through 7 are considered to be the primary “balancing factors,” which represent the primary criteria upon which the analysis of alternatives is based upon. Criteria 8 and 9 are considered to be “modifying considerations,” which are evaluated following comment on the FS and proposed plan and will be addressed once the final cleanup decision is made in the ROD.

The descriptions of each remedial alternative are conceptual and are used for costing purposes. The specific design details and costs for the selected remedy will be re-evaluated during the remedial design. As specified in the FS guidance (EPA, 1988), the costs are intended to be within the target accuracy range of -30 to +50% of the actual cost. Note that administrative costs associated with implementation of institutional controls (except for groundwater) and performance of 5-year reviews have not been included in the alternatives. Section 7.1 presents the detailed analysis of alternatives for groundwater that were retained from the Alternatives Screening in Section 6. Section 7.3 presents the detailed analysis of alternatives for sediment that were retained from the Alternatives Screening in Section 6.

7.1 Groundwater

Two groundwater remedial alternatives have been retained for detailed analysis. The detailed analysis of the remedial action alternatives is summarized in Table 7-1 and presented in the following sections. The alternatives are:

- Alternative GW-1: No Action
- Alternative GW-2: Limited Action: Institutional Controls and Long-Term Monitoring

7.1.1 Alternative GW-1: No Action

The following sections present a detailed analysis of remedial action Alternative GW-1 for groundwater. Table 7-1 presents a summary of this analysis. This alternative is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

Under this alternative, no action would be taken to address groundwater impacts.

7.1.1.1 Overall Protection of Human Health and the Environment

The No Action alternative would not reduce existing contaminant concentrations in groundwater, or provide measures to eliminate or control potential exposure pathways associated with possible future use of groundwater containing contaminants. Additionally, this alternative has the potential to allow groundwater containing contaminants to migrate, potentially impacting downgradient surface water or other potential receptors. Therefore, the No Action alternative would not achieve groundwater RAOs, and would not be protective of human health and the environment.

7.1.1.2 Compliance with ARARs

Alternative GW-1 would not comply with chemical-specific ARARs (see Appendix I, Table I-1a) for groundwater because no action would be taken to control potential exposure pathways or address contaminant concentrations in groundwater. There are no location- or action-specific ARARs for Alternative GW-1.

7.1.1.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence would not be achieved through the No Action alternative because existing contaminant concentrations in groundwater would not be addressed and institutional controls would not be implemented to eliminate or provide long-term control of potential exposure pathways. Additionally,

this alternative has the potential to allow contaminants in groundwater to migrate, potentially intercepting downgradient surface water or other receptors and could increase the eventual future capital and O&M expenditures if future remediation is required.

7.1.1.4 Reduction of Mobility, Toxicity, or Volume Through Treatment.

Alternative GW-1 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in groundwater.

7.1.1.5 Short-Term Effectiveness

Implementation of this alternative would result in minimal exposure risk to the community, workers, and the environment.

7.1.1.6 Implementability

As no technical implementation is required, the No Action alternative is technically feasible and would not limit or interfere with the ability to perform future remedial actions. However, the No Action alternative is unlikely to be administratively feasible due to the anticipated lack of monitoring and protection of human health and the environment.

7.1.1.7 Cost

Table 7-1 and Appendix A present a summary of the present value calculations for Alternative GW-1 and the detailed cost backup, respectively. There are no capital or O&M costs associated with Alternative GW-1. Total costs for this alternative are estimated to be approximately $0.

7.1.2 Alternative GW-2: Limited Action: Institutional Controls and Long-Term Monitoring

The following sections present a detailed analysis of remedial action Alternative GW-2 for groundwater. Under this alternative, site-wide, institutional controls (in the form of deed restrictions) to prohibit the use and/or alteration of groundwater within the compliance boundary of the waste management area and to prevent disturbance to components of the remedy would be implemented. Additional institutional controls may be placed on a buffer zone outside of the compliance boundary to prevent wells from being installed that would draw contaminated groundwater beyond the compliance boundary. There will be at least yearly compliance monitoring to ensure restrictions remain in place and are enforced. Long-term monitoring will ensure contaminated groundwater is not migrating beyond the compliance boundary or into the river. Monitoring will include the appropriate sampling strategy to evaluate degradation processes that may decrease contaminant concentrations in groundwater (lead, cadmium, and organics) and biogeochemical

processes that may increase contaminant concentrations in groundwater (arsenic) and be performed on a regular schedule so as to provide trend analyses and tracking of contaminant behavior, especially during times of variable wet/dry seasonal events. In addition, there will be periodic reviews no less than every five years as required by statute. Table 7-1 presents a summary of this analysis.

7.1.2.1 Overall Protection of Human Health and the Environment

Implementation of this alternative is not expected to result in exposure risks to the community or workers. Site-wide monitoring would be used to ensure groundwater contamination is not migrating beyond the compliance boundary or into the river at levels that would exceed Performance Standards. Institutional controls (i.e., groundwater use restrictions) would protect against human exposure to contaminants in groundwater. Note that an additional buffer zone, beyond the compliance boundary, to prevent groundwater wells from being installed that may draw contaminated groundwater beyond the compliance boundary, may also be established during the design phase (in discussion with local authorities) or, if required, sometime after the remedy is implemented based on future monitoring data and five-year reviews to further increase the protectiveness of the remedy. Groundwater monitoring would be used to assess achievement of RAOs. Alternative GW-2, as long as institutional controls and monitoring are maintained, would protect indefinitely against both current and future human exposure to groundwater and would ensure aquatic resources are not impaired by groundwater discharges. Therefore, the alternative would be protective of human health and the environment.

7.1.2.2 Compliance with ARARs

Alternative GW-2 would comply with chemical-specific ARARs (see Appendix I, Table I-2a) for groundwater by preventing completion of an exposure pathway for groundwater outside of the groundwater compliance boundary. Primary location-specific ARARs involve avoidance/minimization of impacts to wetlands and federally-designated 100-year and 500-year floodplain (see Appendix G for floodplain map). Alternative GW-2 would comply with location- and action-specific ARARs (see Appendix I, Tables I-1b and I-1c, respectively) during installation of monitoring wells and sampling in and around wetlands, floodplain, and the river.

7.1.2.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence would be achieved through institutional controls and site-wide monitoring. Institutional controls, including deed notification and restrictions, would prevent access to contaminants in groundwater and potentially the installation of wells with a buffer zone around the compliance boundary. Institutional controls within the compliance boundary of the waste management area established for the soil remedy will prevent use of contaminated groundwater that exceeds performance

standards. Exceedances of these standards within the compliance boundary will be addressed by institutional controls.

7.1.2.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

Alternative GW-2 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in groundwater.

7.1.2.5 Short-Term Effectiveness

Implementation of this alternative would result in minimal exposure risks to the community, workers, and the environment during groundwater monitoring events. These potential risks will be managed through the use of a site-specific Health and Safety Plan and worker training. Institutional controls (i.e., groundwater use restrictions) would prevent exposure to groundwater.

7.1.2.6 Implementability

Implementation of this alternative is technically feasible, as the technology is conventional. As the contaminants in groundwater do not extend offsite, this alternative is likely administratively feasible as well. The services and materials necessary for the collection and analysis of monitoring samples are readily available. This alternative would not limit or interfere with the ability to perform future remedial actions and institutional controls would be readily implementable.

7.1.2.7 Cost

Table 7-1 and Appendix A present a summary of the present value calculations for Alternative GW-2 and the detailed cost backup, respectively. Capital costs include implementation of institutional controls. O&M costs include site-wide groundwater monitoring for 30 years and institutional controls for 30 years.

Total capital costs are estimated to be approximately $166,000 for placing institutional controls and monitoring well installation. Total annual O&M costs are estimated to be approximately $41,000 per year. Based on the EPA guidance, the total present value life cycle cost of Alternative GW-2 using a discount rate of 7% for 30 years is $671,000 (EPA, 2000).

7.2 Source Control Remedial Alternatives

7.2.1 J.M. Mills Landfill

The detailed analysis of source area soil and waste alternatives is intended to provide sufficient information to select the appropriate components of the presumptive containment approach for the J.M. Mills Landfill, the soils with contaminants exceeding PRGs along the floodplain and riverbank, sediment in Pond N, and for the waste located in the adjacent DFs. Criteria for the analysis of alternatives and the remedy costs are based on existing data and knowledge of the site and do not take into account the potential to extend the cleanup on to the P&W railroad right-of-way. As stated above, RCRA "hazardous waste" was disposed of at the site, but it is unclear when this disposal took place. Therefore, RCRA requirements are not applicable, but are relevant and appropriate. In addition, CERCLA "hazardous substances" were disposed of at the site.

As summarized in Section 3 issues to be addressed at the J.M. Mills Landfill are the waste within the J.M. Mills Landfill itself, soils on the riverbank and floodplain that exceed the site PRGs, sediment in Pond N, and waste within the adjacent DFs.

The riverbank and floodplain soils have contaminants that exceed the human health PRGs. Cadmium exceeds the ecological soil PRG in shallow soils on the floodplain and riverbank. For the purposes of the detailed analysis, the areal extent of the soil impacts to which the remedy will apply were based on the RI sample results. The vertical extent of the impacts was assumed to include the upper 2 feet of soil. The PRPs have recently conducted soil sampling and worm sampling for cadmium and other metals. Additional data may be obtained and would be used during the remedial design phase to evaluate the extent of cadmium and add to a more robust database indicating its significance and the extent of historic upriver sources of contaminants.

For any alternative evaluated, except the No Action alternative, existing soil data would need to be supplemented with additional sampling as a component of pre-design testing. The areal and vertical extent of contaminant concentrations that pose potential risk would need to be more fully defined for design criteria. During development of design criteria, a sampling and analysis program would be implemented to delineate areas for remediation.

Three remedial alternatives for the J.M. Mills Landfill have been retained for detailed analysis. All of the active remedial alternatives take into consideration the current conditions of the J.M. Mills Landfill, the setting of the J.M. Mills Landfill along the Blackstone River floodplain, and the recent groundwater, soil, and worm sampling, as each has potential bearing on the selected remedy.

Under current conditions, both the J.M. Mills Landfill and adjacent floodplain are covered with vegetation, including brush and mature trees. It appears that portions of the J.M. Mills Landfill possess slope gradients

steeper than 3 feet horizontal to 1 foot vertical, the maximum slope allowable by regulatory agencies. The location of the J.M. Mills Landfill between the Blackstone River floodplain and the P&W railroad places space constraints on the remedy. To accommodate the current conditions, both of the proposed active remedial capping alternatives will require clearing and grubbing of the vegetation and extensive regrading of the J.M. Mills Landfill prior to construction of a cap. Both of the proposed active remedial capping alternatives include the removal of soil and/or debris/waste from the floodplain followed by restoration of the floodplain and riverbank.

In addition to incorporating each of the items discussed above, the final design for the selected alternative will need to be integrated with the selected alternatives for the Unnamed Island and Nunes Parcel to allow for maximum onsite accommodation of excavated soil, waste, and sediment. Similarly, any loss of floodplain storage will require compensation/mitigation. For the purposes of this FS, it is currently assumed that this balance will be performed entirely on site. It may, however, be necessary to acquire additional property to perform this compensation. Costs for any necessary acquisitions have not been included in this FS.

The detailed analysis of the remedial action alternatives is summarized in Table 7-2 and presented in the following sections. They are:

- Alternative JM-SO-1: No Action
- Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls
- Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

7.2.1.1 Alternative JM-SO-1: No Action

The following sections present a detailed analysis of remedial action Alternative JM-SO-1 for source area soils and waste. Table 7-2 presents a summary of this analysis. This alternative is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

Under this alternative, no action would be taken to address soil and waste impacts.

7.2.1.1.1 Overall Protection of Human Health and the Environment

Although the No Action alternative does not incorporate any activities that would present significant exposure risks to the community, workers, or the environment, it would not reduce existing contaminant concentrations in soil or waste, or provide measures to eliminate or control potential exposure pathways associated with possible future use of the site. Additionally, this alternative has the potential to allow contaminants in soil/waste to continue to leach to groundwater and to migrate, impacting downgradient surface water or other potential receptors. Therefore, the No Action alternative would not achieve soil or waste RAOs and would not be protective of human health or the environment.

7.2.1.1.2 Compliance with ARARs

Alternative JM-SO-1 would not comply with chemical-specific ARARs (see Appendix I, Table I-3a) for soils or waste because no action would be taken to control potential exposure pathways or address contaminant concentrations in soil or waste. There are no location- or action-specific ARARs for Alternative JM-SO-1.

7.2.1.1.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence would not be achieved through the No Action alternative because existing contaminant concentrations in soil and waste would not be addressed and institutional controls would not be implemented to eliminate or provide long-term control of potential exposure pathways. This alternative will not withstand impacts associated with a 100-year or 500-year storm event. Additionally, this alternative has the potential to allow contaminants in soil and waste to leach to groundwater and to migrate, potentially intercepting downgradient surface water or other receptors and could increase the eventual future capital and O&M expenditures if future remediation is required.

7.2.1.1.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

Alternative JM-SO-1 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in soil/waste.

7.2.1.1.5 Short-Term Effectiveness

This alternative does not implement any activities and, therefore, would not result in any exposure risks to the community, workers, or the environment during implementation of the alternative.

7.2.1.1.6 Implementability

As no technical implementation is required, the No Action alternative is technically feasible and would not limit or interfere with the ability to perform future remedial actions. However, the No Action alternative is unlikely to be administratively feasible due to the anticipated lack of monitoring and protection of human health and the environment.

7.2.1.1.7 Cost

Table 7-2 and Appendix B present a summary of the present value calculations for Alternative JM-SO-1 and the detailed cost backup, respectively. There are no capital or O&M costs associated with Alternative JM-SO-1. Total costs for this alternative are estimated to be approximately $0.

7.2.1.2 Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

The following sections present a detailed analysis of remediation action Alternative JM-SO-2 for soil and waste. Alternative JM-SO-2 includes a full RCRA Subtitle C cap of the J.M. Mills Landfill; removal of vegetation from the riverbank and floodplain; excavation to a depth of approximately 2 feet of soils on the riverbank and floodplain exceeding the ecological risk-based PRG for cadmium; excavation of any floodplain soils exceeding ARARs; removing waste from neighboring debris fields; excavation of Pond N sediments; consolidation of all contaminated material/waste under the landfill cap; restoration of the floodplain and riverbank with appropriate erosion control measures; implementation of potential wetland/floodplain mitigation measures, as required; long-term monitoring; and institutional controls. To accommodate the current conditions, JM-SO-2 will require clearing and grubbing of the vegetation and extensive regrading of the J.M. Mills Landfill prior to construction of a cap. A landfill gas management system will be designed and constructed (passive or active collection/treatment to be determined in design). The cap must be constructed to protect against flooding, up to a 500-year event, and effectively manage stormwater. Outside of the cap area, disturbance to environmentally sensitive areas (floodplain and wetland) will be minimized by using site-specific cleanup standards that will only alter areas of floodplain and wetland where contamination exceeds ecological and recreational risk standards. Mitigation will be carried out, as required, for environmentally-sensitive areas altered. As discussed in Section 5.2.1.3, the extent of replacement of excavated material on the floodplain will be determined during the design phase. Where soil impacts exceeding the PRGs are fully removed, the excavated area may be restored without fill to provide flood storage capacity mitigation. The location of the DFs is shown on Figure 2-2. A site plan of the remedy is presented on Figure 7-1, and a conceptual cross-section of the proposed cover system is presented as Figure 7-2. As stated earlier, a Region I Alternative Cap, which complies with relevant and appropriate RCRA Subtitle C capping standards, has been proposed at this time for costing purposes.

Table 7-2 presents a summary of this analysis.

7.2.1.2.1 Overall Protection of Human Health and the Environment

Implementation of this alternative would potentially result in short-term exposure risks to the community, workers, or the environment during soil removal and installation of the RCRA Subtitle C cap; these potential risks would be managed with engineering controls, access restrictions, and worker training. Contaminants in soil on the riverbank and floodplain would be permanently removed, eliminating the potential exposure pathway in these areas. Capping of the J.M. Mills Landfill, with consolidation of all contaminated material under the cap, will address risks associated with hazardous waste and hazardous substance disposal. Installation of the full RCRA Subtitle C cap will place a physical barrier between potential receptors and contaminated materials in soil and waste, reduce the infiltration and the potential for leaching of contaminants in soil to groundwater, and ensure that contamination is not eroded or washed out of the J.M. Mills Landfill during a flood, up to a 500-year storm event. Deed restrictions controlling land use will be maintained to further protect the integrity of the cap. Alternative JM-SO-2 would be protective of the environment by consolidating contaminant mass within a protective containment system and eliminating potential exposure pathways.

7.2.1.2.2 Compliance with ARARs

Alternative JM-SO-2 complies with all state and federal chemical, location and action specific ARARs. Compliance with chemical-specific ARARs (see Appendix I, Table I-4a) is achieved by capping of the J.M. Mills Landfill and by removing or consolidating contaminated material above remedial goals in soil along the riverbank and floodplain. ICs will prevent activities that will disturb the capped material. Alternative JM-SO-2 complies with location-specific ARARs (see Appendix I, Table I-4b). The remedy implementation has the potential to encroach on existing wetlands, and remedial measures will be designed to mitigate adverse impacts on protected function and achieve no net loss. Alternative JM-SO-2 meets federal Clean Water Act standards to be considered the Least Environmentally Damaging Practicable Alternative (LEDPA). In addition, remedy implementation will need to avoid/minimize impacts to the federally-designated 100-year and 500-year floodplain (see Appendix G for floodplain map). An assessment of impacts to the 500-year floodplain is required for critical actions, which include siting hazardous waste facilities in a floodplain. Installation of a RCRA C compliant cap that can withstand flooding, up to a 500-year storm event, may alter areas of floodplain, as well as state jurisdictional wetlands and buffer zone. Mitigation measures, as required, will be taken to compensate for the resource areas altered by the cap. Alternative JM-SO-2 would comply with action-specific ARARs (see Appendix I, Table I-4c) during remedy construction and monitoring. In particular, relevant and appropriate hazardous waste landfill closure standards will be the primary standards used to design, construct and maintain the landfill cap. Groundwater and water quality monitoring standards will be used to confirm the long-term protectiveness of the capping alternative. Alternative JM-SO-2 will also meet Toxic Substances Control Act (TSCA) regulatory standards by addressing soils

contaminated with PCBs in order to control risk of injury to health or the environment, through excavation of soil exceeding 10 parts-per-million (ppm) and consolidation under the constructed caps.

7.2.1.2.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence will be achieved through Alternative JM-SO-2. This alternative will result in the permanent reduction of contaminant concentrations in soil along the riverbank and floodplains and eliminate the potential for direct contact with contaminants in soil by a receptor in these areas. The consolidation of all contaminated material/debris under the full RCRA Subtitle C cap will ensure that contamination is not eroded or washed out of the J.M. Mills Landfill during flooding, up to a 500-year storm event, and will also reduce the potential exposure pathway and the potential for contaminants in soil/landfill debris to leach to groundwater while the cap is in place and maintained. Some flexibility with respect to the variety of native vegetative restoration for ecological habit can be explored further during the design of the final cap.

7.2.1.2.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

Alternative JM-SO-2 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in soil/waste

7.2.1.2.5 Short-Term Effectiveness

Implementation of this alternative would result in short-term exposure risks to the community and workers that would be managed with engineering controls, including access restrictions, site-specific Health and Safety Plans, traffic control plans, and worker training. Soil removal and installation of the full RCRA Subtitle C cap on the J.M. Mills Landfill could also result in significant impacts to environmental receptors and their habitats due to removal of all trees on the J.M. Mills Landfill cap area and the areas of the riverbank and floodplain where soil removal will occur. However, these impacts are considered short-term, as appropriate groundcover will be applied on the cap and it is further expected that some areas of the river bank and floodplain will either be re-vegetated and/or will return to a natural state on its own. Vegetation at the surface of the full RCRA Subtitle C cap would be limited to grasses and other shallow root zone vegetation. Potential impacts to environmental receptors would be managed through engineering controls. Engineering measures will be used to control potential fugitive dust, surface water runoff, erosion, and sedimentation during excavation and cap construction. Construction of the full RCRA Subtitle C cap will require transporting significant volumes of materials to the site, creating potential short-term risks to the community due to truck traffic and potential risks in the short-term to the environment from vehicle emissions. Short term risks due to emissions may possibly be reduced through coordinated shipments to and from the site conducted by rail as the Providence and Worchester Railroad operates in the immediate vicinity. Waste generated during remedial activities would be managed using approved methods.

7.2.1.2.6 Implementability

Implementation of this alternative is both technically and administratively feasible, as the remedial technology is conventional and proven for these contaminants. Services and materials necessary for implementing the alternative are readily available. Limited site access complicates construction given the large volume of soil and geosynthetic materials required for this alternative. Truck traffic associated with delivery of soils, aggregates, geosynthetics, and other required cap materials would be high under this alternative and may pose complications to existing traffic conditions in the vicinity of the site. Due to the immediate proximity of the Providence and Worchester Railroad, however, coordinated shipments to and from the site conducted by rail, if possible, may alleviate some local traffic concerns both on and within the vicinity of the site. There are also some constraints at the J.M. Mills Landfill boundaries (railroad to the north and floodplain to the south) that may present limitations for access and mobility to grade and install the cover system soils and deploy/install geosynthetic materials. Additional waste exhumation along the landfill slopes would be anticipated to minimize impacts to the floodplains, as well as confirming slope stability/flood protection requirements. It will be necessary to remove and clear vegetation to facilitate the cap construction and meet remedial goals. Mitigation will be carried out, as required, for environmentally-sensitive areas altered. To the extent practical, restoration of various ecological habitats with shallow rooting native vegetation on the cap would also be explored during the design of the final cap. Finally, the location and protection of the cap along the riverbank will present a significant technical challenge which will need to be addressed during design.

7.2.1.2.7 Cost

Table 7-2 and Appendix B present a summary of the present value calculations for Alternative JM-SO-2 and the detailed cost backup, respectively. Capital costs include implementation of institutional controls, removal of soil or waste from the riverbank and floodplain with bank restoration, and construction of a full RCRA Subtitle C cap (Region 1 Alternate Cap assumed) of the J.M. Mills Landfill. O&M costs include cap maintenance and institutional controls for 30 years. Costs associated with any potentially necessary property acquisitions related to floodplain compensation/mitigation have not been included in this FS.

Total capital costs are estimated to be approximately $21,063,000. Total annual O&M costs are estimated to be approximately $40,000 per year. Based on the EPA guidance, the total present value life cycle cost of Alternative JM-SO-2 using a discount rate of 7% for 30 years is $21,559,000 (EPA, 2000).

7.2.1.3 Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

The following sections present a detailed analysis of remediation action Alternative JM-SO-3 for soil and waste. Alternative JM-SO-3 includes a hybrid landfill cap consisting of a RCRA Subtitle C cap over the upper

one-third flatter slopes of the landfill and a perimeter soil cap over the lower two-thirds of the J.M. Mills Landfill, as shown on Figure 7-3; excavation to a depth of approximately 2 feet of soils on the riverbank and floodplain exceeding the ecological risk-based PRG for cadmium; excavation of any floodplain soils exceeding ARARs; removing waste from neighboring debris fields; excavation of Pond N sediments; consolidation of all contaminated material/debris under the landfill cap; restoration of the floodplain and riverbank with appropriate erosion control measures; mitigation measures, as required, to compensate for altered protected resource areas; long-term monitoring; and institutional controls. To accommodate the current conditions, JM-SO-3 will require clearing and grubbing of the vegetation and extensive regrading of the J.M. Mills Landfill prior to construction of a cap. Outside of the cap area, disturbance to environmentally sensitive areas (floodplain and wetland) will be minimized by using site-specific cleanup standards that will only alter areas of floodplain and wetland where contamination exceeds ecological and recreational risk standards. Mitigation will be carried out, as required, for environmentally-sensitive areas altered. A site plan of the remedy is presented on Figure 7-3 and a conceptual cross-section of the proposed cover system is presented as Figure 7-4. For the RCRA Subtitle C portion of the cap, a Region I Alternative Cap, which complies with relevant and appropriate RCRA Subtitle C capping standards, has been proposed at this time for costing purposes.

Table 7-2 presents a summary of this analysis.

7.2.1.3.1 Overall Protection of Human Health and the Environment

Implementation of Alternative JM-SO-3 would potentially result in short-term exposure risks to the community, workers, or the environment during soil removal and installation of the hybrid landfill cap. These potential risks would be managed with engineering controls, access restrictions, and worker training. Permanent removal of contaminated soil on the riverbank and floodplain and consolidation under the cap would be achieved, eliminating the potential exposure pathway in these areas. The installation of the hybrid landfill cap on the J.M. Mills Landfill will place a limited physical barrier between potential receptors and contaminated material in soil and waste to reduce the potential exposure pathway and the soil cap component of the alternative will not address the potential for leaching of contaminated material in soil to groundwater. The maintenance of deed restrictions will also reduce potential human exposure pathways. The perimeter soil cap does not meet the standards for preventing a washout during flooding, up to a500-year storm event. In addition, the hybrid cap does not fully address potential landfill gas releases. Therefore, alternative JM-SO-3 is not fully protective of human health and the environment.

7.2.1.3.2 Compliance with ARARs

Alternative JM-SO-3 would not comply with state and federal chemical-specific ARARs (see Appendix I, Table I-5a) because the soil portion of the cap may not prevent the release of contaminants in the event of flooding, up to a 500-year storm event, that would cause contaminant releases and alter areas of floodplains

and state and federal jurisdictional wetlands. Alternative JM-SO-3 would not fully comply with location-specific ARARs (see Appendix I, Table I-5b), as the perimeter soil cap will not meet required state or federal flood protection standards. Alternative JM-SO-3 does not fully comply with action-specific landfill closure ARARs (see Appendix I, Table I-5c), as the soil portion of the cap does not meet landfill closure standards, in particular, it not does not comply with the Toxic Substances Control Act (TSCA) and RCRA Subtitle C standards throughout the entirety of the cap.

7.2.1.3.3 Long-Term Effectiveness and Permanence

This alternative may not result in the permanent reduction of contaminant concentrations in soil/landfill debris or eliminate the potential for direct contact with contaminants in soil/landfill debris by a receptor in these areas because the perimeter soil cap may not prevent the release of contaminants in the event of flood or though the potential for continued erosion of the soil cap over the long term. The hybrid landfill cap on the J.M. Mills Landfill will not sufficiently reduce the potential exposure pathway to groundwater and the potential for contaminants in soil/landfill debris to leach to groundwater. The hybrid landfill cap will generally reduce stormwater percolation through the final cover system if properly maintained, yet allow for aerobic conditions within the waste mass and subsurface saturated zones. In addition, increased flexibility with respect to the variety of native vegetative restoration can be explored further during the design of the final cap. Long-term effectiveness and permanence will not be achieved through Alternative JM-SO-3 because the soil portion of the cap does not meet TSCA protectiveness standards for PCBs or RCRA Subtitle C performance standards' may not prevent the release of contaminants during flooding, up to a 500-year storm event; and will not effectively address landfill gas emissions .

7.2.1.3.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

Alternative JM-SO-3 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in soil/waste.

7.2.1.3.5 Short-Term Effectiveness

Implementation of this alternative would result in short-term exposure risks to the community and workers that would be managed with engineering controls, including access restrictions, site-specific Health and Safety Plans, traffic control plans, and worker training. Soil removal and installation of the hybrid landfill cap on the J.M. Mills Landfill could also result in short-term impact to environmental receptors due to removal of all trees clearing and grubbing of the vegetation and extensive regrading of the J.M. Mills Landfill prior to construction of a cap and the areas of the riverbank and floodplain where soil removal will occur. Potential impacts to environmental receptors would be managed through engineering controls. Engineering measures will be used to control potential fugitive dust, surface water runoff, erosion, and sedimentation during excavation and cap construction. The construction of the hybrid landfill cap will require transportation of

capping materials, resulting in short-term risks to the community due to truck traffic. However, due to the immediate proximity of the P&W Railroad, any shipments to and from the site conducted by rail may alleviate some local traffic concerns and short term risks within the vicinity of the site. Waste generated during remedial activities would be managed using approved methods.

7.2.1.3.6 Implementability

Implementation of this alternative is both technically and administratively feasible, as the remedial technology is conventional and proven for these contaminants. Services and materials necessary for implementing the alternative are readily available. However, implementation will be challenging given the significant amount of tree removal and clearing of vegetation required in order to meet remedial goals. Soil hauling activities are complicated by limited site access. This alternative potentially offers flexibility with respect to revegetation of native species. There are also some constraints at the J.M. Mills Landfill boundaries (railroad to the north and floodplain to the south) that may present limitations for access and mobility to grade and install the cover system soils and deploy/install geosynthetic materials. Additional waste exhumation along the landfill slopes would be anticipated in order to minimize impacts to the floodplains, as well as confirming slope stability requirements. It will be necessary to remove and clear vegetation to facilitate the cap construction and meet remedial goals. Mitigation will be carried out, as required, for environmentally-sensitive areas altered. To the extent practical, restoration of various ecological habitats with shallow rooting native vegetation on the cap would also be explored during the design of the final cap. Finally, the location and protection of the cap along the riverbank will present a significant technical challenge which would need to be addressed as part of the remedial design.

7.2.1.3.7 Cost

Table 7-2 and Appendix B present a summary of the present value calculations for Alternative JM-SO-3 and the detailed cost backup, respectively. Capital costs include implementation of institutional controls, removal of soil from the riverbank and floodplain with bank restoration, and construction of a low-permeability hybrid cap of the J.M. Mills Landfill. O&M costs include cap maintenance and institutional controls for 30 years. Costs associated with any potentially necessary property acquisitions related to floodplain compensation/mitigation have not been included in this FS.

Total capital costs are estimated to be approximately $13,225,000. Total annual O&M costs are estimated to be approximately $40,000 per year. Based on the EPA guidance, the total present value life cycle cost of Alternative JM-SO-3 using a discount rate of 7% for 30 years is $13,721,000 (EPA, 2000).

7.2.2 Nunes Parcel

The detailed analysis of source area soil and waste alternatives is intended to provide sufficient information to select the appropriate components of the presumptive containment approach for the Nunes Parcel. Criteria for the analysis of alternatives and the remedy costs are based on existing data and knowledge of the site.

The waste will be addressed through the presumptive approach, a landfill cap that encompasses the waste in its current placement. In addition, building structures will be demolished, surrounding soil exceeding PRGs and ARARs will be consolidated under the cap, along with Pond I sediments.

Any loss of floodplain storage will require compensation/mitigation. For the purposes of this FS, it is currently assumed that this balance will be performed entirely on site. It may, however, be necessary to acquire additional property to perform this compensation. Costs for any necessary acquisitions have not been included in this FS.

Three remedial alternatives for the Nunes Parcel have been retained for detailed analysis. The detailed analysis of the remedial action alternatives is summarized in Table 7-3 and presented in the following sections. They are as follows:

- Alternative NP-SO-1: No Action
- Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls
- Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

7.2.2.1 Alternative NP-SO-1: No Action

The following sections present a detailed analysis of remedial action Alternative NP-SO-1 for source area soils and waste. Table 7-3 presents a summary of this analysis. This alternative is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

Under this alternative, no action would be taken to address soil and waste impacts.

7.2.2.1.1 Overall Protection of Human Health and the Environment

Although the No Action alternative does not incorporate any activities that would present significant exposure risks to the community, workers, or the environment, it would not reduce existing concentrations of

contaminants in soil or waste, or provide measures to eliminate or control potential exposure pathways associated with possible future use of the site. Additionally, this alternative has the potential to allow contaminants to continue to leach to groundwater and to migrate, potentially impacting downgradient surface water or other potential receptors. Therefore, the No Action alternative would not achieve soil or waste RAOs or be protective of human health and the environment.

7.2.2.1.2 Compliance with ARARs

Alternative NP-SO-1 would not comply with state or federal chemical-specific ARARs (see Appendix I, Table I-6a) for soils or waste because no further action would be taken to control potential exposure pathways or address contaminant concentrations in soil or waste.

7.2.2.1.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence would not be achieved through the No Action alternative because existing contaminant concentrations in soil and waste would not be addressed and institutional controls would not be implemented to eliminate or provide long-term control of potential exposure pathways. This alternative also has the potential to allow contaminants in soil and waste to leach to groundwater and to migrate, potentially impacting downgradient surface water or other receptors and could increase the eventual future capital and O&M expenditures if future remediation is required.

7.2.2.1.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

No treatment is being performed as part of this alternative; therefore, there is no reduction of mobility, toxicity, or volume due to treatment to evaluate.

7.2.2.1.5 Short-Term Effectiveness

This alternative does not implement any activities and, therefore, would not result in any exposure risks to the community, workers, or the environment during implementation of the alternative.

7.2.2.1.6 Implementability

The No Action alternative is technically feasible, as no technical implementation is required, and would not limit or interfere with the ability to perform future remedial actions. However, the No Action alternative is unlikely to be administratively feasible due to the anticipated lack of monitoring and protection of human health and the environment.

7.2.2.1.7 Cost

Table 7-3 and Appendix B present a summary of the present value calculations for Alternative NP-SO-1 and the detailed cost backup, respectively. There are no capital or O&M costs associated with Alternative NP-SO-1. Total costs for this alternative are estimated to be approximately $0.

7.2.2.2 Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls

The following sections present a detailed analysis of remediation action Alternative NP-SO-2 for soil and waste. Alternative NP-SO-2 includes a full RCRA Subtitle D cap (which also complies with RI Solid Waste Regulations, but not RCRA Subtitle C standards) of the Nunes Parcel and institutional controls. Outside of the cap area, soil exceeding site-specific cleanup standards, as well as Pond I sediments and the soil peninsula associated with Pond I, will be excavated and consolidated under the cap. A building and other small structures on the property will also be removed and disposed of on-site. Mitigation will be carried out, as required, for environmentally-sensitive areas (wetlands and floodplain) altered. Riverbank restoration, along with appropriate erosion control measures, will be implemented as well as establishment of long-term monitoring and institutional controls. A site plan of the remedy is presented on Figure 7-5 and a conceptual cross-section of the proposed cover system is presented as Figure 7-6.

Table 7-3 presents a summary of this analysis.

7.2.2.2.1 Overall Protection of Human Health and the Environment

Implementation of this alternative has the potential to create short-term exposure risks to the community, workers, or the environment that would be managed with engineering controls, access restrictions, and worker training. Capping of the Nunes Parcel (meeting State Solid Waste ARARs) and institutional controls (i.e., deed restrictions) would generally protect against human and ecological exposure to contaminants in soil or waste, although the long-term protectiveness is in question because the cap will allow a greater amount of infiltration through the cap which may permit leaching of landfill contaminants into the groundwater and river. Because of this, the cap is not fully protective, because it will not meet protectiveness standards for the landfilling of hazardous waste. As this is a threshold criterion, Alternative NP-SO-2 is not considered to be fully protective of human health and the environment.

7.2.2.2.2 Compliance with ARARs

Tables I-7a, b, and c in Appendix I present the chemical-, location-, and action-specific ARARs for Alternative NP-SO-2, respectively. Compliance with chemical-specific ARARs (see Appendix I, Table I-7a) is achieved by capping of the Nunes Parcel and by removing or consolidating contaminated material above

remedial goals in soil outside of the planned cap. ICs will prevent activities that will disturb the capped material. Alternative NP-SO-2 complies with location-specific ARARs (see Appendix I, Table I-7b). The remedy implementation has the potential to encroach on existing wetlands, and remedial measures will be designed to mitigate adverse impacts on protected function and achieve no net loss. In addition, remedy implementation will need to avoid/minimize impacts to the federally-designated 100-year and 500-year floodplain (see Appendix G for floodplain map). An assessment of impacts to the 500-year floodplain is required for critical actions, which include siting hazardous waste facilities in a floodplain. Installation of a cap that can withstand a 500-year storm event may alter areas of 100-year floodplain and state jurisdictional wetlands, and perimeter land within 50 feet of wetlands. Mitigation measures, as required, will be taken to compensate for the resource areas altered by the cap.

Alternative NP-SO-3 would not comply with action-specific ARARs (see Appendix I, Table I-7c). As presented in Section 3.2.2.3, RCRA closure standards are relevant and appropriate based on the wastes disposed at the site. The cap proposed in this alternative does not comply with RCRA Subtitle C closure standards.

7.2.2.2.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence would not be fully achieved with Alternative NP-SO-2. The full RCRA Subtitle D cap of the Nunes Parcel and institutional controls would prevent access to contaminants in soil and waste but may not prevent the migration of landfill contaminants into groundwater and the river. Under State requirements, the construction of the RCRA Subtitle D cap includes the installation of a low permeability cover system to reduce the potential exposure pathway for contaminants in soil to leach to groundwater while the cap is in place and maintained, although the standards are not a protective as for hazardous waste landfills. Some flexibility with respect to the variety of shallow rooted native vegetation can be explored during the design of the final cap.

7.2.2.2.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

Alternative NP-SO-2 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in soil/waste.

7.2.2.2.5 Short-Term Effectiveness

Implementation of this alternative would result in short-term exposure risks to the community and workers that would be managed with engineering controls, including access restrictions, site-specific Health and Safety Plans, traffic control plans, and worker training. Installation of the RCRA Subtitle D cap on the Nunes Parcel could also result in significant impacts to environmental receptors due to removal of trees and vegetation on the landfill cap area. However, most of these impacts are considered short-term, as

appropriate shallow rooted native vegetation and ground cover will be applied on the cap and it is further expected that some areas of the riverbank and floodplain will either be re-vegetated and/or will return to a natural state on its own in 1 to 10 years. There may be longer-term impacts in areas where armoring is necessary to protect the cap. Potential impacts to environmental receptors would be managed through engineering controls. Engineering measures will be used to control potential fugitive dust, surface water runoff, erosion, and sedimentation during excavation and cap construction. Construction of the RCRA Subtitle D cap will require transporting cover materials to the site and due to the immediate proximity of the Providence and Worchester Railroad, coordinated shipments to and from the site conducted by rail may alleviate some local traffic concerns and emissions both on and within the vicinity of the site. Waste generated during remedial activities would be managed using approved methods.

7.2.2.2.6 Implementability

Implementation of this alternative is technically and administratively feasible, as the remedial technology is conventional and proven for these contaminants. Services and materials necessary for implementing the alternative are readily available. However, implementation will be challenging due to the amount of tree removal and clearing of vegetation required in order to meet RAOs and the limited access available relative to the volume of soil and materials that will be brought in to construct the cap. This alternative potentially offers flexibility with respect to native revegetation. Construction of the cap along the river will complicate construction, as well as long-term maintenance. Administratively, flood storage capacity mitigation may be required to account for cap thickness.

7.2.2.2.7 Cost

Table 7-3 and Appendix B present a summary of the present value calculations for Alternative NP-SO-2 and the detailed cost backup, respectively. Capital costs include implementation of institutional controls and construction of a full Subtitle D cap (compliant with RIDEM solid waste regulations) of the landfill. O&M costs include cap maintenance and institutional controls for 30 years. Costs associated with any potentially necessary property acquisitions related to floodplain compensation/mitigation have not been included in this FS.

Total capital costs are estimated to be approximately $4,808,000. Total annual O&M costs are estimated to be approximately $10,000 per year. Based on the EPA guidance, the total present value life cycle cost of Alternative NP-SO-2 using a discount rate of 7% for 30 years is $4,932,000 (EPA, 2000).

7.2.2.3 Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

The following sections present a detailed analysis of remediation action Alternative NP-SO-3 for soil and waste. Alternative NP-SO-3 includes a full RCRA Subtitle C cap of the Nunes Parcel, as shown on Figure 7-

5 and Figure 7-7, long-term monitoring, and institutional controls. Outside of the cap area, soil exceeding site-specific cleanup standards, as well as Pond I sediments and the soil peninsula associated with Pond I, will be excavated and consolidated under the cap. Mitigation will be carried out, as required, for environmentally-sensitive areas (wetlands and floodplain) altered. Riverbank restoration, along with appropriate erosion control measures, will be implemented as well as establishment of institutional controls.

Table 7-3 presents a summary of this analysis.

7.2.2.3.1 Overall Protection of Human Health and the Environment

Implementation of this alternative would potentially result in short-term exposure risks to the community, workers, or the environment during installation of the RCRA Subtitle C cap; these potential risks would be managed with engineering controls, access restrictions, and worker training. Installation of the RCRA Subtitle C cap will place a physical barrier between potential receptors and contaminants in soil and waste to reduce the potential exposure pathway and the potential for leaching of contaminants in soil to groundwater. Deed restrictions will be maintained to further reduce potential exposure pathways. Alternative NP-SO-3 would be protective of human health and the environment by permanently storing wastes in a protective containment facility, thereby eliminating potential exposure pathways.

7.2.2.3.2 Compliance with ARARs

Alternative NP-SO-3 complies with all state and federal chemical, location and action specific ARARs. Compliance with chemical-specific ARARs (see Appendix I, Table I-8a) is achieved by capping of the Nunes Parcel and by removing or consolidating contaminated material above remedial goals in soil outside of the planned cap. ICs will prevent activities that will disturb the capped material. Alternative NP-SO-3 complies with location-specific ARARs (see Appendix I, Table I-8b). The remedy implementation has the potential to encroach on existing wetlands, and remedial measures will be designed to mitigate adverse impacts on protected function and achieve no net loss. Alternative NP-SO-3 meets federal Clean Water Act standards to be considered the LEDPA. In addition, remedy implementation will need to avoid/minimize impacts to the federally-designated floodplain (see Appendix G for floodplain map). An assessment of impacts within the 500-year floodplain is required for critical actions, which include siting hazardous waste facilities in a floodplain. Installation of a RCRA C compliant cap that can withstand flooding, up to a 500-year storm event, may alter areas of 100-year floodplain and state jurisdictional wetlands, and perimeter land within 50 feet of wetlands. Mitigation measures, as required, will be taken to compensate for the resource areas altered by the cap. Alternative NP-SO-3 would comply with action-specific ARARs (see Appendix I, Table I-8c) during remedy construction and monitoring. In particular, relevant and appropriate hazardous waste landfill closure standards will be the primary standards used to design, construct and maintain the landfill cap. Groundwater and water quality monitoring standards will be used to confirm the long-term protectiveness of the capping alternative.

7.2.2.3.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence will be achieved through Alternative NP-SO-3. The RCRA Subtitle C cap reduces the potential exposure pathway and the potential for contaminants in soil to leach to groundwater while the cap is in place and maintained, although the impacted soil will remain under the cap. The cap will be constructed to meet performance standards to prevent the release of contaminants during flooding, up to a 500-year storm event, or through continued erosion by storm water over the long term.

7.2.2.3.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

Alternative NP-SO-3 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in soil/waste.

7.2.2.3.5 Short-Term Effectiveness

Implementation of this alternative would result in short-term exposure risks to the community and workers that would be managed with engineering controls, including access restrictions, site-specific Health and Safety Plans, traffic control plans, and worker training. Installation of the RCRA Subtitle C cap on the Nunes Parcel could also result in significant impacts to environmental receptors due to removal of all trees on the landfill cap area. However, most of these impacts are considered short-term, as appropriate shallow rooted native vegetation and ground cover will be applied on the cap, and it is further expected that some areas of the riverbank and floodplain will either be re-vegetated and/or will return to a natural state on its own in 1 to 10 years. There may be longer-term impacts in areas where armoring is necessary to protect the cap. Potential impacts to environmental receptors would be managed through engineering controls. Engineering measures will be used to control potential fugitive dust, surface water runoff, erosion, and sedimentation during excavation and cap construction. Construction of the RCRA Subtitle C cap will require transporting more significant volumes of materials to the site, creating potential short term risks to the community due to truck traffic, and potential risks to the environment from vehicle emissions. However, due to the immediate proximity of the Providence and Worchester Railroad, coordinated shipments to and from the site conducted by rail may alleviate some local traffic concerns and minimize emissions both on and within the vicinity of the site. Waste generated during remedial activities would be managed using approved methods.

7.2.2.3.6 Implementability

Implementation of this alternative is technically and administratively feasible, as the remedial technology is conventional and proven for these contaminants. Services and materials necessary for implementing the alternative are readily available. However, implementation will be challenging given the limited access available relative to the volume of soil and materials that will be brought in to construct the cap.

Construction of the cap along the river will complicate construction, as well as long-term maintenance. Administratively, flood storage capacity mitigation may be required to account for the cap thickness.

7.2.2.3.7 Cost

Table 7-3 and Appendix B present a summary of the present value calculations for Alternative NP-SO-3 and the detailed cost backup, respectively. Capital costs include implementation of institutional controls and construction of a full RCRA Subtitle C cap of the Nunes Parcel. O&M costs include cap maintenance and institutional controls for 30 years. Costs associated with any potentially necessary property acquisitions related to floodplain compensation/mitigation have not been included in this FS.

Total capital costs are estimated to be approximately $5,956,000. Total annual O&M costs are estimated to be approximately $10,000 per year. Based on the EPA guidance, the total present value life cycle cost of Alternative NP-SO-3 using a discount rate of 7% for 30 years is $6,080,000 (EPA, 2000).

7.2.3 Unnamed Island

The detailed analysis of source area soil and waste alternatives is intended to provide sufficient information to select the appropriate remedy for the Unnamed Island. Criteria for the analysis of alternatives and the remedy costs are based on existing data and knowledge of the site.

Three remedial alternatives for the Unnamed Island have been retained for detailed analysis. The detailed analysis of the remedial action alternatives is summarized in Table 7-4 and presented in the following sections. They are as follows:

- Alternative UI-SO-1: No Action
- Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls
- Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

7.2.3.1 Alternative UI-SO-1: No Action

The following sections present a detailed analysis of remedial action Alternative UI-SO-1 for source area soils and waste. Table 7-4 presents a summary of this analysis. This alternative is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

Under this alternative, no action would be taken to address soil and waste impacts.

7.2.3.1.1 Overall Protection of Human Health and the Environment

Although the No Action alternative does not incorporate any activities that would present significant exposure risks to the community, workers, or the environment, it would not reduce existing contaminant concentrations in soil or waste or provide measures to eliminate or control potential exposure pathways associated with possible future use of the site. Additionally, this alternative has the potential to allow contaminants to leach to groundwater and to migrate, potentially impacting downgradient surface water or other potential receptors. Therefore, the No Action alternative would not achieve soil or waste RAOs and is not protective of human health and the environment.

7.2.3.1.2 Compliance with ARARs

Alternative UI-SO-1 would not comply with state or federal chemical-specific ARARs (see Appendix I, Table I-9a) for soils or waste because no further action would be taken to control potential exposure pathways or address contaminant concentrations in soil or waste. There are no location- or action-specific ARARs for the No Action alternative.

7.2.3.1.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence would not be achieved through the No Action alternative because existing contaminant concentrations in soil and waste would not be addressed and institutional controls would not be implemented to eliminate or provide long-term control of potential exposure pathways. This alternative also has the potential to allow contaminants in soil and waste to leach to groundwater and to migrate, potentially impacting downgradient surface water or other receptors and could increase the eventual future capital and O&M expenditures if future remediation is required.

7.2.3.1.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

No treatment is being performed as part of this alternative; therefore, activities and subsequent evaluation surrounding reductions in mobility, toxicity, or impacted volume due to treatment processes will not be implemented.

7.2.3.1.5 Short-Term Effectiveness

This alternative does not implement any activities and, therefore, would not result in any exposure risks to the community, workers, or the environment during implementation of the alternative.

7.2.3.1.6 Implementability

The No Action alternative is technically feasible as no technical implementation is required, and would not limit or interfere with the ability to perform future remedial actions. However, the No Action alternative is unlikely to be administratively feasible due to the anticipated lack of monitoring and protection of human health and the environment.

7.2.3.1.7 Cost

Table 7-4 and Appendix B present a summary of the present value calculations for Alternative UI-SO-1 and the detailed cost backup, respectively. There are no capital or O&M costs associated with Alternative UI-SO-1. Total costs for this alternative are estimated to be approximately $0.

7.2.3.2 Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

The following sections present a detailed analysis of remediation action Alternative UI-SO-2 for soil and waste. As shown on Figure 7-8, Alternative UI-SO-2 includes removal of surface waste and of subsurface waste and shallow soils (0 to 2 feet bgs) where contaminants exceed PRGs. This material will be consolidated on-site under one of the two constructed caps. After soil and debris are removed, construction of a geotextile fabric and overburden stone cover for areas where contaminants exceed PRGs or waste remains at depths greater than 2 feet bgs and institutional controls would be implemented to help maintain the remedy. An equal volume of stone/boulders will replace the waste debris removed, so no net flood compensation would be required. A conceptual cross-section of Alternative UI-SO-2 is presented on Figure 7-9.

Table 7-4 presents a summary of this analysis.

7.2.3.2.1 Overall Protection of Human Health and the Environment

Implementation of this alternative would potentially result in short-term exposure risks to the community, workers, or the environment that would be managed with engineering controls and worker training. Waste and contaminants in shallow soils (0 to 2 feet bgs) would be permanently removed for on-site disposal in one of the landfills to be capped thereby eliminating the potential exposure pathway so long as the capped landfill is designed, constructed, and maintained in a manner to prevent any release of contaminants in the event of a flood, up to a 500-year flood event, and protected from further erosion. The construction and maintenance of a geotextile and riprap cover in areas with PRG exceedances at depths greater than 2 feet bgs will place a physical barrier between potential receptors and contaminants in soil to reduce the potential exposure pathway. However, the long-term protectiveness is questionable based on the potential for the

contaminants to migrate through the barrier, as the cover does not meet RCRA Subtitle C protectiveness standards. The cover also may not meet flood protection standards, requiring contamination to remain in place during flooding, up to a 500-year flood event. Therefore, Alternative UI-SO-2 is not considered to be fully protective of human health and the environment.

7.2.3.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Tables I-10a, b, and c in Appendix I present the chemical-, location-, and action-specific ARARs for Alternative UI-SO-2, respectively. Alternative UI-SO-2 will achieve the soil RAOs in soils from 0 to 2 feet bgs. This alternative will only meet state and federal chemical- and location-specific standards as long as the cover over remaining soils can withstand flooding, up to a 500-year storm event, without release of contamination. Based on the cover design, a release during flooding is likely, as there is no impermeable barrier layer in the cover. Furthermore, as presented in Section 3.2.2.3, RCRA closure standards are relevant and appropriate based on the wastes disposed at the site. The cover system proposed in this alternative does not comply with RCRA Subtitle C closure standards, nor meet the design, construction, and maintenance standards to prevent the release of contaminants either to surface waters (including during flooding events) and groundwater beyond the compliance boundary for the waste management area. Therefore, Alternative UI-SO-2 does not meet ARARs.

7.2.3.2.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence may not be achieved through Alternative UI-SO-2 because, based on the cover design, it is likely that a release from erosional forces over time and/or during flooding would occur as there is no impermeable barrier layer in the cover. Institutional controls will prevent activities that will disturb the cover material, and allow recreational, but not residential use. Permanent reduction of contaminant concentrations in soil will be achieved through excavation of shallow soils (up to 2 ft), which will eliminate the potential for direct contact with contaminants in soil by a receptor in these areas. The geotextile and riprap cover in areas with deeper soils will reduce the potential exposure pathway. Periodic maintenance and long-term monitoring will be required to maintain the required cover and institutional controls.

7.2.3.2.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

Alternative UI-SO-2 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in soil/waste, except to the extent that any water generated from the remedial action (i.e., from dewatering processes) may be treated before discharge back to the river.

7.2.3.2.5 Short-Term Effectiveness

Implementation of this alternative will result in short-term exposure risks to the community and workers that will be managed with engineering controls, including access restrictions, site-specific Health and Safety Plans, traffic control plans, and worker training. Implementation of this alternative could result in significant impacts to environmental receptors due to removal of vegetation and trees, likely habitat alternation, and erosion controls, such as heavy riprap, along the riverbank. However, some of these impacts are considered short-term, as limited habitat niches are expected to repopulate, and it is further expected that some areas of the riverbank and floodplain will either be re-vegetated with native species and/or will return to a natural state on its own in 1 to 10 years. There may be longer-term impacts or an alternation of habitat in areas with rip rap covering. Potential impacts to environmental receptors would be managed through engineering controls. Engineering measures will be used to control potential fugitive dust, surface water runoff, erosion, and sedimentation during excavation and cover construction. Waste generated during remedial activities would be managed using approved methods.

7.2.3.2.6 Implementability

Implementation of this alternative is both technically and administratively feasible, as the remedial technology is conventional and proven for these contaminants. Services and materials necessary for implementing the alternative are readily available. However, implementation will be challenging, as transportation of soils off the Unnamed Island and materials onto the Unnamed Island will require crossing a flood-prone river with heavy equipment and trucks. As the Unnamed Island is also subject to flooding, remedial activities will need to be conducted during periods where flooding is least likely to occur. The greater the volume of material requiring excavation and the larger the excavation, the longer the duration of the remedial activities and the more uncertainty there will be in the implementability of the remedy. There are also significant implementability issues with the use of the cover system within the floodplain to contain site contamination/debris below 2 feet.

7.2.3.2.7 Cost

Table 7-4 and Appendix B present a summary of the present value calculations for Alternative UI-SO-2 and the detailed cost backup, respectively. Capital costs include implementation of institutional controls, soil excavation, and construction of geotextile and riprap cover. O&M costs include cover maintenance and institutional controls for 30 years.

Total capital costs are estimated to be approximately $4,312,000. Total annual O&M costs are estimated to be approximately $5,000 per year. Based on the EPA guidance, the total present value life cycle cost of Alternative UI-SO-2 using a discount rate of 7% for 30 years is $4,374,000 (EPA, 2000).

7.2.3.3 Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

The following sections present a detailed analysis of remediation action Alternative UI-SO-3 for soil and waste. As shown on Figure 7-10, Alternative UI-SO-3 includes removal of all surface and buried waste and of soils where contaminants exceed PRGs (estimated to be up to 12 feet bgs) for on-site consolidation in one of the landfills to be capped. Although further pre-design sampling will be required, preliminary estimates are that 36,000 cy of soil and 40,000 cy of waste will require exaction and consolidation. A conceptual cross-section of Alternative UI-SO-3 is presented as Figure 7-11.

Table 7-4 presents a summary of this analysis.

7.2.3.3.1 Overall Protection of Human Health and the Environment

Implementation of this alternative would potentially result in short-term exposure risks to the community, workers, or the environment that would be managed with engineering controls and worker training. All waste and contaminants in soils would be removed, which would eliminate the potential exposure pathways. Therefore, Alternative UI-SO-3 would be protective of the environment by removing contaminant mass and meet RAOs once implemented.

7.2.3.3.2 Compliance with ARARs

Tables I-11a, b, and c in Appendix I present the chemical-, location-, and action-specific ARARs for Alternative UI-SO-3, respectively. This alternative complies with federal and state chemical, location and action specific ARARs. Alternative UI-SO-3 will achieve the soil and waste RAOs and chemical-specific ARARs by removing all contaminants that exceed risk levels established under state and federal standards and consolidating the material on-site under one of the landfill caps. This alternative would comply with location-specific ARARs by addressing impact on wetlands, floodplain, and fish and wildlife habitat through planning and decision-making regarding remedial alternatives and by taking mitigation measures, as required, to compensate for the resource areas altered by the excavation and cover expansion (at Nunes Parcel). Alternative UI-SO-3 meets federal Clean Water Act standards to be considered the LEDPA. The remedy will be designed and implemented in compliance with action-specific ARARs, in particular, standards for the handling of wastes and hazardous waste closure requirements.

7.2.3.3.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence will be achieved through Alternative UI-SO-3. Permanent elimination of contaminant concentrations in soil will be achieved through excavation of all soils exceeding PRGs and consolidating all waste into one of the on-site landfills to be capped, as long as the landfill is capped in a manner to withstand flooding and is protected from erosional forces over the long term.

7.2.3.3.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

Alternative UI-SO-3 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in soil/waste, except to the extent that any water generated from the remedial action (i.e., from dewatering processes) may be treated before discharge.

7.2.3.3.5 Short-Term Effectiveness

Implementation of this alternative will result in short-term exposure risks to the community and workers that will be managed with engineering controls, including access restrictions, site-specific Health and Safety Plans, traffic control plans, and worker training. Implementation of this alternative could result in significant impacts to environmental receptors due to removal of vegetation and trees and erosion controls along the riverbank. Alteration of some riverine habitat is a potential outcome. However, these impacts are considered short-term, as appropriate habitat niches are expected to repopulate. It is further expected that some areas of the riverbank and floodplain will be re-vegetated with native species and/or will return to a natural state on its own in 1 to 10 years. Potential impacts to environmental receptors would be managed through engineering controls. Engineering measures will be used to control potential fugitive dust, surface water runoff, erosion, and sedimentation during excavation. Waste generated during remedial activities would be managed using approved methods.

7.2.3.3.6 Implementability

Implementation of this alternative is both technically and administratively feasible, as the remedial technology is conventional and proven for these contaminants. Services and materials necessary for implementing the alternative are readily available. However, implementation will be challenging, as transportation of soils off the Unnamed Island will require crossing a flood-prone river with heavy equipment and trucks. As the Unnamed Island is also subject to flooding, remedy activities will need to be conducted during periods where flooding is least likely to occur. The greater the volume of material requiring excavation and the larger the excavation, the longer the duration of the remedy activities and the more uncertainty there will be in the implementability of the remedy. The lack of detailed information on the total volume of waste and impacted soil reduces the implementability of this remedy.

7.2.3.3.7 Cost

Table 7-4 and Appendix B present a summary of the present value calculations for Alternative UI-SO-3 and the detailed cost backup, respectively. Capital costs include soil excavation and waste removal. There are no O&M costs.

Total capital costs are estimated to be approximately $6,136,000. Based on the EPA guidance, the total present value life cycle cost of Alternative UI-SO-3 using a discount rate of 7% for 30 years is $6,136,000 (EPA, 2000).

7.3 Sediment Remedial Alternatives

The detailed analysis of pond sediment alternatives is intended to provide sufficient information to select the appropriate remedy. Ponds with sediment exceeding RAOs are shown on Figure 3-4. Criteria for the analysis of alternatives and the remedy costs are based on existing data and knowledge of the site. Note that sediments in Pond N and Pond I have been included as part of the presumptive approach actions for J.M. Mills Landfill and Nunes Parcel, respectively. The following evaluation applies to the Ponds on Unnamed Island (Ponds A, D, and E).

Four remedial alternatives for the pond sediments have been retained for detailed analysis. The detailed analysis of the remedial action alternatives is summarized in Table 7-5 and presented in the following sections. They are as follows:

- Alternative SE-1: No Action
- Alternative SE-2: Remove/Consolidate Sediment Exceeding PRGs
- Alternative SE-3: Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls
- Alternative SE-4: Subaqueous Cover (No Sediment Removal) with Institutional Controls

7.3.1 Alternative SE-1: No Action

The following sections present a detailed analysis of remedial action Alternative SE-1 for pond sediments. Table 7-5 presents a summary of this analysis. This alternative is retained for detailed analysis as required by the NCP as a baseline for evaluating the remaining alternatives.

Under this alternative, no action would be taken to address sediment impacts.

7.3.1.1 Overall Protection of Human Health and the Environment

Although the No Action alternative does not incorporate any activities that would present significant exposure risks to the community, workers, or the environment, it would not reduce existing contaminant concentrations in sediments or provide measures to eliminate or control potential exposure pathways

associated with possible future use of the site. The No Action alternative would not achieve sediment RAOs and is not protective of human health and the environment.

7.3.1.2 Compliance with ARARs

Alternative SE-1 would not comply with chemical-specific ARARs/TBCs (see Appendix I, Table I-12a) for sediments because no further action would be taken to control potential exposure pathways or address contaminant concentrations in sediment. There are no location- or action-specific ARARs for the No Action alternative.

7.3.1.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence would not be achieved through the No Action alternative because existing contaminant concentrations in sediments would not be addressed and institutional controls would not be implemented to eliminate or provide long-term control of potential exposure pathways.

7.3.1.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

No treatment is being performed as part of this alternative; therefore, activities and subsequent evaluation surrounding reductions in mobility, toxicity, or impacted volume due to treatment processes will not be implemented.

7.3.1.5 Short-Term Effectiveness

This alternative does not implement any activities and, therefore, would not result in any exposure risks to the community, workers, or the environment during implementation of the alternative.

7.3.1.6 Implementability

The No Action alternative is technically feasible, as no technical implementation is required, and would not limit or interfere with the ability to perform future remedial actions. However, the No Action alternative is unlikely to be administratively feasible due to the anticipated lack of monitoring and protection of the environment.

7.3.1.7 Cost

Table 7-5 and Appendix B present a summary of the present value calculations for Alternative SE-1 and the detailed cost backup, respectively. There are no capital or O&M costs associated with Alternative SE-1. Total costs for this alternative are estimated to be approximately $0.

7.3.2 Alternative SE-2: Remove/Consolidate Sediment Exceeding PRGs

The following sections present a detailed analysis of remediation action Alternative SE-2 for sediments. As shown on Figure 7-12, Alternative SE-2 includes removal of all sediments containing contaminants above the PRGs, dewatering of sediment, treatment of water generated from dewatering prior to a discharge location, and on-site consolidation at one of the landfills to be capped. Although pre-design testing (horizontal and vertical sediment characterization) will be required to confirm volumes, initial estimates are for removal of sediments to a depth of 2 feet over an area of approximately 5.4 acres (4.7 of which are in Pond A, the remainder in Ponds D and E), resulting in an approximate volume of 17,400 cubic yards. The 2 foot excavation depth was selected for costing purposes under the assumption that this constitutes an average depth over the several pond sediment areas exceeding PRGs. However, it is possible, due to the alleged site operations which included several dredging and filling operations on the island, and re-mixing and further deposition occurring over time, that the depth of the contaminated sediment may vary and could be deeper than 2 feet in several locations. Additional data collection would be required during design to establish excavation depths.

Table 7-5 presents a summary of this analysis.

7.3.2.1 Overall Protection of Human Health and the Environment

Implementation of this alternative would potentially result in short-term exposure risks to the community, workers, or the environment that would be managed with engineering controls and worker training. Contaminants in sediments will be permanently removed, which will eliminate the potential exposure pathway to this media. Therefore, Alternative SE-2 would be protective of human health and the environment by removing contaminant mass for on-site consolidation at one of the landfills to be capped thereby eliminating potential exposure pathways if the capped landfill is capped in a manner to withstand a flooding event and protected from erosion.

7.3.2.2 Compliance with ARARs

Tables I-13a, b, and c in Appendix I present the chemical-, location-, and action-specific ARARs for Alternative SE-2, respectively. This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk by removing all contaminated sediments that exceed PRGs. Remedial measures will be designed to mitigate adverse impacts on protected wetland function and achieve no net loss. In addition, remedy implementation will need to minimize impacts within the federally-designated 100-year and 500-year floodplain (see Appendix G for floodplain map). An assessment of impacts to the 500-year floodplain is required for critical actions, which include siting hazardous waste facilities (the onsite landfills which will contain the sediments) in a floodplain. Mitigation measures, as required, will be taken to compensate for the resource areas altered by cap expansion performed to accommodate the sediment.

The removal would be performed in compliance with appropriate location- and action-specific ARARs, including standards for dredging and the testing/treatment of any water generated from the dewatering process prior to discharge. Therefore, Alternative SE-2 would comply with state and federal chemical-, location- and action-specific ARARs.

7.3.2.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence will be achieved through Alternative SE-2. Permanent reduction of contaminant concentrations in sediment will be achieved through excavation, which will eliminate the potential for direct contact with contaminants in sediment by a receptor and consolidation in capped landfill(s).

7.3.2.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

Alternative SE-2 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in sediment, except for the potential treatment of water generated by dewatering prior to discharge and any potential addition of bulking agents to the sediments prior to consolidation under the landfill cap(s).

7.3.2.5 Short-Term Effectiveness

Implementation of this alternative will result in short-term exposure risks to the community and workers that will be managed with engineering controls and worker training. Implementation of this alternative could result in significant impacts to environmental receptors due to removal of trees and brush near the excavation areas and likely suspension of sediment within the ponds. Potential impacts to environmental receptors would be managed through engineering controls. No O&M activities would be needed once sediment removal is complete. No statutory 5-year review would be needed. Waste generated during remedial activities would be managed using approved methods.

7.3.2.6 Implementability

Implementation of this alternative is both technically and administratively feasible, as the remedial technology is conventional and proven for these contaminants and services and materials necessary for implementing the alternative are readily available. However, implementation will be challenging, as excavation and transportation of sediments from the Unnamed Island will require crossing a flood-prone river with heavy equipment and trucks. As the Unnamed Island is also subject to flooding, remedial activities will need to be conducted during periods where flooding is least likely to occur. The greater the volume of material requiring removal, the longer the duration of the remedial activities and the more uncertainty there will be with the implementability of the remedy.

7.3.2.7 Cost

Table 7-5 and Appendix B present a summary of the present value calculations for Alternative SE-2 and the detailed cost backup, respectively. Capital costs include sediment removal. Once sediment removal is complete, the RAOs have been met and no O&M is needed.

Total capital costs are estimated to be approximately $8,120,000. Based on the EPA guidance, the total present value life cycle cost of Alternative SE-2 using a discount rate of 7% for 30 years is $8,120,000 (EPA, 2000).

7.3.3 Alternative SE-3: Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

The following sections present a detailed analysis of remediation action Alternative SE-3 for sediment. As shown on Figure 7-13, Alternative SE-3 includes excavation of sediment (0-1 ft) exceeding ecological PRGs (approx. 8,700 cu. yds.), dewatering of excavated sediments with potential treatment of the water generated prior to discharge, placement of a subaqueous cover comprised of sediment/substrate engineered with amendments, as necessary, to limit migration of any remaining contaminants in areas where PRG exceedances remain, consolidation in one of the on-site landfills to be capped, long-term monitoring and institutional controls. Horizontal and vertical sediment characterization in the ponds would be performed during pre-design to further define contamination extents. If the difference in dredged volume is relatively small, additional dredging could be performed to reduce or potentially eliminate the need for a subaqueous cover and future maintenance. Additional studies would be performed during pre-design to evaluate the hydrodynamics of the ponds, as this information would be utilized during subaqueous cover design.

Table 7-5 presents a summary of this analysis.

7.3.3.1 Overall Protection of Human Health and the Environment

Implementation of this alternative would potentially result in short-term exposure risks to the community, workers, or the environment that would be managed with engineering controls and worker training. Contaminants in the top one foot of sediments would be removed, which would eliminate the potential exposure pathway in these areas. The construction and maintenance of a subaqueous cover in areas where PRG exceedances are not fully removed will place a physical barrier between potential receptors and contaminants in sediment to reduce the potential exposure pathway. Additional supplements may be added to the cap material, to be determined as part of the remedial design, to enhance the barrier to further prevent contaminant migration. Deed restrictions will be implemented to assist in maintaining the remedy. Therefore, Alternative SE-3 would be protective of human health and the environment by reducing potential

exposure pathways as long as both the subaqueous cover (for remaining sediment) and landfill caps can prevent future erosion or washout of contaminated material during flooding, up to a 500-year flood event.

7.3.3.2 Compliance with ARARs

Tables I-14a, b, and c in Appendix I present the chemical-, location-, and action-specific ARARs for Alternative SE-3, respectively. This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk by removing the top foot of contaminated sediments that exceed PRGs, dewatering, treatment of water generated prior to discharge, disposing of the sediment in one of the on-site landfills to be capped and adding a foot of clean material over remaining deeper contaminated sediments. The subaqueous cover would be comprised of sediment/substrate engineered with amendments, as necessary, to limit migration of any remaining contaminants in areas where PRG exceedances remain. Remedial measures will be designed to mitigate adverse impacts on protected wetland function and achieve no net loss. Alternative SE-3 meets federal Clean Water Act standards to be determined to be the LEDPA. In addition, remedy implementation will need to minimize impacts within the federally-designated 100-year and 500-year floodplain (see Appendix G for floodplain map). An assessment of impacts to the 500-year floodplain is required for critical actions, which include siting hazardous waste facilities (the onsite landfills which will contain the sediments) in a floodplain. Mitigation measures, as required, will be taken to compensate for the resource areas altered by cap expansion performed to accommodate the sediment. The remedial actions would be performed in compliance with appropriate location- and action-specific ARARs, including standards for wetland dredging/filling and the testing/treatment of any water generated from the dewatering process prior to discharge. Therefore, Alternative SE-3 will comply with chemical, location-, and action-specific ARARs.

7.3.3.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence is expected to be achieved through Alternative SE-3. Permanent reduction of contaminant concentrations in the surface sediment is expected to be achieved through excavation, which is expected to eliminate the potential for direct contact with contaminants in sediment by a receptor in these areas. The clean fill cover in areas where sediments with contaminants exceeding PRGs are not completely removed is expected to reduce the potential exposure pathway. Similar to other cover systems, long-term monitoring and routine maintenance will be periodically required. In addition, the use of amendments along with standard cover materials will be evaluated during the remedial design phase to determine if protectiveness (related to future potential erosion) can be improved in a cost-effective manner.

7.3.3.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

Alternative SE-3 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in sediment, except for any treatment of dewatering water and the addition of any bulking agents to the dredged sediment prior to consolidation under the cap(s).

7.3.3.5 Short-Term Effectiveness

Implementation of this alternative will result in short-term exposure risks to the community and workers, which will be managed with engineering controls and worker training. Implementation of this alternative could result in significant impacts to environmental receptors due to removal of trees and brush near the excavation areas and likely suspension of sediment within the ponds. Potential impacts to environmental receptors would be managed through engineering controls. Waste generated during remedial activities would be managed using approved methods.

7.3.3.6 Implementability

Implementation of this alternative is both technically and administratively feasible, as the remedial technology is conventional and proven for these contaminants. Services and materials necessary for implementing the alternative are readily available. However, implementation will be challenging, as excavation and transportation of sediments from the Unnamed Island and materials onto the Unnamed Island will require crossing a flood-prone river with heavy equipment and trucks. As the Unnamed Island is also subject to flooding, remedial activities will need to be conducted during periods where flooding is least likely to occur. The greater the volume of material requiring removal and transport to the Unnamed Island, the longer the duration of the remedial activities and the more uncertainty there will be with the implementability of the remedy. Placement of the cover materials will also be difficult, but can be managed using the proper equipment and procedures. Use of amendments in the subaqueous cover, if determined to be cost-effective, may reduce challenges associated with cover maintenance.

7.3.3.7 Cost

Table 7-5 and Appendix B present a summary of the present value calculations for Alternative SE-3 and the detailed cost backup, respectively. Capital costs include implementation of institutional controls, sediment removal, and placement of a clean fill subaqueous cover. O&M costs include cover maintenance and institutional controls for 30 years.

Total capital costs are estimated to be approximately $5,103,000. Total annual O&M costs are estimated to be approximately $50,000 per year. Based on the EPA guidance, the total present value life cycle cost of Alternative SE-3 using a discount rate of 7% for 30 years is $5,804,000 (EPA, 2000).

7.3.4 Alternative SE-4: Subaqueous Cover (No Sediment Removal) with Institutional Controls

The following sections present a detailed analysis of remediation action Alternative SE-4 for sediments. As shown on Figure 7-14, Alternative SE-4 includes placement of a subaqueous cover comprised of sediment/substrate engineered with amendments, as necessary, to limit migration of contaminants in areas of PRG exceedances as well as institutional controls to assist in maintaining the remedy. Additional studies would be performed during pre-design to evaluate the hydrodynamics of the ponds, as this information would be utilized during subaqueous cover design.

Table 7-5 presents a summary of this analysis.

7.3.4.1 Overall Protection of Human Health and the Environment

Implementation of this alternative would potentially result in short-term exposure risks to the community, workers, or the environment that would be managed with engineering controls and worker training. The construction and maintenance of a subaqueous cover in areas with PRG exceedances will place a physical barrier between potential receptors and contaminants in sediment to reduce the potential exposure pathway. Deed restrictions will be implemented to assist in maintaining the remedy. Therefore, Alternative SE-4 would be protective of human health and the environment by reducing potential exposure pathways if the subaqueous cover (including amendments, if necessary) can prevent future erosion or washout of contaminated material during flooding, up to a 500-year flood event.

7.3.4.2 Compliance with ARARs

Tables I-15a, b, and c in Appendix I present the chemical-, location-, and action-specific ARARs for Alternative SE-4, respectively. This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk by placing a one-foot subaqueous cover over contaminated sediments. The subaqueous cover would be comprised of sediment/substrate engineered with amendments, as necessary, to limit migration of covered contaminants in the event flooding, up to a 500-year flood event. Remedial measures will be designed to mitigate adverse impacts on protected wetland function and achieve no net loss. In addition, remedy implementation will need to minimize impacts within the federally-designated 100-year and 500-year floodplain (see Appendix G for floodplain map). Mitigation measures, as required, will be taken to compensate for the resource areas and any flood storage capacity altered by the remedy. The remedial actions would be performed in compliance with appropriate regulatory requirements. Therefore, Alternative SE-4 will comply with chemical, location-, and action-specific ARARs.

7.3.4.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence is expected to be achieved through Alternative SE-4. The subaqueous cover is expected to reduce the potential exposure pathway while the cover is in place and maintained, although the impacted sediments will stay in place. Similar to other cover systems, routine maintenance will be periodically required. In addition, the use of amendments along with standard cover materials will be evaluated during the remedial design phase to determine if protectiveness (related to future potential erosion) can be improved in a cost-effective manner.

7.3.4.4 Reduction of Mobility, Toxicity, or Volume Through Treatment

Alternative SE-4 does not involve treatment processes to reduce contaminant mobility, toxicity, or volume of contaminants in sediment.

7.3.4.5 Short-Term Effectiveness

Implementation of this alternative will result in short-term exposure risks to the community, environment, and workers that will be managed with engineering controls and worker training. Engineering measures will be used to control potential fugitive dust, surface water runoff, erosion, and sedimentation during cover construction. Waste generated during remedial activities would be managed using approved methods. There is the potential for loss of ecological habitat in shallower zones when placing the cover without prior excavation (the cover may extend above the waterline). Any reduction in flood storage capacity due to the use of cover materials will be mitigated elsewhere on site.

7.3.4.6 Implementability

Implementation of this alternative is both technically and administratively feasible, as the remedial technology is conventional and proven for these contaminants. Services and materials necessary for implementing the alternative are readily available. However, implementation will be challenging, as transportation of materials onto the Unnamed Island will require crossing a flood-prone river with heavy equipment and trucks. Use of amendments in the subaqueous cover, if determined to be cost-effective, may reduce challenges associated with cover maintenance.

7.3.4.7 Cost

Table 7-5 and Appendix B present a summary of the present value calculations for Alternative SE-4 and the detailed cost backup, respectively. Capital costs include implementation of institutional controls and placement of a subaqueous cover. O&M costs include cover maintenance and institutional controls for 30

years. Costs associated with any potentially necessary property acquisitions related to flood storage compensation/mitigation have not been included in this FS.

Total capital costs are estimated to be approximately $2,883,000. Total annual O&M costs are estimated to be approximately $50,000 per year. Based on the EPA guidance, the total present value life cycle cost of Alternative SE-4 using a discount rate of 7% for 30 years is $3,584,000 (EPA, 2000).

8. Comparative Analysis of Alternatives

The development of remedial action alternatives has followed the process below:

- Identification of RAOs and requirements for remediation (Section 3).
- Identification and screening of applicable technologies and formulation of remedial action alternatives for groundwater, source area soils and waste, and sediments (Sections 4 through 6).
- Individual analysis of remedial action alternatives for groundwater, source area soils and waste, and sediments (Section 7).

The identification of and selection of the preferred remedial action alternative are based on consideration of the major trade-offs among the alternatives in terms of the nine evaluation criteria. The EPA has categorized the evaluation criteria into three groups:

- *Threshold Criteria* – The selected remedial action alternative must be protective of human health and the environment and comply with ARARs. Therefore, the EPA has designated overall protection of human health and the environment and compliance with ARARs as the two threshold criteria. Absent an appropriate case for a waiver of some ARARs, an alternative must meet both criteria to be eligible for selection as the remedial action alternative.
- *Balancing Criteria* – The five primary balancing criteria are long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. This balancing provides a preliminary assessment of the maximum extent to which permanent solutions and treatment can be used practicably in a cost-effective manner. The alternative that is protective of human health and the environment, complies with the ARARs, and affords the most favorable balancing criteria is identified as the preferred remedial action alternative.

- *Modifying Criteria* – State and community acceptance are factored into a final evaluation that determines which remedial action alternatives are acceptable. As stated at the beginning of Section 7, state and community acceptance will be addressed after comments to this FS have been received.

A comparative analysis of the remedial action alternatives for groundwater, source area soils and waste, and pond sediments are presented using the threshold and balancing evaluation criteria in Sections 8.1 through 8.3.

8.1 Comparative Analysis of Remedial Alternatives for Groundwater

A summary of the individual analysis of the groundwater remedial action alternatives is presented in Table 8-1. This section provides a comparative analysis of the expected performance of each alternative relative to the other alternatives to identify their respective advantages and disadvantages.

8.1.1 Overall Protection of Human Health and the Environment

Alternative GW-1 is not protective because it does not address risks posed by contaminated groundwater within the OU. Alternative GW-1 will not provide measures to eliminate or control potential migration of contaminants in groundwater. Alternative GW-2 will achieve the RAOs identified for groundwater once ICs are established and a groundwater monitoring plan is implemented. Alternative GW-2 is protective of human health and the environment by limiting potential exposure pathways through the implementation of institutional controls and by ensuring contaminated groundwater from the Site does not migrate beyond the compliance boundary for the waste management area or into the river at levels which would exceed performance standards identified in the ROD.

8.1.2 Compliance with ARARs

Alternative GW-1 does not meet ARARs or risk-based standards for addressing contaminated groundwater because no action would be taken to control potential exposure pathways or address contaminant concentrations in groundwater consistent with the requirements of the Safe Drinking Water Act Maximum Contaminant Levels and the Rhode Island Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases. Alternative GW-2 meets all ARARs requirements through ICs and long-term monitoring. ARARs and risk-based Performance Standards will be used to ensure that groundwater contamination is not migrating beyond the compliance boundary for the waste management area or into the river at levels which would exceed performance standards to be identified in the ROD. ICs within the compliance boundary of the waste management area established for the soil remedy will prevent use of contaminated groundwater that exceeds PSs.

8.1.3 Long-Term Effectiveness and Permanence

Alternative GW-1 would provide the least long-term effectiveness because there would be no controls to limit potential exposure to contaminants in groundwater or monitoring to indicate when PSs have been reached. Alternative GW-2 will be more effective than Alternative GW-1 because institutional controls will limit potential exposure to contaminants in groundwater and site-wide groundwater monitoring will verify when Performance Standards are not being exceeded outside of the compliance boundary and in the river.

8.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Neither of the alternatives involves treatment processes.

8.1.5 Short-Term Effectiveness

Alternative GW-1 is the most effective at attaining short-term results with minimal risks, as there would not be any activities to implement and, therefore, no potential exposure risks. Alternative GW-2 would permanently require limited activities (long-term groundwater monitoring), which would result in minor short-term exposure risks to workers, the community, or the environment. These activities would be managed through engineering controls and worker training.

8.1.6 Implementability

Alternative GW-1 requires no implementation and involves no O&M. Alternative GW-2 is also highly implementable, although there may be administrative impediments with establishing ICs on buffer zone properties surrounding the OU. For evaluation purposes, it is assumed that O&M will be required for up to 30 years.

Alternative GW-1 is unlikely to be administratively feasible because there will be no controls on potential exposure pathways or monitoring of contaminant concentrations in groundwater. Alternative GW-2 is administratively feasible because potential exposure pathways will be limited and groundwater concentrations will be monitored.

8.1.7 Cost

Alternative GW-1, with no cost, is the most economical option. Alternative GW-2, estimated to cost $671,000, is still economical, with monitoring costs spread over 30 years.

8.2 Comparative Analysis of Remedial Alternatives for Source Areas

8.2.1 J.M. Mills Landfill

A summary of the individual analysis of the source area remedial action alternatives for the J.M. Mills Landfill is presented in Table 8-2. This section provides a comparative analysis of the expected performance of each alternative relative to the other alternatives to identify their respective advantages and disadvantages.

8.2.1.1 Overall Protection of Human Health and the Environment

The HHRA presumed that the J.M. Mills Landfill will be capped to eliminate exposure to the contaminant-impacted waste in these areas. Physical hazards associated with debris fields were also noted that are required to be addressed under landfill closure standards. In addition, the BERA indicated potential ecological risks to birds exposed to floodplain soils near the J.M. Mills Landfill. Alternative JM-SO-1 is not protective as no action would be taken to control exposure to or reduce concentrations in landfill waste, debris fields, and floodplain soils. JM-SO-2 is protective since it addresses current and potential future exposure risks through restricting exposure to landfill waste and other contaminated media (through consolidation, containment and institutional controls). Only alternative JM-SO-2, which includes a RCRA Subtitle C cap over the entire J.M. Mills Landfill, will be fully protective of human health and the environment by placing a physical barrier between potential receptors and contaminated materials in soil and waste, reducing the infiltration and the potential for leaching of contaminants in soil to groundwater, fully addressing potential landfill gas releases, and ensuring that contamination is not eroded or washed out of the J.M. Mills Landfill during any flood, up to a 500-year event. JM-SO-3 is not protective because it does not establish a completely protective physical barrier between potential receptors and contaminated materials in soil and waste, does not fully reduce the infiltration and the potential for leaching of contaminants in soil to groundwater, does not fully address potential landfill gas releases, and does not ensure that contamination is not eroded or washed out of the J.M. Mills Landfill during any flood, up to a 500-year event.

8.2.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative JM-SO-1, No Action, will not meet state or federal ARARs related to addressing site risks or cleanup standards because no action would be taken to control potential exposure pathways or address contaminant concentrations in soil or waste. Alternative JM-SO-2 will fully meet all landfill state and federal closure ARARs, as well as all other chemical, location, and action-specific ARARs standards by capping of the J.M. Mills Landfill (RCRA Subtitle C cap on entire landfill) and by removing or consolidating contaminated material above remedial goals in soil along the riverbank and floodplain. Alternative JM-SO-3 (hybrid cap) does not fully meet chemical-specific, location-specific, or action-specific ARARs, because the soil portion of the cap may not prevent the release of contaminants in the event of a flood, up to a 500-year storm event that would alter areas of floodplains and state and federal jurisdictional wetlands. Further, the

soil portion of the cap does not meet Rhode Island closure standards and does not comply with RCRA Subtitle C standards throughout the entirety of the cap. The proposed cover also will not allow for landfill gas control standards to be achieved. As a result, Alternative JM-SO-2 is the only alternative that can be designed and implemented to comply with applicable state and federal ARARs. In addition, Alternative JM-SO-2 meets federal Clean Water Act standards to be determined to be the Least Environmentally Damaging Practicable Alternative, because it provides the best balance of addressing contaminated soil/debris within and adjacent to wetlands and waterways with minimizing both temporary and permanent alteration of wetlands and aquatic habitats on site. Alternative JM-SO-2 will also meet TSCA regulatory standards by addressing soils contaminated with PCBs in order to control risk of injury to health or the environment, through excavation of soil exceeding 10 parts-per-million (ppm) and consolidation under the constructed caps.

8.2.1.3 Long-Term Effectiveness and Permanence

Alternative JM-SO-1 would provide the least long-term effectiveness because there would be no controls to limit exposure to contaminants in soil or waste. Alternative JM-SO-2 is the only alternative that will address risks associated with hazardous waste and hazardous substance disposal by installation of a full RCRA Subtitle C cap which places a physical barrier between potential receptors and contaminated materials in soil and waste over the entire source area, further reduces the infiltration and the potential for leaching of contaminants in soil to groundwater, addresses landfill gas releases, and ensures that contamination is not eroded or washed out along the side slopes of the J.M. Mills Landfill during a flood, up to a 500-year storm event. Alternative JM-SO-2 will be protective of the environment by containing the contaminant mass and eliminating potential exposure pathways. While both Alternatives JM-SO-2 and JM-SO-3 implement deed restrictions to control land use to further protect the integrity of the cap, unlike Alternative JM-SO-2, long-term effectiveness and permanence will not be achieved through Alternative JM-SO-3 because the soil portion of the cap does not meet RCRA Subtitle C performance standards, and may not prevent the release of contaminants in the event of a flood, up to a 500-year storm event or through continued erosion of the side slopes (if not properly maintained) over the long term.

8.2.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

None of the alternatives involve treatment processes.

8.2.1.5 Short-Term Effectiveness

No short-term impacts to the local community, on-site remedial workers or the environment will occur under Alternative JM-SO-1. The soil removal activities in the active remedial alternatives (JM-SO-2 and JM-SO-3) are the same and, therefore, the short-term exposure risks to workers, the community, or the environment

from soil removal are equal for these alternatives. The soil removal activities will be managed through engineering controls and worker training.

Both of the remaining presumptive approach alternatives (JM-SO-2 and JM-SO-3) include removal of all trees, clearing and grubbing of the vegetation, and extensive regrading of the J.M. Mills Landfill prior to construction of a cap and the areas of the riverbank and floodplain where soil removal will occur that will create short-term exposure risks to workers, the community, or the environment. During implementation, engineering measures will be used to restrict access, control potential air emissions, fugitive dust, or surface water runoff. Comparatively, Alternative JM-SO-2 will require a higher volume of materials to be brought onsite. While Alternative JM-SO-3 may present a lesser impact to the traffic in the surrounding community through reduced materials handling, use of the active rail system may also reduce traffic impacts for both JM-SO-2 and JM-SO-3.

8.2.1.6 Implementability

Alternative JM-SO-1 is simple to implement and involves no O&M. For the capping alternatives (JM-SO-2 and JM-SO-3), the location and protection of the caps along the riverbank will present a significant technical challenge. Each alternative requires phased design/construction planning elements, large quantities of material handling, and there are known space and access limitations that may interfere with construction of either cap. Both are equal in that each includes the removal, clearing and grubbing of the vegetation, and regrading of the landfill (prior to capping) and the areas of the riverbank and floodplain where soil removal will occur. Alternative JM-SO-2 may be more difficult to implement than JM-SO-3, because there is a larger impermeable cap area and larger volumes of material to manage in building a full RCRA Subtitle C cap than is required for a hybrid cap.

Alternative JM-SO-1 is likely to be administratively feasible, but most likely not acceptable because there will be no controls on potential exposure pathways or the potential leaching of contaminants in soil to groundwater. Alternatives JM-SO-2 and JM-SO-3 are both administratively feasible, but similar to JM-SO-1, JM-SO-3 (hybrid cap) is most likely not acceptable in that this alternative does not fully meet protectiveness standards or ARARs.

Alternative JM-SO-3 is easier to implement than Alternative JM-SO-2 given the lower volume of materials required to construct the cover and the proportionally lower truck traffic through the surrounding community. The smaller footprint of the geosynthetics for Alternative JM-SO-3 reduces the complexity of construction. However, steepness of slope and soil cover stability along the side slopes in both the short- and long-term is a factor which may further complicate implementability for JM-SO-3; while constructing JM-SO-2 may be more difficult, it may be the most stable over the long-term because it is designed to withstand a flood up to a 500-year storm event.

8.2.1.7 Cost

The most economical option is Alternative JM-SO-1, at no cost. Alternative JM-SO-2 is the most costly alternative with a present worth cost estimate of $21,559,000. JM-SO-3 presents a lower cost of $13,721,000. The capital costs presented for JM-SO-2 and JM-SO-3 may increase based on design constraints, such as working alongside a new railroad spur and protecting the cover against river flooding, but these additional costs are expected to be within the margin of error expected in the FS stage.

8.2.2 Nunes Parcel

A summary of the individual analysis of the source area remedial action alternatives for the Nunes Parcel is presented in Table 8-3. This section provides a comparative analysis of the expected performance of each alternative relative to the other alternatives to identify their respective advantages and disadvantages.

8.2.2.1 Overall Protection of Human Health and the Environment

Alternative NP-SO-1 (No Action) is not protective because it will not reduce existing contaminant concentrations in soil or provide measures to eliminate or control potential exposure pathways to soil or waste.

As indicated in Table 8-3, Alternative NP-SO-2 is not fully protective because it will not meet protectiveness standards for the landfilling of hazardous waste. NP-SO-3 is protective because it will achieve the RAOs for soil and waste which provide overall protection of human health and the environment by meeting the protective requirements for the hazardous waste cap.

8.2.2.2 Compliance with ARARs

Alternative NP-SO-1, No Action, does not meet state or federal ARARs, as impacted soils and waste remain in place and are not capped; site risks would not be addressed and cleanup standards would not be achieved. Alternative NP-SO-2 does not comply with RCRA Subtitle C closure standards. Alternative NP-SO-3 attains state and federal RCRA Subtitle C landfill closure ARARs, as well as all other identified chemical, location, and action-specific ARARs. In addition, Alternative NP-SO-3 meets federal Clean Water Act standards to be the LEDPA, because it provides the best balance of addressing contaminated soil/debris within and adjacent to wetlands and waterways with minimizing both temporary and permanent alteration of wetlands and aquatic habitats on site.

8.2.2.3 Long-Term Effectiveness and Permanence

Alternative NP-SO-1 would provide the least long-term effectiveness because there would be no controls to limit exposure to contaminants in soil or waste, nor would it control the potential for contaminants in soil/waste to leach to groundwater. Alternatives NP-SO-2 and NP-SO-3 are the most effective alternatives in the long-term. These two alternatives would be nearly equally effective and permanent because the landfill caps will equally reduce potential exposure pathways, however, the cap in Alternative NP-SO-2 would allow more infiltration to occur through the cap, thereby allowing for potentially more leachate to be generated via waste contact. Lastly, both caps will be constructed to meet performance standards to prevent the release of contaminants in the event of a flood, up to a 500-year storm event or through continued erosion by storm water over the long term.

8.2.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

None of the alternatives involve treatment processes.

8.2.2.5 Short-Term Effectiveness

Alternative NP-SO-1 is the most effective at attaining short-term results with minimal risks because there will be no activities to implement and, therefore, no exposure risks.

Both NP-SO-2 and NP-SO-3 include construction of a landfill cap, which includes removal of vegetation, grubbing and regrading that will create short-term exposure risks to workers, the community, or the environment. During implementation, engineering measures will be used to control potential air emissions, fugitive dust, or surface water runoff. Comparatively, Alternative NP-SO-3 will create the highest potential risk to the community, workers, or environment due to the greater volume of materials to be brought onsite and increased amount of labor needed to construct the cap. Alternative NP-SO-2 will require a lower volume of materials and less labor to construct and, therefore, create a lower potential risk to the community, workers, or the environment. In either case, if the active rail system is used, risks to the community and the environment due to the high volume of materials to be brought onsite may be lowered through reduced traffic and emissions.

8.2.2.6 Implementability

Alternative NP-SO-1 involves no implementation and no O&M. Alternative NP-SO-1 is likely to be administratively feasible, but most likely not acceptable because there will be no controls on potential exposure pathways or the potential leaching of contaminants in waste/soil to groundwater. Alternative NP-SO-2 is a less-complicated remedy to implement than Alternative NP-SO-3 due to smaller volumes of material and a simpler design. Both caps (Alternatives NP-SO-2 and NP-SO-3) will require

protection/armoring against flooding of the Blackstone River which will not be simple to design. In addition, inclusion of the soils/sediments around Pond I will increase the difficulty of implementation.

8.2.2.7 Cost

The most economical option is Alternative NP-SO-1, at no cost. Alternative NP-SO-2 is estimated to cost $4,932,000. Alternative NP-SO-3 is the most costly alternative with a present worth cost estimate of $6,080,000. The capital costs presented for JM-SO-2 and JM-SO-3 may increase based on design constraints, such as protecting the cover against river flooding and inclusion of soils/sediments associated with Pond I, but these additional costs are expected to be within the margin of error expected in the FS stage.

8.2.3 Unnamed Island

A summary of the individual analysis of the source area remedial action alternatives for the Unnamed Island is presented in Table 8-4. This section provides a comparative analysis of the expected performance of each alternative relative to the other alternatives to identify their respective advantages and disadvantages.

8.2.3.1 Overall Protection of Human Health and the Environment

Alternative UI-SO-1 will not reduce existing contaminant concentrations in soil or provide measures to eliminate or control potential exposure pathways to soil or waste.

Alternative UI-SO-2 might achieve the RAOs for soil and waste and provide overall protection of human health and the environment if a protective cover can be designed, constructed and maintained to prevent any release of contaminants in the event of a flood, up to a 500-year event. The protectiveness of the cover is also questionable related to any hazardous substances/materials/wastes which may exist on the Unnamed Island, as the cover is does not meet RCRA Subtitle C protectiveness standards. UI-SO-3 will achieve all RAOs for soil and waste and be protective of human health and the environment because all contaminated soil and waste will be removed from the Unnamed Island. Alternative UI-SO-3 will achieve RAOs in the shortest timeframe by removal of all waste and soil exceeding PRGs thereby eliminating the need to implement institutional controls and to perform O&M on the cover placed over the soil and waste deposits under Alternative UI-SO-2.

8.2.3.2 Compliance with ARARs

Alternative UI-SO-1, No Action, does not meet ARARs, as impacted soils remain in place and potential exposure pathways are not controlled. Alternative UI-SO-2 will achieve the soil RAOs in soils from 0 to 2 feet bgs, but any remaining contaminants below 2 feet would not meet chemical- and location-specific

ARARs, as the cover design does not protect against the release of contaminants through continued leaching or during a flood event because there is no impermeable barrier layer in the cover. Furthermore, Alternative UI-SO-2 would not comply with RCRA Subtitle C closure requirements. Alternative UI-SO-3 would attain all state and federal ARARs by removing all contaminants that exceed risk levels established under state and federal standards and consolidating the material on-site under one of the landfill caps. In addition, Alternative UI-SO-3 meets federal Clean Water Act standards to be the LEDPA, because it provides the best balance of addressing contaminated soil/debris within and adjacent to wetlands and waterways with minimizing both temporary and permanent alteration of wetlands and aquatic habitats on site.

8.2.3.3 Long-Term Effectiveness and Permanence

Alternative UI-SO-1 would provide the least long-term effectiveness because there would be no controls to limit exposure to contaminants in soil or waste. Alternative UI-SO-2 may not achieve long-term effectiveness and permanence because there is no impermeable barrier layer in the cover, making it likely that a release will occur from continued leaching, further erosion over time, and/or during a flood, up to a 500-year storm event. Alternative UI-SO-3 is the most effective alternative in the long-term because all waste and soils exceeding PRGs would be excavated and placed under one of the on-site landfill caps.

8.2.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

None of the alternatives involve treatment processes.

8.2.3.5 Short-Term Effectiveness

Alternative UI-SO-1 is the most effective at attaining short-term results with minimal risks because there will be no activities to implement and, therefore, no exposure risks to the community, workers, or the environment during implementation of the alternative.

Alternative UI-SO-2 will require limited activities (limited excavation, soil cover installation and maintenance) that will result in short-term exposure risks to workers, the community, or the environment, although these activities will be managed through engineering controls and worker training. Under Alternative UI-SO-3, potential risks to the community, workers, and/or the environment will increase compared to Alternative UI-SO-2 due to the anticipated larger and deeper excavation area. These potential risks will be managed through engineering controls and worker training.

8.2.3.6 Implementability

Alternative UI-SO-1 involves no implementation and no O&M. Although the implementation of each of the active alternatives (UI-SO-2 and UI-SO-3) is both technically and administratively feasible, as the remedial technology is conventional and proven for these contaminants, both Alternatives UI-SO-2 and UI-SO-3 will be challenging because the location of the Unnamed Island will require a temporary bridge to move equipment and vehicles, and flooding could disrupt work or damage equipment. Alternative UI-SO-3 will be the most difficult alternative to implement because this alternative requires excavation below the water table. Alternative UI-SO-2 will involve the simplest technical implementation for the active remedy alternatives due to the shallower depth of excavation. In addition, due to the lower amount of material requiring excavation, uncertainty related to the seasonal construction and potential flooding of the Unnamed Island is significantly reduced. However, the reliability of the cover design for Alternative UI-SO-2 is questionable with respect to protectiveness during flood scenarios.

Alternative UI-SO-1 is likely to be administratively feasible, but most likely not accepted because there will be no controls on potential exposure pathways. Alternatives UI-SO-2 and UI-SO-3 are administratively feasible with the level of difficulty increasing respectively.

8.2.3.7 Cost

The most economical option is Alternative UI-SO-1, at no cost. Alternative UI-SO-2, estimated to cost $4,374,000, is the most economical of the active remedy alternatives; Alternative UI-SO-3 has a present worth cost estimate of $6,136,000. The capital costs presented for UI-SO-3 may increase based on additional information gathered with respect to waste depth, but these additional costs are expected to be within the margin of error expected in the FS stage. Note that there would be O&M and institutional control costs associated with maintenance of the cap in Alternative UI-SO-2, but no O&M and institutional control costs associated with waste and soil deposits remaining on the island in UI-SO-3, as they will have been removed.

8.3 Comparative Analysis of Remedial Alternatives for Sediments

A summary of the individual analysis of the pond sediment remedial action alternatives is presented in Table 8-5. This section provides a comparative analysis of the expected performance of each alternative relative to the other alternatives to identify their respective advantages and disadvantages.

8.3.1 Overall Protection of Human Health and the Environment

Alternative SE-1 will not include monitoring to evaluate changes in risks or determine when RAOs are met. Alternative SE-1 does not reduce the potential exposure pathways and is not protective of the environment.

Alternatives SE-2, SE-3, and SE-4 achieve the RAOs for sediment and will provide overall protection of the environment. Under these three alternatives, surface water quality in the ponds is expected to achieve water quality standards once the sediment remedy is implemented. Alternative SE-2 will achieve the RAOs in the shortest period of time through removal of all sediments with contaminants exceeding PRGs, with on-site consolidation in one of the landfills to be capped. In contrast, Alternatives SE-3 and SE-4 will permanently require monitoring and maintenance of the subaqueous covers and institutional controls (necessary to protect the remedy) as long as the underlying sediment still poses a risk. Alternative SE-3 will be more protective of the environment than Alternative SE-4 because contaminant mass in the top 1 foot of sediment will be removed and consolidated in one of the on-site landfills to be capped, as well as with covering any areas with deeper exceedances. Alternative SE-4 will cover sediments, but not actively reduce contaminant mass or volume.

8.3.2 Compliance with ARARs

Alternative SE-1 would not reduce existing contaminant concentrations below risk-based levels (as developed using To Be Considered guidance documents) in sediments or provide measures to eliminate or control potential exposure pathways associated with possible future use of the site and, therefore, does not meet ARARs. Alternatives SE-2 through SE-4 can all achieve these standards. Alternatives SE-2 through SE-4 would all be designed/implemented to comply with ARARs and TBC standards. Subaqueous covers included in Alternatives SE-3 and SE-4 would be engineered (through use of amendments, if necessary) to remain protective in the event of a flood, up to a 500-year event. In addition, Alternative SE-3 meets federal Clean Water Act standards to be the LEDPA, because it provides a better balance of addressing contaminated sediment within and adjacent to wetlands and waterways.

8.3.3 Long-Term Effectiveness and Permanence

Alternative SE-1 would provide the least long-term effectiveness because there would be no controls to limit exposure to contaminants in sediment. Alternative SE-4 would be more effective than Alternative SE-1 because a cover, periodic monitoring, O&M of the cover, institutional controls, and statutory review would be implemented to reduce potential exposure pathways.

Alternatives SE-2 and SE-3 would be more effective than Alternative SE-4 because sediment removal will be implemented to prevent potential exposure to contaminants in sediment. Alternative SE-3 will use a combination of excavation and covering to reduce potential exposure pathways and institutional controls to protect the cover. As part of Alternative SE-3, some impacted sediments will stay in place under the cover and require periodic monitoring and O&M of the cover, maintenance of institutional controls, and statutory review. Alternative SE-2 will excavate all sediments exceeding PRGs and provides the greatest permanence in the shortest timeframe. Alternative SE-2 also eliminates the need for further monitoring, O&M, institutional controls, and statutory review because all contaminated sediments that exceed PRGs will

be fully removed. All of the alternatives may be impacted to a limited extent from upriver sources of contaminated sediments discussed in the Blackstone River Watershed TMDL report for the foreseeable future. However, it is not expected that contaminant concentrations would reach actionable levels in the future.

8.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

None of the alternatives involve treatment processes, except for limited treatment of water from dewatering process and potential bulking of dredged sediments prior to disposal under the landfill cap(s) in Alternatives SE-2 and SE-3.

8.3.5 Short-Term Effectiveness

Alternative SE-1 is the most effective at attaining short-term results with minimal risk, because there will be no activities to implement and, therefore, no additional exposure risks. Alternative SE-4 will require less intrusive activities (subaqueous cover periodic monitoring and maintenance) that will result in short-term exposure risks to workers, the community, and/or the environment, although these activities will be managed through engineering controls and worker training. However, there is also the potential for loss of ecological habitat in shallower zones when placing the cover without prior excavation. In addition, any flood storage capacity lost during cover installation in Alternative SE-4 will require mitigation elsewhere at the site. Under Alternative SE-3, potential risks to the community, workers, or the environment will increase compared to Alternative SE-4 due to the addition of excavation. These potential risks will be managed through engineering controls and worker training. The sediment excavation included as Alternative SE-2 may result in the greatest short-term exposure risks to workers (predominantly due to excavation and consolidation), but these potential risks will be managed through engineering controls and worker training. Alternative SE-2 may also result in the highest short-term exposure risks to the environment and community, because this alternative has the largest volume of sediment to be transported off of the Unnamed Island.

8.3.6 Implementability

Alternative SE-1 involves no implementation and no maintenance. Implementation of Alternatives SE-2, SE-3 and SE-4 are technically and administratively feasible, as the remedial technologies are conventional and proven for the site contaminants. Services and materials necessary for implementing the alternatives are readily available, although design studies will be performed to ascertain the stability and performance of the various cover options and treatability studies may be needed if amendments are to be used as part of any subaqueous cover (Alternatives SE-3 and SE-4). The longer duration required for the excavation under Alternative SE-2 increases risk to equipment due to periodic flooding of the Unnamed Island. In addition, dewatering of the excavated sediment will most likely be required prior to consolidation at the Nunes Parcel. Alternative SE-3 also requires excavation, as well as installation of a subaqueous cover, while Alternative

SE-4 will include only a subaqueous cover. Alternatives SE-2, SE-3, and SE-4 will use conventional equipment that is readily available, but a temporary bridge will be required to move heavy equipment and trucks across the Blackstone River. Due to the difficulties of moving equipment and materials across a channel of the Blackstone River and the potential for flooding to disrupt work or damage equipment, the implementability of the alternatives is primarily controlled by the level of uncertainty in the volume of material requiring transport and the duration of the remedy activities. Thus, Alternative SE-2 is the least implementable and Alternative SE-4 is the most implementable.

8.3.7 Cost

Alternative SE-1, with no cost, is the most economical option. Alternative SE-2 is the most costly alternative, with a present worth cost of $8,120,000 and the highest degree of cost uncertainty due to the potential for excavation beyond currently assumed horizontal and vertical extents. Alternative SE-3 at $5,804,000 has a higher capital cost than SE-4 (at $3,584,000) because of the removal of the uppermost sediment prior to placement of a subaqueous cover.

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TABLES

Table ES-1 - Comparison of Cleanup Alternatives

➢ **Area/Media:**	J.M. Mills Landfill			Nunes Parcel			Unnamed Island			Pond Sediment				Groundwater	
Nine Criteria	JM-SO-1 No Action	JM-SO-2 RCRA C Cap	JM-SO-3 Hybrid Cap	NP-SO-1 No Action	NP-SO-2 RCRA D Cap	NP-SO-3 RCRA C Cap	UI-SO-1 No Action	UI-SO-2 Remove 2 ft and Cover	UI-SO-3 Full Removal	SE-1 No Action	SE-2 Full Removal	SE-3 Remove 1 ft and Cover	SE-4 Subaqueous Cover	GW-1 No Action	GW-2 Long-Term Monitoring
Protects human health & environment	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✓	✓	✓	✗	✓
Meets federal & state requirements	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✓	✓	✓	✗	✓
Provides long term protection	✗	✓	✓	✗	✓	✓	✗	✓	✓	✗	✓	✓	✓	✗	✓
Reduces mobility, toxicity & volume through treatment	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Provides short-term protection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Implementable	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cost (millions)	$0.0	$21.6	$13.7	$0.0	$4.9	$6.1	$0.0	$4.4	$6.1	$0.0	$8.1	$5.8	$3.6	$0.0	$0.7
State agency acceptance	To be determined after the public comment period														
Community Acceptance	To be determined after the public comment period														

✓ **Meets or exceeds criterion** ✓ **Partially meets criterion** ✗ **Does NOT meet criterion**

Table 2-1
Summary of Well Construction Information

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Well	Formation Code[(1)]	Date Installed	Well Diameter (inches)	Well Material	Screen Type	Total Boring Depth (feet bgs)	Well Screen Interval depth (feet bgs)	Ground Surface Elevation (feet NGVD)	Well Screen Midpoint Elevation (feet NGVD)	Formation Material Screened
Monitoring Wells										
GLF-700A	IN	Nov-05	2.0	Sch. 40 PVC	0.010" factory slot	70.0	40 - 49.7	59.5	14.7	SAND, fine to coarse
GLF-704	SH	Nov-05	2.0	Sch. 40 PVC	0.010" factory slot	20.0	10 - 19.7	60.8	46.0	GRAVEL, fine to coarse
GLF-706	SH	Oct-05	2.0	Sch. 40 PVC	0.010" factory slot	20.0	10 - 19.7	64.3	49.5	SAND and GRAVEL
GLF-706A	IN	Oct-05	2.0	Sch. 40 PVC	0.010" factory slot	95.0	55 - 64.7	64.8	4.9	SAND, fine to medium
GNP-705	SH	Oct-05	2.0	Sch. 40 PVC	0.010" factory slot	20.0	10 - 19.7	73.7	58.9	Silty fine SAND
GNP-705B	DP	Oct-05	2.5	Sch. 80 PVC	0.010" factory slot	168.0	117 - 126.7	73.6	-48.3	SAND and GRAVEL
GNP-707	SH	Oct-05	2.0	Sch. 40 PVC	0.010" factory slot	36.0	25.4 - 35.4	75.0	44.6	SAND, fine to coarse
GNP-708	SH	Oct-05	2.5	Sch. 80 PVC	0.010" factory slot	20.0	10.5 - 20.5	68.5	53.0	SAND, fine to coarse
GNP-708A	IN	Oct-05	2.0	Sch. 40 PVC	0.010" factory slot	85.0	63.7 - 73.7	68.3	-0.4	SAND, fine to coarse
GUI-701	SH	Nov-05	1.5	Sch. 40 PVC	0.010" factory slot	20.0	8 - 17.7	62.2	49.4	SAND and GRAVEL
GUI-702	SH	Nov-05	1.5	Sch. 40 PVC	0.010" factory slot	20.0	8 - 17.7	64.0	51.2	SAND and GRAVEL
GUI-703	SH	Nov-05	1.5	Sch. 40 PVC	0.010" factory slot	20.0	5 - 14.7	61.8	52.0	GRAVEL
GZ-1-1	SH	Feb-81	1.5	Sch. 80 PVC	0.010" slot	19.9	9 - 19	64.62	50.6	SAND, fine to coarse
GZ-1-1	SH	Feb-81	1.5	Sch. 80 PVC	0.010" factory slot	19.9	9 19	64.60	50.6	SAND, fine to coarse
GZ-1-2	IN	Feb-81	B	B	B	45.2	43.5 48.2	64.60	18.8	SAND, fine to medium
GZ-1-2	----	Feb-81	B	B	B	45.2	43.5 - 48.2	----	----	SAND, fine to medium
GZ-1-3	DP	Feb-81	B	B	B	87.6	80.1 89	64.60	-20.0	SAND, fine
GZ-1-3	---	Feb-81	B	B	B	87.6	80.1 - 89	----	---	SAND, fine
GZ-2-1	SH	Feb-81	1.5	Sch. 80 PVC	0.010" slot	19.8	9.8 - 19.8	---	---	SAND, fine to medium
GZ-2-1	SH	Feb-81	1.5	Sch. 80 PVC	0.010" factory slot	19.8	9.8 19.8	---	---	SAND, fine to medium
GZ-2-2	---	Feb-81	B	B	B	38.3	35 - 40.4	---	---	SAND, fine to coarse
GZ-2-2	IN	Feb-81	B	B	B	38.3	35 40.4	---	---	SAND, fine to coarse
GZ-2-3	---	Feb-81	B	B	B	57.1	53.5 - 61.5	---	---	SAND, fine
GZ-2-3	DP	Feb-81	B	B	B	57.1	53.5 61.5	---	---	SAND, fine

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Feasibility Study
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Cumberland and Lincoln, Rhode Island

Well	Formation Code[(1)]	Date Installed	Well Diameter (inches)	Well Material	Screen Type	Total Boring Depth (feet bgs)	Well Screen Interval depth (feet bgs)	Ground Surface Elevation (feet NGVD)	Well Screen Midpoint Elevation (feet NGVD)	Formation Material Screened
GZ-3-1	SH	Feb-81	1.5	Sch. 80 PVC	0.010" slot	19.1	9.8 - 19.8	---	---	SAND and GRAVEL
GZ-3-1	SH	Feb-81	1.5	Sch. 80 PVC	0.010" factory slot	19.1	9.8 19.8	---	---	SAND and GRAVEL
GZ-3-2	---	Feb-81	B	B	B	36.6	30.4 - 52	---	---	SAND and GRAVEL
GZ-3-2	IN	Feb-81	B	B	B	36.6	30.4 52	---	---	SAND and GRAVEL
GZ-3-3	---	Feb-81	B	B	B	57.4	53.1 - 64	---	---	SAND and GRAVEL
GZ-3-3	DP	Feb-81	B	B	B	57.4	53.1 64	---	---	SAND and GRAVEL
GZ-4-1	SH	Feb-81	1.5	Sch. 80 PVC	0.010" slot	18.5	8.5 - 18.5	62.25	48.8	SAND, fine to coarse
GZ-4-1	SH	Feb-81	1.5	Sch. 80 PVC	0.010" factory slot	18.5	8.5 18.5	62.30	48.8	SAND, fine to coarse
GZ-4-2	---	Feb-81	B	B	B	49.6	41 - 57.8	---	---	SAND and GRAVEL
GZ-4-2	IN	Feb-81	B	B	B	49.6	41 57.8	62.30	12.9	SAND and GRAVEL
GZ-4-3	---	Feb-81	B	B	B	83.7	79 - 97	---	---	SAND and GRAVEL
GZ-4-3	DP	Feb-81	B	B	B	83.7	79 97	62.30	-25.7	SAND and GRAVEL
L-1	---	---	---	---	---	---	--- - 60.8	---	---	---
L-2	IN	---	---	---	---	---	--- - 45.5	68.19	22.7	---
L-3	---	---	---	---	---	---	--- - 73.5	---	---	---
L-4	---	---	---	---	---	---	--- - 71.1	---	---	---
L-5	---	---	---	---	---	---	--- - 16.7	---	---	---
MW-106A	SH	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	18.0	7.5 - 17.5	66.79	54.3	FILL, SAND, and GRAVEL
MW-106B	IN	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	43.2	32.7 - 42.7	66.79	29.1	SAND and GRAVEL
MW-106C	BR	Jul-87	1.5	Sch. 40 PVC	0.020" saw-slot	74.0	53.9 - 73.9	66.79	2.9	BEDROCK (schist)
MW-107A	SH	Apr-87	2.0	Sch. 40 PVC	0.010" factory slot	35.4	13.9 - 33.9	79.54	55.6	SAND, SAND and GRAVEL
MW-107B	IN	Apr-87	2.0	Sch. 40 PVC	0.010" factory slot	50.1	40.1 - 45.1	79.54	36.9	SAND and GRAVEL
MW-107C	BR	Apr-87	1.5	Sch. 40 PVC	0.020" saw-slot	75.0	49 - 69	79.54	20.5	BEDROCK (schist)
MW-108A	IN	Jun-87	2.0	Sch. 40 PVC	0.010" factory slot	45.0	33.7 - 43.7	67.41	28.7	SAND, fine to coarse
MW-108AA	SH	Jun-87	2.0	Sch. 40 PVC	0.010" factory slot	20.8	10.3 - 20.3	67.41	52.1	SAND, fine to medium

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Well	Formation Code[(1)]	Date Installed	Well Diameter (inches)	Well Material	Screen Type	Total Boring Depth (feet bgs)	Well Screen Interval depth (feet bgs)	Ground Surface Elevation (feet NGVD)	Well Screen Midpoint Elevation (feet NGVD)	Formation Material Screened
MW108B	DP	Jun-87	2.0	Sch. 40 PVC	0.010" factory slot	98.0	87 - 97	67.41	-24.6	SAND, fine to medium
MW-108C	BR	Jun-87	1.5	Sch. 40 PVC	0.020" saw-slot	140.7	117.4 - 117.4	67.41	-50.0	BEDROCK (orthoquartzite)
MW-109A	DP	Jun-87	2.0	Sch. 40 PVC	0.010" factory slot	87.2	76.6 - 86.6	67.16	-14.4	SAND and GRAVEL
MW-109AA	SH	Jun-87	2.0	Sch. 40 PVC	0.010" factory slot	21.7	11.2 - 21.2	67.16	51.0	SAND and GRAVEL
MW-109B	TL	May-87	1.5	Sch. 40 PVC	0.020" saw-slot	148.0	137.2 - 147.2	67.16	-75.0	Sandy TILL
MW-109C	BR	Apr-87	1.5	Sch. 40 PVC	0.020" saw-slot	179.0	158.5 - 178.5	67.16	-101.3	BEDROCK (orthoquartzite)
MW-110A	SH	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	17.5	6.8 - 16.8	65.89	54.1	SAND and GRAVEL
MW-110B	TL	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	65.0	54.4 - 64.4	65.89	6.5	TILL
MW-110C	BR	Jun-87	1.5	Sch. 40 PVC	0.020" saw-slot	100.0	78.1 - 98.1	65.89	-22.2	BEDROCK (schist/orthoquartzite)
MW-111A	IN	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	75.7	64.7 - 74.7	62.56	-7.1	SAND, fine
MW-111AA	SH	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	26.0	15.1 - 25.1	62.56	42.5	SAND and GRAVEL
MW-111B	DP	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	121.0	109.3 - 119.3	62.56	-51.7	SAND and GRAVEL
MW-111C	BR	Jul-87	1.5	Sch. 40 PVC	0.020" saw-slot	163.3	140.6 - 160.6	62.56	-88.0	BEDROCK (orthoquartzite)
MW-112A	IN	Aug-87	2.0	Sch. 40 PVC	0.010" factory slot	56.0	45.1 - 55.1	66.70	16.6	SAND and GRAVEL
MW-112AA	SH	Aug-87	2.0	Sch. 40 PVC	0.010" factory slot	21.0	9.3 - 19.3	66.70	52.4	SAND and GRAVEL
MW-112B	DP	Aug-87	2.0	Sch. 40 PVC	0.010" factory slot	82.4	71.7 - 81.7	66.70	-10.0	SAND, fine
MW-112C	BR	Aug-87	1.5	Sch. 40 PVC	0.020" saw-slot	120.0	99.6 - 119.6	66.70	-42.9	BEDROCK (orthoquartzite)
MW-501A	SH	---	2.0	Sch. 40 PVC	---	15.0	5 - 15	65.78	55.8	---
MW-501B	IN	---	2.0	Sch. 40 PVC	---	57.0	47 - 57	65.78	13.8	---
MW-501C	DP	---	2.0	Sch. 40 PVC	---	102.0	90 - 100	65.78	-29.2	---
MW-502	IN	---	2.0	Sch. 40 PVC	---	60.0	50 - 60	71.08	16.1	---
MW-A1	DP	Nov-80	1.5	Sch. 40 PVC	10-ft long saw-slot	85.0	75 - 85	63.23	-16.8	SAND, fine
MW-A2	SH	Nov-80	1.5	Sch. 40 PVC	10-ft long saw-slot	15.0	5 - 15	63.23	53.2	SAND, fine
MW-B1	IN	Nov-80	1.5	Sch. 40 PVC	10-ft long saw-slot	60.0	50 - 60	60.53	5.5	SAND, fine
MW-B2	SH	Oct-80	1.5	Sch. 40 PVC	10-ft long saw-slot	16.5	6.5 - 16.5	60.53	49.0	SAND, fine to medium

Table 2-1
Summary of Well Construction Information

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
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Well	Formation Code[(1)]	Date Installed	Well Diameter (inches)	Well Material	Screen Type	Total Boring Depth (feet bgs)	Well Screen Interval depth (feet bgs)	Ground Surface Elevation (feet NGVD)	Well Screen Midpoint Elevation (feet NGVD)	Formation Material Screened
MW-C1	IN	Nov-80	1.5	Sch. 40 PVC	10-ft long saw-slot	70.0	60 - 70	59.52	-5.5	SAND, fine
MW-C2	SH	Oct-80	1.5	Sch. 40 PVC	10-ft long saw-slot	15.0	5 - 15	59.52	49.5	SAND, fine
MW-EA-1	SH	3-Jun	2.0	Sch. 40 PVC	0.010" factory slot	40.0	25 - 40	90.20	57.7	SAND, some Silt, Gravel
MW-EA-2	BR	3-Jun	2.0	Sch. 40 PVC	0.010" factory slot	32.0	7 - 32	76.30	56.8	BEDROCK
MW-EA-3	BR	3-Jun	2.0	Sch. 40 PVC	0.010" factory slot	52.0	22 - 52	76.80	39.8	BEDROCK
MW-EA-4	BR	3-Jun	2.0	Sch. 40 PVC	0.010" factory slot	25.0	15 - 25	77.80	57.8	BEDROCK
P-6	SH	Jul-87	2.0	Sch. 40 PVC	0.010" wire-wrap	30.0	15 - 25	66.15	46.2	SAND, fine
P-7	SH	Jun-87	2.0	Sch. 40 PVC	0.010" wire-wrap	38.3	27.8 - 37.8	70.03	37.2	SAND, fine, and SILT
P-8	SH	Aug-87	2.0	Sch. 40 PVC	0.010" wire-wrap	20.5	10 - 20	59.95	45.0	SAND and GRAVEL, SAND
P-9	SH	Jun-87	2.0	Sch. 40 PVC	0.010" wire-wrap	29.0	18.3 - 20.3	66 *(estimated)*	46.7	SAND, v. fine, and SILT
PZ-01	SH	Jul-03	1.2	Steel	0.010" wire-wrap	5.5	3.2 5.2	59.71	55.5	---
PZ-02	SH	Jul-03	1.2	Steel	0.010" wire-wrap	5.0	2.7 4.7	60.39	56.7	---
PZ-03	SH	Jul-03	1.2	Steel	0.010" wire-wrap	3.7	1.7 3.7	61.14	58.4	---
PZ-04	SH	Jul-03	1.2	Steel	0.010" wire-wrap	3.0	0.7 2.7	61.11	59.4	---
PZ-04A	SH	Jul-03	1.2	Steel	0.010" wire-wrap	5.1	2.8 4.8	53.99	50.2	---
PZ-05	SH	Jul-03	1.2	Steel	0.010" wire-wrap	6.3	4 6	59.93	54.9	---
PZ-06	SH	Jul-03	1.2	Steel	0.010" wire-wrap	4.8	2.5 4.5	58.89	55.4	---
PZ-06A	SH	Jul-03	1.2	Steel	0.010" wire-wrap	7.3	5 7	26.6	20.6	---
PZ-07	SH	Jul-03	1.2	Steel	0.010" wire-wrap	6.8	3.5 6.5	59.6	54.6	---
PZ-08	SH	Jul-03	1.2	Steel	0.010" wire-wrap	14.1	10.8 13.8	63.26	51.0	---
PZ-09	SH	Jul-03	1.2	Steel	0.010" wire-wrap	4.9	11.6 14.6	57.75	44.7	---
PZ-10	SH	Jul-03	1.2	Steel	0.010" wire-wrap	3.7	0.4 3.4	63.7	61.8	---
PZ-11	SH	Jul-03	1.2	Steel	0.010" wire-wrap	4.0	0.7 3.7	63.55	61.4	---
PZ-12	SH	Jul-03	1.2	Steel	0.010" wire-wrap	4.0	0.7 3.7	64.14	61.9	---
PZ-13	SH	Jul-03	1.2	Steel	0.010" wire-wrap	4.5	1.2 4.2	65.11	62.4	---

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Well	Formation Code[(1)]	Date Installed	Well Diameter (inches)	Well Material	Screen Type	Total Boring Depth (feet bgs)	Well Screen Interval depth (feet bgs)	Ground Surface Elevation (feet NGVD)	Well Screen Midpoint Elevation (feet NGVD)	Formation Material Screened
PZ-14	SH	Jul-03	1.2	Steel	0.010" wire-wrap	4.2	0.9 3.9	61.68	59.3	---
PZ-15	SH	Jul-03	1.2	Steel	0.010" wire-wrap	3.6	0.3 3.3	68.49	66.7	---
PZ-15A	SH	Jul-03	1.2	Steel	0.010" wire-wrap	5.2	2.6 4.6	69.12	65.5	---
PZ-16	SH	Jul-03	1.2	Steel	0.010" wire-wrap	12.0	8.7 11.7	66.08	55.9	---
PZ-17	SH	Jul-03	1.2	Steel	0.010" wire-wrap	12.0	8.7 11.7	65.15	55.0	---
PZ-18	SH	Jul-03	1.2	Steel	0.010" wire-wrap	14.9	11.6 14.6	65.97	52.9	---
PZ-19	SH	Jul-03	1.2	Steel	0.010" wire-wrap	13.2	9.9 12.9	69.69	58.3	---
PZ-20	SH	Jul-03	1.2	Steel	0.010" wire-wrap	4.5	2.2 4.2	59.11	55.9	---
PZ-21	SH	Sep-05	1.25	Steel	1.6-foot steel well point	6.0	4.0 - 5.6	50.4 *(estimated)*	45.6	driven well - no samples collected
PZ-22	SH	Sep-05	1.25	Steel	1.6-foot steel well point	6.5	4.6 - 6.2	54.3 *(estimated)*	48.9	driven well - no samples collected
PZ-23	SH	Sep-05	1.25	Steel	1.6-foot steel well point	6.0	4.0 - 5.6	49.1 *(estimated)*	44.3	driven well - no samples collected
SEA-601	SH	Sep-03	2.0	Sch. 40 PVC	0.010" factory slot	20.4	10.2 - 20.2	60.42	45.2	SAND, some Gravel
SEA-602A	SH	Sep-03	2.0	Sch. 40 PVC	0.010" factory slot	20.5	10.3 - 20.3	59.76	44.5	SAND and GRAVEL
SEA-602B	IN	Sep-03	2.0	Sch. 40 PVC	0.010" factory slot	61.5	51.3 - 61.3	59.76	3.5	SAND, fine to coarse
SEA-603	SH	Sep-03	2.0	Sch. 40 PVC	0.010" factory slot	20.2	10 - 20	59.23	44.2	SAND and GRAVEL
SEA-604	SH	Sep-03	2.0	Sch. 40 PVC	0.010" factory slot	20.2	10 - 20	62.34	47.3	SAND, fine to medium, and SILT
SEA-605	SH	Sep-03	2.0	Sch. 40 PVC	0.010" factory slot	20.2	10 - 20	62.32	47.3	SAND, some Silt, and Gravel
SEA-606	SH	Sep-03	2.0	Sch. 40 PVC	0.010" factory slot	20.2	10 - 20	61.65	46.7	SAND and GRAVEL
SEA-607	SH	Sep-03	2.0	Sch. 40 PVC	0.010" factory slot	20.3	10.1 - 20.1	63.14	48.0	SAND and GRAVEL
SEA-608	SH	Sep-03	2.0	Sch. 40 PVC	0.010" factory slot	20.2	10 - 20	64.68	49.7	SAND and GRAVEL

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Well	Formation Code[(1)]	Date Installed	Well Diameter (inches)	Well Material	Screen Type	Total Boring Depth (feet bgs)	Well Screen Interval depth (feet bgs)	Ground Surface Elevation (feet NGVD)	Well Screen Midpoint Elevation (feet NGVD)	Formation Material Screened
Former Municipal Supply Wells										
Linc-1 (LW-383)	---	1957	24.0	Steel	---	62.0	--- - 63	---	---	OVERBURDEN
Lenox St (CW-405)	---	1964	---	Steel	---	---	--- - 59.5	---	---	OVERBURDEN
Linc-6 (LW-420)	---	1969	24.0	Steel	---	64.0	--- - 47	---	---	OVERBURDEN
Linc-9	---	1975	16.0	Steel	---	65.0	----	---	---	OVERBURDEN

Notes:
--- = information not available
B = BarCad Sampler interval (temporary well screen for vertical groundwater quality profiling)
bgs = below ground surface
NGVD29 = elevation datum is National Geodetic Vertical Datum 1929
PVC = polyvinyl chloride
Information on wells installed prior to 2005 compiled by Shield Environmental Associates, Inc.
(1) Formation Codes:
SH = screen in unconsolidated sediments, middle screen elevation above 35 feet
IN = screen in unconsolidated sediments, middle screen elevation between -10 feet and 35 feet
DP = screen in unconsolidated sediments, middle screen elevation below -10 feet
TL = screened interval in till
BR = screened interval in bedrock

Table 2-2
Hydraulic Conductivity Summary

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Unit	Formation Code[3]	Unit Description	Hydraulic Conductivity (feet per day)				
			Single Well Pumping Test[1]	Cone Penetrometer[1]	Aquifer Tests[1]	USGS Model[2]	ARCADIS Specific-Capacity Tests
Upper Glaciofluvial	SH	Wells screened in glaciofluvial sediments; the screen midpoint elevation is above 35 feet NGVD29.	251	30	140	120	--
	IN	Wells screened in glaciofluvial sediments; the screen midpoint elevation is between -10 and 35 feet NGVD29.	115				--
Lower Glaciofluvial	DP	Wells screened in glaciofluvial sediments; the screen midpoint elevation is below -10 feet NGVD29.	4	--	--	20	10
Till	TL	Wells screened in till just above bedrock.	7.7	--	--	--	--
Bedrock	BR	Wells screened in bedrock.	0.39	--	--	--	--

Notes:
NGVD29 = elevation datum is National Geodetic Vertical Datum 1929
-- = not available
USGS = United States Geogical Survey

(1) Shield. 2004. *RI/FS Phase 1A Initial Site Characterization Report, Peterson Puritan Superfund Site - Operable Unit 2*. Report prepared for Peterson/Puritan OU2 PRP Group. February 2004.

(2) Friesz, P.J. 2004. Delineation of areas of contributing recharge to selected public-supply wells in glacial valley-fill and wetland settings. Rhode Island: U.S. Geological Survey Scientific Investigators Report 2004-5070, 57 p.

(3) Formation Codes:
SH = screen in unconsolidated sediments, middle screen elevation above 35 feet
IN = screen in unconsolidated sediments, middle screen elevation between -10 feet and 35 feet
DP = screen in unconsolidated sediments, middle screen elevation below -10 feet
TL = screened interval in till
BR = screened interval in bedrock

Table 2-3
Groundwater Elevation Data

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Measuring Point	Measuring Point Reference Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Bottom (feet)	Bottom Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)
		May 6-8, 2002		August 13 & 14, 2003		August 25-27, 2003		September 25, 2003		August 27, 2004		September 20, 2004		April 27, 2005		October 4, 2005		November 14 & 15, 2005				November 28 & 29, 2005	
Upper Glaciofluvial Formation - wells screened above 35 feet elevation																							
GLF-704	63.62	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	5.77	57.85
GLF-706	67.35	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	8.81	58.54
GNP-705	76.55	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	18.53	58.02
GNP-707	78.04	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	19.69	58.35
GNP-708	71.50	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	16.50	55.00	23.82	47.68	15.63	55.87
GUI-701	64.97	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	6.71	58.26
GUI-702	66.49	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	7.99	58.50
GUI-703	64.21	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	5.73	58.48
GZ-1	67.08	8.45	58.63	8.98	58.10	9.94	57.14	9.14	57.94	9.92	57.16	7.84	59.24	6.59	60.49	NC	NC	NC	NC	NC	NC	7.24	59.84
GZ-4	63.49	NC	NC	NC	NC	8.09	55.40	NC	NC	8.05	55.44	5.12	58.37	3.68	59.81	NC	NC	NC	NC	NC	NC	4.41	59.08
MW-106A	68.61	10.71	57.90	NC	NC	12.47	56.14	11.65	56.96	12.62	55.99	10.28	58.33	8.70	59.91	NC	NC	NC	NC	NC	NC	9.16	59.45
MW-107A	81.46	18.25	63.21	19.22	62.24	20.98	60.48	22.56	58.90	21.72	59.74	21.73	59.73	18.01	63.45	NC	NC	NC	NC	NC	NC	18.01	63.45
MW-108AA	69.19	9.68	59.51	10.14	59.05	11.78	57.41	11.47	57.72	12.22	56.97	11.15	58.04	7.51	61.68	NC	NC	NC	NC	NC	NC	7.81	61.38
MW-109AA	67.77	10.66	57.11	11.60	56.17	12.88	54.89	12.28	55.49	12.93	54.84	10.46	57.31	8.76	59.01	NC	NC	NC	NC	NC	NC	9.26	58.51
MW-110A	66.91	7.70	59.21	8.28	58.63	9.56	57.35	11.69	55.22	11.02	55.89	10.62	56.29	5.84	61.07	NC	NC	NC	NC	NC	NC	6.02	60.89
MW-111AA	64.53	7.80	56.73	8.29	56.24	9.59	54.94	9.65	54.88	10.01	54.52	8.24	56.29	5.41	59.12	NC	NC	NC	NC	NC	NC	6.00	58.53
MW-112AA	68.59	10.48	58.11	11.25	57.34	12.64	55.95	14.20	54.39	13.89	54.70	12.77	55.82	11.61	56.98	NC	NC	NC	NC	NC	NC	9.38	59.21
MW-501A	68.68	NC	NC	ob@9.40	ob@59.28	ob@9.76	ob@58.92	ob@10.41	ob@58.27	11.28	57.40	9.46	59.22	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
MW-501B	68.46	NC	NC	10.19	58.27	11.10	57.36	10.38	58.08	11.04	57.42	9.24	59.22	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
MW-A2	65.20	7.60	57.60	8.25	56.95	9.60	55.60	8.38	56.82	9.57	55.63	6.73	58.47	5.27	59.93	NC	NC	NC	NC	NC	NC	5.52	59.68
MW-B2	62.04	4.76	57.28	5.75	56.29	7.06	54.98	5.82	56.22	7.01	55.03	4.10	57.94	2.79	59.25	NC	NC	NC	NC	NC	NC	3.33	58.71
MW-C2	61.48	4.70	56.78	5.61	55.87	6.82	54.66	5.69	55.79	6.79	54.69	3.99	57.49	2.66	58.82	NC	NC	NC	NC	NC	NC	3.23	58.25
MW-EA1	92.24	NC	NC	NC	NC	NC	NC	30.23	62.01	30.22	62.02	30.36	61.88	22.85	69.39	NC	NC	NC	NC	NC	NC	22.72	69.52
P-6	67.83	8.89	58.94	9.54	58.29	10.48	57.35	9.71	58.12	10.42	57.41	8.59	59.24	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
P-7	71.79	12.39	59.40	13.44	58.35	14.89	56.90	13.61	58.18	14.84	56.95	11.75	60.04	NC	NC	NC	NC	NC	NC	NC	NC	10.85	60.94
P-8	62.53	5.22	57.31	6.22	56.31	7.56	54.97	6.04	56.49	7.45	55.08	4.32	58.21	3.15	59.38	NC	NC	NC	NC	NC	NC	3.80	58.73
P-9	66.07	8.04	58.03	NC	NC	10.01	56.06	10.47	55.60	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	6.25	59.82
PZ-01 inside	59.71	NC	NC	4.00	55.71	5.24	54.47	4.19	55.52	5.24	54.47	2.46	57.25	1.40	58.31	6.26	53.45	NC	NC	NC	NC	1.95	57.76
PZ-02 inside	60.39	NC	NC	4.56	55.83	5.73	54.66	4.60	55.79	5.66	54.73	2.82	57.57	NC	NC	7.59	52.80	NC	NC	NC	NC	3.64	56.75
PZ-03 inside	61.14	NC	NC	4.20	56.94	6.87	54.27	4.85	56.29	5.79	55.35	3.07	58.07	2.03	59.11	dry@6.05	dry@55.09	NC	NC	NC	NC	2.61	58.53
PZ-04 inside	55.87	NC	NC	3.33	52.54	4.03	51.84	3.43	52.44	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
PZ-04A inside	53.99	NC	NC	NC	NC	NC	NC	NC	NC	2.28	51.71	0.85	53.14	Underwater		not found		NC	NC	NC	NC	NC	NC
PZ-05 inside	59.93	NC	NC	3.44	56.49	5.73	54.20	6.33	53.60	6.37	53.56	1.81	58.12	0.99	58.94	dry@6.49	dry@53.44	NC	NC	NC	NC	NC	NC
PZ-06 inside	58.89	NC	NC	4.70	54.19	dry@4.84	dry@54.47	dry@4.88	dry@54.43	5.31	53.58	2.31	56.58	Underwater		5.32	53.57	NC	NC	NC	NC	1.33	57.56
PZ-06A inside	56.60	NC	NC	NC	NC	NC	NC	NC	NC	2.98	53.62	0.50	56.10	Unable to Open		4.20	52.40	1.80	54.80	8.28	48.32	NC	NC
PZ-07 inside	59.60	NC	NC	4.54	55.06	5.57	54.03	4.97	54.63	5.60	54.00	2.10	57.50	10.30	49.30	6.47	53.13	2.45	57.15	7.20	52.40	2.21	57.39
PZ-08 inside	63.26	NC	NC	8.18	55.08	9.35	53.91	8.71	54.55	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
PZ-09 inside	57.75	NC	NC	2.14	61.12	3.86	53.89	3.66	54.09	3.25	54.50	2.17	55.58	NC	NC	4.28	53.47	NC	NC	NC	NC	Underwater	
PZ-09 inside	57.75	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
PZ-10 inside	63.70	NC	NC	3.98	59.72	5.46	58.24	7.31	56.39	5.79	57.91	5.79	57.91	1.33	62.37	dry@7.84	dry@55.86	NC	NC	NC	NC	1.52	62.18
PZ-11 inside	63.55	NC	NC	3.64	59.91	5.27	58.28	7.49	56.06	5.84	57.71	5.22	58.33	1.29	62.26	could not locate		NC	NC	NC	NC	1.41	62.14
PZ-12 inside	64.14	NC	NC	4.21	59.93	6.07	58.07	6.58	57.56	6.45	57.69	5.57	58.57	1.66	62.48	dry@8.3	dry@55.84	NC	NC	NC	NC	1.85	62.29
PZ-13 inside	65.11	NC	NC	3.98	61.13	4.04	61.07	4.22	60.89	4.05	61.06	3.91	61.20	2.04	63.07	could not locate		NC	NC	NC	NC	NC	NC
PZ-14 inside	61.68	NC	NC	4.45	57.23	4.63	57.05	4.57	57.11	5.08	56.60	3.37	58.31	3.36	58.32	6.27	55.41	NC	NC	NC	NC	4.09	57.59
PZ-15 inside	68.49	NC	NC	dry	dry	dry@6.03	dry@62.46	5.80	62.69	dry@5.98	dry@62.51	dry@5.95	dry@62.54	dry	dry	dry@6.03	dry@62.46	NC	NC	NC	NC	5.70	62.79
PZ-15A inside	69.12	NC	NC	NC	NC	NC	NC	NC	NC	7.10	62.02	7.27	61.85	7.05	62.07	7.39	61.73	NC	NC	NC	NC	7.03	62.09
PZ-16 inside	66.08	NC	NC	11.00	55.08	12.17	53.91	11.24	54.84	12.17	53.91	9.57	56.51	7.71	58.37	12.47	53.61	9.75	56.33	15.66	50.42	8.57	57.51
PZ-17 inside	65.15	NC	NC	9.52	55.63	10.87	54.28	9.98	55.17	10.81	54.34	8.49	56.66	6.33	58.82	11.30	53.85	8.63	56.52	19.78	45.37	7.06	58.09
PZ-18 inside	65.97	NC	NC	10.08	55.89	11.25	54.72	10.29	55.68	11.20	54.77	8.44	57.53	6.92	59.05	11.69	54.28	9.11	56.86	18.23	47.74	7.52	58.45
PZ-19 inside	69.69	NC	NC	NC	NC	12.44	57.25	12.38	57.31	12.42	57.27	11.47	58.22	7.75	61.94	14.18	55.51	NC	NC	NC	NC	8.02	61.67

Table 2-3
Groundwater Elevation Data

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Measuring Point	Measuring Point Reference Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Bottom (feet)	Bottom Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)
		May 6-8, 2002		August 13 & 14, 2003		August 25-27, 2003		September 25, 2003		August 27, 2004		September 20, 2004		April 27, 2005		October 4, 2005		November 14 & 15, 2005				November 28 & 29, 2005	
Upper Glaciofluvial Formation - wells screened above 35 feet elevation (cont.)																							
PZ-20 inside	59.11	NC	NC	NC	NC	NC	NC	NC	NC	3.14	55.97	1.07	58.04	--	NA	3.41	55.70	NC	NC	NC	NC	-	-
PZ-21 inside	61.28	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	6.75	54.53	NC	NC	NC	NC	2.56	58.72
PZ-22 inside	66.40	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	12.25	54.15	9.30	57.10	18.00	48.40	7.88	58.52
PZ-23 inside	59.89	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	6.60	53.29	NC	NC	NC	NC	1.67	58.22
SEA-601	63.47	NC	NC	NC	NC	NC	NC	6.96	56.51	8.67	54.80	5.22	58.25	4.00	59.47	NC	NC	NC	NC	NC	NC	4.67	58.80
SEA-602A	62.51	NC	NC	NC	NC	NC	NC	6.00	56.51	7.53	54.98	4.34	58.17	3.15	59.36	NC	NC	NC	NC	NC	NC	3.80	58.71
SEA-603	61.97	NC	NC	NC	NC	NC	NC	5.61	56.36	6.94	55.03	3.86	58.11	2.65	59.32	NC	NC	NC	NC	NC	NC	3.23	58.74
SEA-604	65.34	NC	NC	NC	NC	NC	NC	9.38	55.96	10.38	54.96	7.62	57.72	6.11	59.23	NC	NC	NC	NC	NC	NC	6.68	58.66
SEA-605	65.20	NC	NC	NC	NC	NC	NC	9.74	55.46	10.76	54.44	8.08	57.12	6.55	58.65	NC	NC	NC	NC	NC	NC	7.18	58.02
SEA-606	64.43	NC	NC	NC	NC	NC	NC	11.29	53.14	11.70	52.73	10.12	54.31	11.61	52.82	12.30	52.13	NC	NC	NC	NC	8.68	55.75
SEA-607	65.82	NC	NC	NC	NC	NC	NC	11.31	54.51	11.77	54.05	9.93	55.89	6.93	58.89	Unable to open		NC	NC	NC	NC	7.74	58.08
SEA-608	67.02	NC	NC	NC	NC	NC	NC	12.47	54.55	12.96	54.06	10.37	56.65	8.18	58.84	13.24	53.78	NC	NC	NC	NC	8.80	58.22
Upper Glaciofluvial Formation - wells screened between 10 and 35 feet elevation																							
GLF-700A	61.93	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	3.00	58.93
GLF-706A	67.84	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	9.12	58.72
GNP-708A	71.09	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	16.28	54.81	76.75	-5.66	15.53	55.56
L-2	69.94	11.46	53.33	12.13	57.81	13.27	56.67	12.50	57.44	13.27	56.67	11.08	58.86	9.66	60.28	NC	NC	NC	NC	NC	NC	10.21	59.73
MW-106B	68.55	NC	NC	11.46	57.09	12.54	56.01	11.53	57.02	12.46	56.09	10.21	58.34	8.55	60.00	NC	NC	NC	NC	NC	NC	9.06	59.49
MW-107B	81.53	19.26	62.27	19.91	61.62	21.53	60.00	22.71	58.82	22.07	59.46	21.80	59.73	18.59	62.94	NC	NC	NC	NC	NC	NC	18.69	62.84
MW-108A	69.00	9.66	59.34	10.10	58.90	11.73	57.27	11.33	57.67	12.16	56.84	10.98	58.02	7.46	61.54	NC	NC	NC	NC	NC	NC	7.79	61.21
MW-111A	64.13	7.35	56.78	7.89	56.24	9.18	54.95	9.44	54.69	9.64	54.49	8.19	55.94	5.07	59.06	NC	NC	NC	NC	NC	NC	5.50	58.63
MW-112A	68.09	10.23	57.86	10.78	57.31	12.34	55.75	13.77	54.32	13.64	54.45	12.54	55.55	8.85	59.24	NC	NC	NC	NC	NC	NC	8.97	59.12
MW-B1	61.92	3.92	58.00	5.15	56.77	6.54	55.38	5.50	56.42	6.64	55.28	3.71	58.21	2.47	59.45	NC	NC	NC	NC	NC	NC	3.07	58.85
MW-C1	61.06	3.83	57.23	4.72	56.34	6.02	55.04	5.12	55.94	6.03	55.03	3.39	57.67	1.78	59.28	NC	NC	NC	NC	NC	NC	2.33	58.73
SEA-602B	61.99	NC	NC	NC	NC	NC	NC	5.46	56.53	6.71	55.28	3.73	58.26	2.31	59.68	NC	NC	NC	NC	NC	NC	2.95	59.04
Deep Glaciofluvial Formation - wells screened below 10 feet elevation																							
GNP-705B	76.67	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	19.25	57.42
MW-108B	69.31	11.18	58.13	11.73	57.58	13.16	56.15	12.89	56.42	13.38	55.93	11.50	57.81	8.87	60.44	NC	NC	NC	NC	NC	NC	9.32	59.99
MW-109A	68.64	10.47	58.17	11.27	57.37	12.64	56.00	12.92	55.72	12.91	55.73	11.48	57.16	8.43	60.21	NC	NC	NC	NC	NC	NC	8.79	59.85
MW-111B	64.01	7.22	56.79	7.75	56.26	9.03	54.98	9.30	54.71	9.51	54.50	8.05	55.96	4.94	59.07	NC	NC	NC	NC	NC	NC	5.37	58.64
MW-112B	68.20	11.52	56.68	12.04	56.16	13.37	54.83	13.94	54.26	14.12	54.08	12.65	55.55	9.61	58.59	NC	NC	NC	NC	NC	NC	9.91	58.29
MW-501C	68.47	NC	NC	10.15	58.32	11.08	57.39	10.37	58.10	10.99	57.48	9.20	59.27	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
MW-502	73.47	NC	NC	15.56	57.91	16.68	56.79	15.90	57.57	16.68	56.79	14.56	58.91	13.18	60.29	NC	NC	NC	NC	NC	NC	13.75	59.72
MW-A1	64.79	7.06	57.73	7.82	56.97	9.13	55.66	7.91	56.88	9.08	55.71	6.26	58.53	4.82	59.97	NC	NC	NC	NC	NC	NC	5.97	58.82
Till Formation																							
MW-109B	69.13	11.21	57.92	11.98	57.15	13.32	55.81	13.53	55.60	13.62	55.51	12.17	56.96	9.07	60.06	NC	NC	NC	NC	NC	NC	9.48	59.65
MW-110B	67.50	8.73	58.77	9.32	58.18	10.64	56.86	12.38	55.12	11.99	55.51	11.75	55.75	6.83	60.67	NC	NC	NC	NC	NC	NC	7.11	60.39
Bedrock Formation																							
MW-106C	68.20	NC	NC	10.98	57.22	12.00	56.20	11.08	57.12	11.95	56.25	10.78	57.42	8.14	60.06	NC	NC	NC	NC	NC	NC	8.54	59.66
MW-107C	81.55	20.07	61.48	20.65	60.90	22.17	59.38	23.00	58.55	22.59	58.96	21.99	59.56	19.25	62.30	NC	NC	NC	NC	NC	NC	19.45	62.10
MW-108C	69.26	11.23	58.03	11.77	57.49	13.18	56.08	12.89	56.37	13.39	55.87	11.49	57.77	8.90	60.36	NC	NC	NC	NC	NC	NC	9.37	59.89
MW-109C	69.30	11.35	57.95	12.20	57.10	13.56	55.74	13.65	55.65	13.81	55.49	12.15	57.15	9.36	59.94	NC	NC	NC	NC	NC	NC	9.70	59.60
MW-110C	67.93	8.79	59.14	9.39	58.54	10.59	57.34	11.97	55.96	11.77	56.16	11.39	56.54	6.39	61.54	NC	NC	NC	NC	NC	NC	6.63	61.30
MW-111C	64.50	6.06	58.44	6.62	57.88	7.86	56.64	8.74	55.76	8.71	55.79	7.96	56.54	3.70	60.80	NC	NC	NC	NC	NC	NC	4.03	60.47
MW-112C	68.09	11.31	56.78	11.87	56.22	13.21	54.88	13.74	54.35	13.89	54.20	10.51	57.58	9.35	58.74	NC	NC	NC	NC	NC	NC	9.70	58.39
MW-EA2	78.32	NC	NC	NC	NC	NC	NC	15.21	63.11	14.96	63.36	14.35	63.97	14.20	64.12	NC	NC	NC	NC	NC	NC	14.45	63.87
MW-EA3	78.76	NC	NC	NC	NC	NC	NC	20.46	58.30	20.36	58.40	19.27	59.49	15.15	63.61	NC	NC	NC	NC	NC	NC	14.66	64.10
MW-EA4	79.75	NC	NC	NC	NC	NC	NC	17.03	62.72	15.48	64.27	15.61	64.14	15.15	64.60	NC	NC	NC	NC	NC	NC	NC	NC

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Measuring Point	Measuring Point Reference Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)	Depth to Bottom (feet)	Bottom Elevation (ft NGVD29)	Depth to Water (feet)	Water-Level Elevation (ft NGVD29)
		May 6-8, 2002		August 13 & 14, 2003		August 25-27, 2003		September 25, 2003		August 27, 2004		September 20, 2004		April 27, 2005		October 4, 2005		November 14 & 15, 2005				November 28 & 29, 2005	
Surface-Water Measuring Points																						
HW-01	69.64	NC	NC	NC	NC	3.43	66.21	dry@3.32	dry@66.32	dry		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
HW-02	59.37	NC	NC	NC	NC	NC	NC	2.57	56.80	1.36	58.01	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
PZ-01 outside	59.71	NC	NC	4.50	55.21	5.63	54.08	4.29	55.42	5.59	54.12	2.59	57.12	1.75	57.96	dry@6.18	dry@53.53	NC	NC	NC	NC	2.35	57.36
PZ-02 outside	60.39	NC	NC	4.82	55.57	dry@5.14	dry@55.28	4.68	55.71	dry@4.95	dry@55.44	2.98	57.41	NC	NC	dry@9.41	dry@50.98	NC	NC	NC	NC	3.89	56.50
PZ-03 outside	61.14	NC	NC	4.72	56.42	dry@4.79	dry@56.32	dry@4.72	dry@56.39	dry@4.55	dry@56.59	3.06	58.08	2.26	58.88	dry@4.78	dry@56.36	NC	NC	NC	NC	2.83	58.31
PZ-04 outside	55.87	NC	NC	3.50	52.37	4.03	51.84	3.31	52.56	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
PZ-04A outside	53.99	NC	NC	NC	NC	NC	NC	NC	NC	2.29	51.70	0.82	53.17	Underwater		not found		NC	NC	NC	NC	NC	NC
PZ-05 outside	59.93	NC	NC	3.44	56.49	5.67	54.26	dry@6.16	dry@53.79	dry@5.95	dry@53.98	1.84	58.09	0.99	58.94	dry@6.16	dry@53.77	NC	NC	NC	NC	NC	NC
PZ-06 outside	58.89	NC	NC	4.89	54.00	dry@4.94	dry@54.37	4.83	54.06	dry@5.00	dry@53.89	2.50	56.39	Underwater		5.49	53.40	NC	NC	NC	NC	1.56	57.33
PZ-06A outside	56.60	NC	NC	NC	NC	NC	NC	NC	NC	3.19	53.41	0.22	56.38	Unable to Open		4.38	52.22	2.20	54.40	NC	NC	NC	NC
PZ-07 outside	59.60	NC	NC	4.50	55.10	5.37	54.23	4.95	54.65	5.40	54.20	1.70	57.90	NC	NC	dry@5.68	dry@53.92	2.40	57.20	NC	NC	2.21	57.39
PZ-08 outside	63.26	NC	NC	NC	NC	dry@3.89	dry@59.37	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
PZ-09 outside	57.75	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
PZ-09 outside	57.75	NC	NC	2.08	55.67	3.84	53.91	3.64	54.11	3.22	54.53	2.18	55.57	NC	NC	4.28	53.47	NC	NC	NC	NC	Underwater	
PZ-10 outside	63.70	NC	NC	3.98	59.72	5.45	58.25	dry@5.58	dry@58.12	dry@5.40	dry@58.30	dry@5.45	dry@58.25	1.33	62.37	dry@5.38	dry@58.32	NC	NC	NC	NC	1.50	62.20
PZ-11 outside	63.55	NC	NC	3.64	59.91	5.06	58.49	dry@5.36	dry@58.17	dry@5.37	dry@58.18	5.15	58.40	1.32	62.23	could not locate		NC	NC	NC	NC	1.42	62.13
PZ-12 outside	64.14	NC	NC	4.18	59.96	dry@5.00	dry@59.14	dry@4.88	dry@59.26	dry@4.82	dry@59.32	dry@4.85	dry@59.29	1.63	62.51	dry@4.87	dry@59.27	NC	NC	NC	NC	1.92	62.22
PZ-13 outside	65.11	NC	NC	4.27	60.84	4.43	60.68	4.64	60.47	4.69	60.42	4.51	60.60	2.63	62.48	could not locate		NC	NC	NC	NC	NC	NC
PZ-14 outside	61.68	NC	NC	4.56	57.12	5.03	56.65	4.61	57.07	dry@4.62	dry@57.06	3.44	58.24	3.41	58.27	6.03	55.65	NC	NC	NC	NC	4.15	57.53
PZ-15 outside	68.49	NC	NC	1.86	66.63	1.87	66.62	1.75	66.74	1.94	66.55	1.94	66.55	1.40	67.09	1.69	66.80	NC	NC	NC	NC	1.35	67.14
PZ-15A outside	69.12	NC	NC	NC	NC	NC	NC	NC	NC	2.60	66.52	2.59	66.53	2.01	67.11	2.38	66.74	NC	NC	NC	NC	1.95	67.17
PZ-16 outside	66.08	NC	NC	NC	NC	dry@3.36	dry@62.72	NC	NC	NC	NC	NC	NC	NC	NC	dry@3.40	dry@62.68	NC	NC	NC	NC	dry	dry
PZ-17 outside	65.15	NC	NC	NC	NC	dry@3.31	dry@61.84	NC	NC	NC	NC	NC	NC	NC	NC	dry@3.18	dry@61.97	NC	NC	NC	NC	dry	dry
PZ-18 outside	65.97	NC	NC	NC	NC	dry@3.67	dry@62.29	NC	NC	NC	NC	NC	NC	NC	NC	dry@6.33	dry@59.64	NC	NC	NC	NC	dry	dry
PZ-19 outside	69.69	NC	NC	NC	NC	NC	NC	NC	NC	dry@2.85	dry@66.84	NC	NC	NC	NC	dry@2.98	dry@66.71	NC	NC	NC	NC	2.82	66.87
PZ-20 outside	59.11	NC	NC	NC	NC	NC	NC	NC	NC	3.22	55.89	1.15	57.96	3.20	55.91	3.53	55.58	NC	NC	NC	NC	NC	NC
PZ-21 outside	61.28	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	dry@9.46	dry@51.82	NC	NC	NC	NC	2.72	58.56
PZ-22 outside	66.40	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	12.03	54.37	9.32	57.08	NC	NC	7.98	58.42
PZ-23 outside	59.89	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	dry@9.48	dry@50.41	NC	NC	NC	NC	2.58	57.31
SEA-606 outside	64.43	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	dry@2.83	dry@61.60	NC	NC	NC	NC	NC	NC
SEA-607 outside	65.82	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	10.00	55.82	22.22	43.60	NC	NC
SEA-608 outside	67.02	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	dry@2.13	dry@64.89	NC	NC	NC	NC	NC	NC
SG-1	72.57	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	21.27	51.30	19.70	52.87	NC	NC	19.20	53.37
SG-2	69.30	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	17.70	51.60	14.00	55.30	NC	NC	13.02	56.28

Notes:
NC = not collected (measuring point may have not have been installed)
ft NGVD29 = elevation datum is National Geodetic Vertical Datum 1929. All elevation values shown are in feet NGVD29.
ob = obstruction in well encountered

Table 2-4
Vertical Hydraulic Gradients

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Measuring Point	Middle Screen Elev. (ft NGVD29)	Water-Level Elevation (feet NGVD29)										Vertical Hydraulic Gradient[1] (positive value = upward flow; negative value = downward flow)										
		5/6-5/8/02	8/13-8/14/03	8/15-8/27/03	9/25/03	8/27/04	9/20/04	4/27/05	10/4/05	11/14-11/15/05	11/28-11/29/05	5/6-5/8/02	8/13-8/14/03	8/15-8/27/03	9/25/03	8/27/04	9/20/04	4/27/05	10/4/05	11/14-11/15/05	11/28-11/29/05	Average
GLF-706	49.5	NC	NC	NC	NC	NC	NC	NC	NC	NC	58.54	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0040	0.0040
GLF-706A	5.0	NC	NC	NC	NC	NC	NC	NC	NC	NC	58.72	---	---	---	---	---	---	---	---	---	---	---
GNP-705	58.9	NC	NC	NC	NC	NC	NC	NC	NC	NC	58.02	NA	NA	NA	NA	NA	NA	NA	NA	NA	-0.0056	-0.0056
GNP-705B	-48.3	NC	NC	NC	NC	NC	NC	NC	NC	NC	57.42	---	---	---	---	---	---	---	---	---	---	---
GNP-708	53.0	NC	NC	NC	NC	NC	NC	NC	NC	55.00	55.87	NA	NA	NA	NA	NA	NA	NA	NA	-0.0036	-0.0058	-0.0047
GNP-708A	0.0	NC	NC	NC	NC	NC	NC	NC	NC	54.81	55.56	---	---	---	---	---	---	---	---	---	---	---
MW-106A	54.3	57.90	NC	56.14	56.96	55.99	58.33	59.91	NC	NC	59.45	NA	NA	-0.0052	0.0024	0.0040	0.0004	0.0036	NA	NA	0.0016	0.0011
MW-106B	29.1	NC	57.09	56.01	57.02	56.09	58.34	60.00	NC	NC	59.49	NA	0.0050	0.0073	0.0038	0.0061	-0.0351	0.0023	NA	NA	0.0065	-0.00060
MW-106C	2.9	NC	57.22	56.20	57.12	56.25	57.42	60.06	NC	NC	59.66	---	---	---	---	---	---	---	---	---	---	---
MW-107A	55.6	63.21	62.24	60.48	58.90	59.74	59.73	63.45	NC	NC	63.45	-0.050	-0.033	-0.026	-0.004	-0.015	0.0000	-0.027	NA	NA	-0.033	-0.024
MW-107B	36.9	62.27	61.62	60.00	58.82	59.46	59.73	62.94	NC	NC	62.84	-0.048	-0.044	-0.038	-0.016	-0.030	-0.010	-0.039	NA	NA	-0.045	-0.034
MW-107C	20.5	61.48	60.90	59.38	58.55	58.96	59.56	62.30	NC	NC	62.10	---	---	---	---	---	---	---	---	---	---	---
MW-108AA	52.1	59.51	59.05	57.41	57.72	56.97	58.04	61.68	NC	NC	61.38	-0.0073	-0.0064	-0.0060	-0.0021	-0.0056	-0.00085	-0.0060	NA	NA	-0.0073	-0.0052
MW-108A	28.7	59.34	58.90	57.27	57.67	56.84	58.02	61.54	NC	NC	61.21	-0.023	-0.025	-0.021	-0.023	-0.017	-0.0039	-0.021	NA	NA	-0.023	-0.020
MW-108B	-24.6	58.13	57.58	56.15	56.42	55.93	57.81	60.44	NC	NC	59.99	-0.0028	-0.0025	-0.0020	-0.0014	-0.0017	-0.0011	-0.0023	NA	NA	-0.0028	-0.0021
MW-108C	-60.0	58.03	57.49	56.08	56.37	55.87	57.77	60.36	NC	NC	59.89	---	---	---	---	---	---	---	---	---	---	---
MW-109AA	51.0	57.11	56.17	54.89	55.49	54.84	57.31	59.01	NC	NC	58.51	0.016	0.018	0.017	0.0035	0.014	-0.0023	0.018	NA	NA	0.020	0.013
MW-109A	-14.4	58.17	57.37	56.00	55.72	55.73	57.16	60.21	NC	NC	59.85	-0.0041	-0.0036	-0.0031	-0.0020	-0.0036	-0.0033	-0.0025	NA	NA	-0.0033	-0.0032
MW-109B	-75.0	57.92	57.15	55.81	55.60	55.51	56.96	60.06	NC	NC	59.65	0.0011	-0.0019	-0.0027	0.0019	-0.00076	0.0072	-0.0046	NA	NA	-0.0019	-0.00019
MW-109C	-101.3	57.95	57.10	55.74	55.65	55.49	57.15	59.94	NC	NC	59.60	---	---	---	---	---	---	---	---	---	---	---
MW-110A	54.1	59.21	58.63	57.35	55.22	55.89	56.29	61.07	NC	NC	60.89	-0.0092	-0.0095	-0.010	-0.0021	-0.0080	-0.011	-0.0084	NA	NA	-0.011	-0.0087
MW-110B	6.5	58.77	58.18	56.86	55.12	55.51	55.75	60.67	NC	NC	60.39	0.013	0.013	0.017	0.029	0.023	0.028	0.030	NA	NA	0.032	0.023
MW-110C	-22.2	59.14	58.54	57.34	55.96	56.16	56.54	61.54	NC	NC	61.30	---	---	---	---	---	---	---	---	---	---	---
MW-111AA	42.5	56.73	56.24	54.94	54.88	54.52	56.29	59.12	NC	NC	58.53	NA	0.0000	0.00020	-0.0038	-0.00060	-0.0071	-0.0012	NA	NA	0.0020	-0.0015
MW-111A	-7.1		56.24	54.95	54.69	54.49	55.94	59.06	NC	NC	58.63	NA	0.00045	0.00067	0.00045	0.00022	0.00045	0.00022	NA	NA	0.00022	0.00038
MW-111B	-51.7	56.79	56.26	54.98	54.71	54.50	55.96	59.07	NC	NC	58.64	0.045	0.045	0.046	0.029	0.036	0.016	0.048	NA	NA	0.050	0.039
MW-111C	-88.0	58.44	57.88	56.64	55.76	55.79	56.54	60.80	NC	NC	60.47	---	---	---	---	---	---	---	---	---	---	---
MW-112AA	52.4	58.11	57.34	55.95	54.39	54.70	55.82	56.98	NC	NC	59.21	-0.0070	-0.00084	-0.0056	-0.0020	-0.0070	-0.0075	0.063	NA	NA	-0.0025	0.0038
MW-112A	16.6	57.86	57.31	55.75	54.32	54.45	55.55	59.24	NC	NC	59.12	-0.044	-0.043	-0.035	-0.0023	-0.014	0.0000	-0.024	NA	NA	-0.031	-0.024
MW-112B	-10.0	56.68	56.16	54.83	54.26	54.08	55.55	58.59	NC	NC	58.29	0.0030	0.0018	0.0015	0.0027	0.0036	0.062	0.0046	NA	NA	0.0030	0.010
MW-112C	-42.9	56.78	56.22	54.88	54.35	54.20	57.58	58.74	NC	NC	58.39	---	---	---	---	---	---	---	---	---	---	---
MW-501A	55.8	NC	ob@59.28	ob@58.92	ob@58.27	57.40	59.22	NC	NC	NC	NC	NA	NA	NA	NA	0.00048	0.0000	NA	NA	NA	NA	0.0002
MW-501B	13.8	NC	58.27	57.36	58.08	57.42	59.22	NC	NC	NC	NC	NA	0.0012	0.00070	0.00047	0.0014	0.0012	NA	NA	NA	NA	0.0010
MW-501C	-29.2	NC	58.32	57.39	58.10	57.48	59.27	NC	NC	NC	NC	---	---	---	---	---	---	---	---	---	---	---

Table 2-4
Vertical Hydraulic Gradients

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Measuring Point	Middle Screen Elev. (ft NGVD29)	Water-Level Elevation (feet NGVD29)										Vertical Hydraulic Gradient[(1)] (positive value = upward flow; negative value = downward flow)										
		5/6-5/8/02	8/13-8/14/03	8/15-8/27/03	9/25/03	8/27/04	9/20/04	4/27/05	10/4/05	11/14-11/15/05	11/28-11/29/05	5/6-5/8/02	8/13-8/14/03	8/15-8/27/03	9/25/03	8/27/04	9/20/04	4/27/05	10/4/05	11/14-11/15/05	11/28-11/29/05	Average
MW-A2	53.2	57.60	56.95	55.60	56.82	55.63	58.47	59.93	NC	NC	59.68	0.0019	0.00029	0.00086	0.00086	0.0011	0.00086	0.0006	NA	NA	-0.012	-0.0007
MW-A1	-16.8	57.73	56.97	55.66	56.88	55.71	58.53	59.97	NC	NC	58.82	---	---	---	---	---	---	---	---	---	---	---
MW-B2	49.0	57.28	56.29	54.98	56.22	55.03	57.94	59.25	NC	NC	58.71	0.0166	0.0110	0.0092	0.0046	0.0057	0.0062	0.0046	NA	NA	0.0032	0.0076
MW-B1	5.5	58.00	56.77	55.38	56.42	55.28	58.21	59.45	NC	NC	58.85	---	---	---	---	---	---	---	---	---	---	---
MW-C2	49.5	56.78	55.87	54.66	55.79	54.69	57.49	58.82	NC	NC	58.25	0.0082	0.0085	0.0069	0.0027	0.0062	0.0033	0.0084	NA	NA	0.0087	0.0066
MW-C1	-5.5	57.23	56.34	55.04	55.94	55.03	57.67	59.28	NC	NC	58.73	---	---	---	---	---	---	---	---	---	---	---
PZ-01 inside	49.3	NC	55.71	54.47	55.52	54.47	57.25	58.31	53.45	NC	57.76	NA	0.085	0.082	0.016	0.073	0.017	0.040	NA	NA	0.050	0.052
PZ-01 outside	NA	NC	55.21	54.08	55.42	54.12	57.12	57.96	dry@53.53	NC	57.36	---	---	---	---	---	---	---	---	---	---	---
PZ-02 inside	51.5	NC	55.83	54.66	55.79	54.73	57.57	NC	52.80	NC	56.75	NA	0.064	NA	0.019	NA	0.027	NA	NA	NA	0.050	0.040
PZ-02 outside	NA	NC	55.57	dry@55.28	55.71	dry@55.44	57.41	NC	dry@50.98	NC	56.50	---	---	---	---	---	---	---	---	---	---	---
PZ-03 inside	53.9	NC	56.94	54.27	56.29	55.35	58.07	59.11	dry@55.09	NC	58.53	NA	0.21	NA	NA	NA	-0.0024	0.046	NA	NA	0.050	0.075
PZ-03 outside	NA	NC	56.42	dry@56.32	dry@56.39	dry@56.59	58.08	58.88	dry@56.36	NC	58.31	---	---	---	---	---	---	---	---	---	---	---
PZ-04 inside	48.8	NC	52.54	51.84	52.44	NC	NC	NC	NC	NC	NC	NA	0.048	0.000	-0.032	NA	NA	NA	NA	NA	NA	0.0052
PZ-04 outside	NA	NC	52.37	51.84	52.56	NC	NC	NC	NC	NC	NC	---	---	---	---	---	---	---	---	---	---	---
PZ-05 inside	53.0	NC	56.49	54.20	53.60	53.56	58.12	58.94	dry@53.44	NC	NC	NA	0.000	-0.048	NA	NA	0.0059	0.000	NA	NA	NA	-0.010
PZ-05 outside	NA	NC	56.49	54.26	dry@53.79	dry@53.98	58.09	58.94	dry@53.77	NC	NC	---	---	---	---	---	---	---	---	---	---	---
PZ-06 inside	50.3	NC	54.19	dry@54.47	dry@54.43	53.58	56.58	underwater	53.57	NC	57.56	NA	0.051	NA	NA	NA	0.031	0.000	0.055	NA	0.033	0.034
PZ-06 outside	NA	NC	54.00	dry@54.37	54.06	dry@53.89	56.39	underwater	53.40	NC	57.33	---	---	---	---	---	---	---	---	---	---	---
PZ-07 inside	49.0		55.06	54.03	54.63	54.00	57.50	49.30	53.13	57.15	57.39	NA	-0.007	-0.038	-0.0035	-0.038	-0.045	NA	NA	-0.0061	0.000	-0.020
PZ-07 outside	NA	NC	55.10	54.23	54.65	54.20	57.90	NC	dry@53.92	57.20	57.39	---	---	---	---	---	---	---	---	---	---	---
PZ-10 inside	56.0	NC	59.72	58.24	56.39	57.91	57.91	62.37	dry@55.86	NC	62.18	NA	0.000	-0.004	NA	NA	NA	0.000	NA	NA	-0.0032	-0.0019
PZ-10 outside	NA	NC	59.72	58.25	dry@58.12	dry@58.30	dry@58.25	62.37	dry@58.32	NC	62.20	---	---	---	---	---	---	---	---	---	---	---
PZ-11 inside	55.9	NC	59.91	58.28	56.06	57.71	58.33	62.26	not located	NC	62.14	NA	0.000	-0.081	NA	NA	-0.028	0.0047	0.000	NA	0.0016	-0.017
PZ-11 outside	NA	NC	59.91	58.49	dry@58.17	dry@58.18	58.40	62.23	not located	NC	62.13	---	---	---	---	---	---	---	---	---	---	---
PZ-12 inside	56.5	NC	59.93	58.07	57.56	57.69	58.57	62.48	dry@55.84	NC	62.29	NA	-0.0087	NA	NA	NA	NA	-0.005	NA	NA	0.012	-0.0005
PZ-12 outside	NA	NC	59.96	dry@59.14	dry@59.26	dry@59.32	dry@59.29	62.51	dry@59.27	NC	62.22	---	---	---	---	---	---	---	---	---	---	---
PZ-13 inside	57.4	NC	61.13	61.07	60.89	61.06	61.20	63.07	not located	NC	NC	NA	0.084	0.12	0.14	0.21	0.19	0.12	0.000	NA	NA	0.12
PZ-13 outside	NA	NC	60.84	60.68	60.47	60.42	60.60	62.48	not located	NC	NC	---	---	---	---	---	---	---	---	---	---	---
PZ-14 inside	54.1	NC	57.23	57.05	57.11	56.60	58.31	58.32	55.41	NC	57.59	NA	0.036	0.16	0.013	NA	0.017	0.012	-0.15	NA	0.017	0.014
PZ-14 outside	NA	NC	57.12	56.65	57.07	dry@57.06	58.24	58.27	55.65	NC	57.53	---	---	---	---	---	---	---	---	---	---	---

Notes:
[(1)] Values shown in each row represent the vertical gradient between the well in that row and the well in the row beneath (i.e., the value in the MW-106A row is the gradient between MW-106A and MW-106B).
NC = not collected (measuring point may have not have been installed)
NA = not applicable
ft NGVD29 = elevation datum is National Geodetic Vertical Datum 1929
ob = obstruction in well encountered

Table 2-5
Summary of Investigation Activities

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Investigation	Date of Sampling	Objective	Media Sampled	Analyses Performed	Comments
Goldberg-Zoino Associates Inc.	1980 and 1981	Determine source of volatile organic compound (VOC) contamination in Quinville well field groundwater.	Groundwater	VOCs	Report concluded that the probable source of VOC contamination in the Quinnville well field was the Peterson Puritan Superfund Site. Wells installed within Operable Unit 2 (OU2), specifically Quinnville well field, could not be located.
Malcom Pirnie, Inc.	1982	Evaluate VOC concentrations in groundwater near the Peterson Puritan Superfund Site OU2.	Groundwater	VOCs	Wells installed within OU2 could not be located.
Camp, Dresser & Mckee Inc.	1987	Evaluate groundwater at the Peterson Puritan Superfund Site OU2.	Groundwater	Split samples collected, analyses unknown	Six wells and three piezometers (one piezometer was damaged) are located within OU2.
GHR Engineering Corp.	1981	Install monitoring wells at landfill.	Groundwater	Metals	Seven wells installed at OU2 but one cannot be located and one was damaged.
Sitewide Remedial Investigation	1987 to 1989	Characterize nature and extent of contamination in soil, groundwater, surface water, and sediment at the Peterson Puritan Superfund Site OU2.	Groundwater	VOCs, semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, and cyanide	Performed seismic refraction survey to evaluate elevation of bedrock and wetlands mapping to delineate extent and type of wetlands.
			Surface water	VOCs, SVOCs, pesticides, PCBs, metals, and cyanide	
			Sediment	VOCs, SVOCs, pesticides, PCBs, metals, and cyanide	
Pre-Phase 1 Preparatory Assessment	2002	Locate existing monitoring wells in OU2 and evaluate moisture content of sediment.	Sediment	Moisture content and polycyclic aromatic hydrocarbons (PAHs)	At the United Staets Environmental Protection Agency's (USEPA's) request, PAH sediment data will not be used in the remedial investigation/feasibility study (RI/FS).
Bikeway Investigation	2000 to 2002	Evaluate soil quality in area of planned bikeway construction.	Soil	Pesticides, metals, and total petroleum hydrocarbons (TPH)	Construction of bikeway includes excavation and removal of about 6,500 cubic yards of material.

Table 2-5
Summary of Investigation Activities

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Investigation	Date of Sampling	Objective	Media Sampled	Analyses Performed	Comments
Owens Corning Limited Removal	2003	Investigate extent of fibreglass waste present on island.	Soil	VOCs, SVOCs, pesticides, PCBs, metals, TPH, and TCLP metals.	Removed fiberglass waste on island in 2003.
McNulty Properties	2003	Evaluate groundwater quality and hydraulic relationship to known groundwater contamination to the south and northwest.	Groundwater	VOCs and metals	Installed four wells along the northeastern boundary of the wetlands.
			Surface water	VOCs, SVOCs, and metals	
			Sediment	VOCs, SVOCs, and metals	
Phase 1A Investigation	2003	Meet objectives of RI/FS scope identified in the scope of work.	Soil	VOCs, SVOCs, pesticides, PCBs, metals, cyanide, and conventionals	Results are presented in the *Revised Database Summary Report* (DBSR2) and discussed in Sections 2 and 4 of the RI. Performed electromagnetic induction survey to evaluate extent of buried waste.
			Groundwater	VOCs, SVOCs, pesticides, PCBs, metals, cyanide, and conventionals	Performed electrical conductivity/membrane interface probe survey to evaluate VOCs at toe of landfill. Performed cone penetrometer tests to evaluate landfill slope stability.
			Surface water	VOCs, SVOCs, pesticides, PCBs, metals, cyanide, and conventionals	Performed potentiometric survey, hydraulic well test, and surface flow measurements to evaluate groundwater and surface-water flow.
			Sediment	VOCs, SVOCs, pesticides, PCBs, metals, cyanide, and conventionals	
			Air	VOCs	

Table 2-5
Summary of Investigation Activities

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Investigation	Date of Sampling	Objective	Media Sampled	Analyses Performed	Comments
Phase 1A Expanded Investigation	2004	Fill data gaps identified in Phase 1A investigation.	Soil	VOCs, SVOCs, pesticides, PCBs, metals, cyanide, and conventionals	Results are presented in the DBSR2 and discussed in Sections 2 and 4 of the RI. Performed potentiometric survey, hydraulic well test, and surface flow measurements to evaluate groundwater and surface-water flow.
			Groundwater	VOCs, SVOCs, pesticides, PCBs, metals, cyanide, and conventionals	
			Surface water	VOCs, SVOCs, pesticides, PCBs, metals, cyanide, and conventionals	
			Sediment	VOCs, SVOCs, pesticides, PCBs, metals, cyanide, and conventionals	
Phase 1B Investigation	2005	To support RI and FS and fill data gaps.	Soil	VOCs, PAHs, non-PAH SVOCs, PCBs and pesticides, metals and cyanide, and polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans	Results are presented in the DBSR2 and discussed in Sections 2 and 4of the RI. Performed seismographic geophysical evaluation of bedrock surface along suspected bedrock dip.
			Groundwater	VOCs, PAHs, non-PAH SVOCs, PCBs and Pesticides, metals and cyanide	

Table 2-5
Summary of Investigation Activities

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Investigation	Date of Sampling	Objective	Media Sampled	Analyses Performed	Comments
Phase 1B Investigation	2005		Surface water	PAHs, PCBs, pesticides, metals, and miscellaneous parameters	
			Sediment	VOCs, PAHs, non-PAH SVOCs, PCBs, Pesticides, metals and miscellaneous	Conducted sediment probing in Blackstone River; benthic community surveys and benthic toxicity tests.
			Fish tissue	PAHs, SVOCs, PCBs, Pesticides, and metals	Fish community survey conducted in Blackstone River; fish samples collected on whole bodies, filets, and carcasses; wildlife and vegetation habitats surveys conducted; and rapid bioassessment protocal conducted.
Nunes Parcel Investigation	2006	To delineate limits of buried waste.	Soil	VOCs, SVOCs, Pesticides, PCBs, metals, and cyanide	
Supplemental Groundwater Investigation	3/2007	Evaluate groundwater quality.	Groundwater	VOCs and metals	
RI Report	6/2007	Compiled investigation data completed since 2003	(see above)	(see above)	(see above)
Additional Data Collection at Unnamed Island	11/2009	Evaluated soil and groundwater quality.	Soil	VOCs, SVOCs, PCBs, pesticides, metals, cyanide, dioxin, furans	
			Groundwater	VOCs, SVOCs, PCBs, pesticides, metals, cyanide	
Supplemental Data Investigation	11/2012	Further evaluate reference data for soil and sediment; evaluate earthworm bioaccumulation	Earthworms	Cd	
			Soil	BEHP, PAHs, select metals	
			Sediment	BEHP, PAHs, select metals	

Table 3-1
Chemical-Specific ARARs, Criteria, Advisories, and Guidance

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Groundwater				
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLs), 40 CFR Subparts B and G	Relevant and Appropriate	Establishes MCLs for common organic and inorganic contaminants applicable to public drinking water supplies. Used as relevant and appropriate standards for aquifers and surface water bodies that are potential drinking water sources.	Remedial actions will be designed and implemented to meet this requirement.
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Goals (MCLGs), 40 CFR Subpart F	Relevant and Appropriate	Establishes maximum contaminant level goals (MCLGs) for public water supplies. MCLGs are health goals for drinking water sources. These unenforceable health goals are available for a number of organic and inorganic compounds.	Remedial actions will be designed and implemented to meet this requirement.
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in groundwater.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	Used to calculate potential carcinogenic risks to children caused by exposure to contaminants.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are considered to be the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime	Used to compute the individual non-carcinogenic risk resulting from exposure to non-carcinogenic contaminants in groundwater.
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in groundwater.

Table 3-1
Chemical-Specific ARARs, Criteria, Advisories, and Guidance

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Federal Requirements	EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	The Health Advisories were used to develop groundwater performance standards.
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases, CRIR12-180-001; DEM-DSR-01-93, section 8.03	Applicable	These regulations set remediation standards for groundwater at NPL sites within the state based on groundwater classification.	State standards that are more stringent than federal standards were used to develop groundwater performance standards.
Soil				
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	Used to calculate potential carcinogenic risks to children caused by exposure to contaminants.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are considered to be the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime.	Used to compute the individual non-carcinogenic risk resulting from exposure to non-carcinogenic contaminants in soil/debris.

Table 3-1
Chemical-Specific ARARs, Criteria, Advisories, and Guidance

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in soil/debris.
Federal Requirements	EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	Recommendations of the Technical Review Workgroup for Lead for an approach to Assessing Risks Associated with Adult Exposure to Lead In Soil, EPA-540-R-03-001 (January 2003)	TBC	EPA Guidance for evaluating risks posed by lead in soil.	Used to calculate potential risks caused by exposure to lead in soil/debris.
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, sections 8.02 and 8.04	Applicable	These regulations set remediation standards for soil at NPL sites when they are more stringent than federal standards.	State standards that are more stringent than federal standards were used to develop soil performance standards.

Table 3-1
Chemical-Specific ARARs, Criteria, Advisories, and Guidance

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Sediment				
Federal Requirements	NOAA Effects Range-Low (ERL) values for marine and estuarine sediments (Long et al., 1995; Long and Morgan, 1990)	TBC	The ERL value is equivalent to the lower 10th percentile of the available toxicity data, which is estimated to be the approximate concentration at which adverse effects are likely to occur in sensitive life stages and/or species of sediment-dwelling organisms.	ERLs were used for selecting Chemicals of Potential Concern (COPCs) and for characterizing ecological effects.
Federal Requirements	U.S. DOE, Office of Environmental Management, Secondary Chronic Values (SCVs) (Jones et al., 1997)	TBC	The SCVs are toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota.	SCVs were used for selecting COPCs and for characterizing ecological effects.
Federal Requirements	U.S. EPA Sediment Quality Criterion (SQC) and Sediment Quality Benchmarks (SQBs) (USEPA, 1996)	TBC	SQCs and SQBs were established to provide screening toxicity thresholds.	SQCs and SQBs were used for selecting COPCs and for characterizing ecological effects.
Federal Requirements	NOAA Screening Quick Reference Tables, Threshold Effects Level (TEL) (Buchman, 1999)	TBC	TELs represent the concentration below which adverse effects are expected to occur only rarely.	TELs were used for selecting COPCs and for characterizing ecological effects.

Notes:

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table 3-2
Location-Specific ARARs, Criteria, Advisories, and Guidance

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Groundwater				
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this alternative.
Federal Requirements	Clean Water Act, Section 404; Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Activities involving discharge of dredged material and/or excavation and/or installation or maintenance of monitoring wells that include dredging or filling in wetlands will be implemented to meet these requirements, including mitigation of altered wetlands/aquatic resources, as required.

Table 3-2
Location-Specific ARARs, Criteria, Advisories, and Guidance

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
State Regulatory Requirements	Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; RIDEM Rules And Regulations Governing the Administration and Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00-6.00, 10.00, 11.00 and 13.00.	Applicable	Defines and establishes provisions for the protection of swamps, marshes and other fresh water wetlands resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland.	Action taken will be done in compliance with this requirement.
Soil				
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this alternative.

Table 3-2
Location-Specific ARARs, Criteria, Advisories, and Guidance

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Federal Requirements	Clean Water Act, Section 404; Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Remedial actions will be conducted in a manner to minimize the area of wetlands altered, to the extent possible. Areas of altered wetlands will be mitigated, as required.
Federal Requirements	Fish and Wildlife Coordination Act, 16 U.S.C. §661 *et seq.*	Applicable	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or other federal waters for any purpose to take action to protect fish and wildlife resources that may be affected by the action.	Measures to mitigate or compensate adverse project related impacts to fish and wildlife resources will be taken, if determined necessary.
Federal Requirements	National Historical Preservation Act, U.S.C. 469 *et seq.*; 36 C.F.R. Part 65	Applicable	When a federal agency finds, or is notified, that its activities in connection with a federal construction project may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archeological data, the substantive standards under the Act will be met.	If, during the remedial design or remedial action, it is determined that remedial actions may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archaeological data, substantive standards under the Act will be met.

Table 3-2
Location-Specific ARARs, Criteria, Advisories, and Guidance

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
State Requirements	Rhode Island Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; DEM Rules And Regulations Governing the Administration And Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00 and 5.00	Applicable	Defines and establishes provisions for the protection of swamps, marshes, 100-year floodplain and other fresh water wetland resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland.	Remedial actions will be done in compliance with this requirement.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.21	Relevant and Appropriate	Establishes seismic standards for solid waste disposal facilities	Covers will be designed, constructed and maintained to meet seismic requirements.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.22	Relevant and Appropriate	Solid waste disposal facilities located in unstable areas must demonstrate that engineering measures have been incorporated into the facility's unit's design to ensure that the integrity of the structural components of the facility will not be disrupted.	Waste management area may be established within a 100-year flood zone. The substantive requirements of this section of the regulations will be met through covering the waste left in place in a manner that prevents the release of contaminants during a 100 year flood event.

Table 3-2
Location-Specific ARARs, Criteria, Advisories, and Guidance

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
State Requirements	Rhode Island Historic Preservation Act, RIGL 42-45 *et seq.*	Applicable	Requires action to take into account effects on properties included on or eligible for the National register of Historic Places and minimizes harm to National Historic Landmarks.	Features with potential historical/cultural significance will be evaluated during the remedial design phase and activities will be coordinated with the State Agency as required.
Sediment				
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this alternative.

Table 3-2
Location-Specific ARARs, Criteria, Advisories, and Guidance

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Federal Requirements	Clean Water Act, Section 404 Guidelines for Discharge of Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Activities must be conducted in accordance with these requirements including, but not limited to, mitigation and/or restoration.
Federal Requirements	Fish and Wildlife Coordination Act, 16 U.S.C. §661 *et seq.*	Applicable	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or other federal waters for any purpose to take action to protect fish and wildlife resources that may be affected by the action.	Measures to mitigate or compensate adverse project related impacts to fish and wildlife resources will be taken, if determined necessary.
Federal Requirements	National Historical Preservation Act, U.S.C. 469 *et seq.*; 36 C.F.R. Part 65	Applicable	When a federal agency finds, or is notified, that its activities in connection with a federal construction project may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archeological data, the substantive standards under the Act will be met.	If, during the remedial design or remedial action, it is determined that this alternative may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archaeological data, substantive standards under the Act will be met.

Table 3-2
Location-Specific ARARs, Criteria, Advisories, and Guidance

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
State Requirements	Rhode Island Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; DEM Rules And Regulations Governing the Administration And Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00 and 5.00	Applicable	Defines and establishes provisions for the protection of swamps, marshes, 100-year floodplain and other fresh water wetland resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland. Also establishes standards for land within 50 feet of the edge of state-regulated wetlands.	Action taken under this alternative will be done in compliance with this requirement.
State Requirements	Rhode Island Historic Preservation Act, RIGL 42-45 *et seq.*	Applicable	Requires action to take into account effects on properties included on or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks.	Features with potential historical/cultural significance will be evaluated during the remedial design phase and activities will be coordinated with the State Agency, as required.

Notes:

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

TABLE 3-3
HUMAN HEALTH PRELIMINARY REMEDIATION GOALS (PRGs) FOR SOIL[1]

Contaminant	Selected PRG (mg/kg)	Basis[2]
Benzene[3]	0.0012	ILCR = 10^{-6}
Benzo(a)anthracene	0.9	Res. DEC
Benzo(a)pyrene	0.30	Reference
Benzo(b)fluoranthene	0.9	Res. DEC
Benzo(g,h,i)perylene	0.8	Res. DEC
Benzo(k)fluoranthene	0.9	Res. DEC
bis(2-Ethylhexyl)phthalate	46	Res. DEC
Chrysene	0.4	Res. DEC
Dibenz(a,h)anthracene[4]	0.21 / 0.4	ILCR = 10^{-6} / Res. DEC
Fluoranthene	20	Res. DEC
Indeno(1,2,3-cd)pyrene	0.9	Res. DEC
Naphthalene[3]	0.13	ILCR = 10^{-6}
Pyrene	13	Res. DEC
Chlordane	0.5	Res. DEC
Dioxin TEQ[3]	0.000023	Reference
PCBs	10	Res. DEC
Dieldrin	0.04	Res. DEC
Antimony	10	Res. DEC
Arsenic	5.1	Reference
Beryllium	1.5	Res. DEC
Lead	150	Res. DEC
Manganese	390	Res. DEC
Thallium	5.5	Res. DEC

Notes

1. Cleanup goals were not developed for undetected contaminants where the laboratory detection limits were in excess of ARARs. Additional sampling will be performed during the design phase using analytical methods capable of measuring concentrations at levels below the ARARs. These data will be evaluated to assess impacts, if any, to the proposed cleanup goals. In addition, all numeric criteria included in ARARs identified for the site must also be met by the cleanup regardless of whether or not they are identified above except where reference is an issue.

2. See Appendix C.6 for PRG development and basis:
   Res. DEC - RIDEM Remediation Regulations, DEM-DSR-01-93, February 2004, Table 1 (Residential Direct Exposure Criteria [DEC]); RIDEM utilizes Residential DECs for evaluation of Recreational User exposures
   Reference - If RIDEM criteria or risk-based PRGs were below reference concentrations for the site, the reference concentration was selected.
   ILCR - Incremental Lifetime Cancer Risk

3. PRGs developed for benzene, naphthalene, and dioxin are applicable only at Nunes Parcel based on exceedance of risk criteria for a commercial worker.

4. The risk-based PRG developed for dibenz(a,h)anthracene (0.21 mg/kg) is applicable only at Nunes Parcel based on exceedance of risk criteria for a commercial worker. The Residential DEC (0.4 mg/kg) is applicable to the rest of the site.

ARAR - Applicable or Relevant and Appropriate Requirement

TABLE 3-4
HUMAN HEALTH PERFORMANCE STANDARDS (PSs) FOR GROUNDWATER

Media/ Scenario	Contaminant	Regulatory Criteria			Risk-Based PSs - Ingestion/Dermal/Inhalation				Additional Information				Selected PS	Basis
		Federal MCLs	RIDEM Rem. Regs.	RI GQS	ILCR 10^{-6}	ILCR 10^{-5}	ILCR 10^{-4}	HQ = 1	Site-specific Range of Background Levels[1]	RI Background[2]	Health Advisory[3]	Non-zero MCLGs		
Groundwater - ug/L Site-wide (Residential Scenario)														
	1,4-Dichlorobenzene	75	75	75	0.42	4.2	42	466	- -	- -	- -	- -	75	MCL
	Benzene	5	5	5	0.39	3.9	39	29	- -	- -	- -	- -	5	MCL
	Chloroform	- -	- -	- -	0.19	1.9	19	84	- -	- -	- -	- -	0.19	ILCR=10^{-6}
	Ethylbenzene	700	700	700	1.3	13	130	668	- -	- -	- -	700	700	MCL
	Methyl tert-butyl ether	- -	40	40	12	124	1238	2647	- -	- -	- -	- -	40	GQS
	Trichloroethene	5	5	5	0.44	4.4	44	2.6	- -	- -	- -	- -	5	MCL
	Vinyl chloride	2	2	2	0.015	0.15	1.5	36	- -	- -	- -	- -	2	MCL
	1,4-Dioxane	- -	- -	- -	0.67	6.7	67	468	- -	- -	- -	- -	0.67	ILCR=10^{-6}
	4-Chloroaniline	- -	- -	- -	0.32	3.2	32	59	- -	- -	- -	- -	0.32	ILCR=10^{-6}
	Atrazine	3	- -	3	0.26	2.6	26	487	- -	- -	- -	3	3	MCL
	Benzo(a)anthracene	- -	- -	- -	0.029	0.29	2.9	N/A	- -	- -	- -	- -	0.029	ILCR=10^{-6}
	Benzo(a)pyrene	0.2	0.2	0.2	0.0029	0.029	0.29	N/A	- -	- -	- -	- -	0.2	MCL
	Benzo(b)fluoranthene	- -	- -	- -	0.029	0.29	2.9	N/A	- -	- -	- -	- -	0.029	ILCR=10^{-6}
	bis(2-Ethylhexyl)phthalate	6	- -	6	4.8	48	480	313	- -	- -	- -	- -	6	MCL
	Indeno(1,2,3-cd)pyrene	- -	- -	- -	0.029	0.29	2.9	N/A	- -	- -	- -	- -	0.029	ILCR=10^{-6}
	Naphthalene	- -	20	100	0.14	1.4	14	6.1	- -	- -	- -	- -	20	RIDEM Rem. Regs.
	Aroclor-1242	0.5	0.5	0.5	0.034	0.34	3.4	0.31	- -	- -	- -	- -	0.5	MCL
	Aroclor-1248	0.5	0.5	0.5	0.034	0.34	3.4	0.31	- -	- -	- -	- -	0.5	MCL
	Aroclor-1254	0.5	0.5	0.5	0.034	0.34	3.4	0.31	- -	- -	- -	- -	0.5	MCL
	Aldrin	- -	- -	- -	0.0040	0.040	0.40	0.47	- -	- -	- -	- -	0.0040	ILCR=10^{-6}
	Dieldrin	- -	- -	- -	0.0015	0.015	0.15	0.28	- -	- -	- -	- -	0.0015	ILCR=10^{-6}
	Aluminum	- -	- -	- -	N/A	N/A	N/A	15540	- -	- -	- -	- -	15540	HQ = 1
	Arsenic	10	- -	10	0.045	0.45	4.5	4.7	- -	- -	- -	- -	10	MCL
	Cadmium	5	5	5	N/A	N/A	N/A	6.9	- -	- -	- -	5	5	MCL
	Cobalt	- -	- -	- -	N/A	N/A	N/A	4.7	- -	- -	- -	- -	4.7	HQ = 1
	Iron	- -	- -	- -	N/A	N/A	N/A	10878	- -	- -	- -	- -	10878	HQ = 1
	Lead[4]	15	15	15	N/A	N/A	N/A	N/A	- -	- -	- -	- -	15	Fed Actn Lvl
	Manganese	- -	- -	- -	N/A	N/A	N/A	322	- -	- -	300	- -	300	Health Adv.
	Thallium	2	2	2	N/A	N/A	N/A	0.16	- -	- -	- -	0.5	0.5	non-zero MCLG

Notes

MCL - Maximum Contaminant Level

MCLG - Maximum Contaminant Level Goal

GQS - Rhode Island Groundwater Quality Standards, June 2010

RIDEM Rem. Regs. - RIDEM Remediation Regulations, DEM-DSR-01-93, February 2004, Table 3 (GA Objectives)

ILCR - Incremental Lifetime Cancer Risk

HQ - Hazard Quotient

N/A - Not carcinogenic, or a carcinogen was not evaluated for potential non-carcinogenic effects

1. While there are some wells which may be considered site-specific background in the RI report, the data set covers multiple flow zones and is not robust enough to use as background for PS development; - - = not applicable
2. No specific background values are currently available from Rhode Island; - - = not applicable
3. Health Advisory on Manganese (EPA-822-R-04-003; January 2004)
4. Lead was identified in the HHRA as a risk-driver, however, it was not quantitatively evaluated. Lead is regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps to correct that.

TABLE 3-5
ECOLOGICAL PRGS FOR SOIL

Area	COC	Recommended PRG (mg/kg) [1]
J.M. Mills Landfill (small omnivorous birds)	Cadmium (Cd)	3.93
Unnamed Island (small omnivorous birds)	Lead (Pb)	161
	BEHP	6.2

Notes
COC - Contaminant of Concern
PRG - Preliminary Remediation Goal
BEHP - bis(2-ethylhexyl)phthalate

[1] Refer to Appendix D for development of recommended PRGs

TABLE 3-6
ECOLOGICAL PRGs FOR SEDIMENT

Area	Contaminant	PRG[1] (mg/kg)	PRG[1] Basis
Ponds on the Unnamed Island			
Ponds A, D, and E	Cadmium (Cd)	9.8	Reference - No Effects
	Chromium (Cr)	120	Reference - No Effects
	Copper (Cu)	160	Reference - No Effects
	Lead (Pb)	300	Reference - No Effects
	Zinc (Zn)	490	Reference - No Effects
	Total PAHs	18	Reference - No Effects
Ponds Adjacent to the Blackstone River			
Pond I	Cadmium (Cd)	9.8	Reference - No Effects
	Chromium (Cr)	120	Reference - No Effects
	Copper (Cu)	160	Reference - No Effects
	Total PAHs	18	Reference - No Effects
Pond N	Cadmium (Cd)	9.8	Reference - No Effects

Notes

[1] Refer to Appendix D for development of PRGs

PRG - Preliminary Remediation Goal

PAHs - Polycyclic aromatic hydrocarbons

Table 4-1
Initial Screening of Potentially Applicable Technologies and Process Options for Groundwater

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

General Response	Potential Remedial	Process Option	Description	Retained? (Yes/No)	Initial Screening
No Further Action	None	None	No additional action.	Yes	Used as a baseline for comparison to other process options.
Institutional Controls	Access Restrictions	Deed Restrictions	Deed restrictions issued for property in potentially contaminated areas to control groundwater use.	Yes	Potentially implementable.
	Scheduled Monitoring	Water-Level Monitoring and Groundwater Sampling	Ongoing monitoring of wells.	Yes	Potentially implementable.
Containment	Vertical Subsurface Barrier	Slurry Wall	Trenches surrounding area of contamination are filled with soil and/or cement bentonite slurry.	No	Not relevant as groundwater plume is in equilibrium and does not require containment.
		Grout Curtain	Pressure injection of grout to depth of contamination in closely spaced boreholes.	No	Not relevant as groundwater plume is in equilibrium and does not require containment.
		Sheet Piling	Steel sheet piling driven to depth around the area of contamination.	No	Not relevant as groundwater plume is in equilibrium and does not require containment.
Removal	Hydraulic Control	Phytoremediation	Use of plants to extract groundwater from the subsurface.	Yes	Potentially implementable in areas off the caps. Results in volatilization of volatile organic compounds (VOCs), but has the potential for bioaccumulation of dissolved metals.
		Groundwater Extraction	Use extraction wells or trenches to pump large volumes of water. Typically requires ex-situ treatment to meet discharge criteria.	Yes	Results in physical removal of dissolved constituents of concern and reduces potential for plume migration.
In-Situ Treatment	Attenuation	Monitoring Natural Attenuation	Natural subsurface processes are allowed to reduce contaminant concentrations to acceptable levels.	Yes	Potentially implementable.
	Chemical Treatment	Enhanced Anaerobic Biodegradation	Injection of electron donors promote reducing environment enhancing anaerobic dechlorination.	No	High groundwater velocities limit practibility. Not effective on all dissolved metals and associated reduced conditions have potential to mobilize stable metals.
		Chemical Oxidation	Injection of chemical oxidant results in destruction of organic compounds.	Yes	Not effective on all dissolved metals and limited effectiveness on polycyclic aromatic hydrocarbons, but effective on VOCs, which are currently the only exceedances. Short treatment duration requires that source removal be completed for it to be effective.
In-Situ Treatment	Physical Treatment	Air Sparging	Injection of air below the groundwater table to physically strip VOCs from groundwater. Resulting increase in oxygen concentration promotes aerobic biodegradation of aromatic hydrocarbons.	Yes	Potentially implementable in areas downgradient of caps.
Ex-Situ Treatment	Physical Treatment	Air Stripping	Extracted groundwater is treated with an air stripping tower.	Yes	Potentially implementable. Necessary component for treatment of VOCs associated with groundwater extraction.

Shading indicates that the process option was eliminated during the initial screening stage.

Table 4-2
Initial Screening of Potentially Applicable Technologies and Process Options for Soil - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

General Response Action	Potential Remedial Technology	Process Option	Description	Retained? (Yes/No)	Initial Screening
No Further Action	None	None	No additional action.	Yes	Used as a baseline for comparison to other process options.
Institutional Controls	Access Restrictions	Deed Restrictions	Deed restrictions issued for property in potentially contaminated areas to control land use.	Yes	Potentially implementable, if there is a deed for the Unnamed Island. Deed restrictions would not limit potential ecological receptor contact with soils.
		Fencing	Fencing will minimize access to impacted soils and waste material.	Yes	Potentially implementable.
	Scheduled Monitoring	Soil Sampling	Ongoing monitoring of soils.	Yes	Potentially implementable.
Containment	Capping	Geosynthetic Membrane	Impermeable manufactured geosynthetic membrane placed over impacted areas.	Yes	Potentially implementable. Would prevent receptor contact and reduce surface-water infiltration.
		Geotextile Fabric and Overburden Stone Material	Permeable cap placed over impacted areas.	Yes	Potentially implementable. Would prevent receptor contact.
		Compacted Clay Cover	Impermeable cap placed over impacted areas.	Yes	Potentially implementable. Would prevent receptor contact and reduce surface-water infiltration.
		Vegetative Cover	Vegetation planted within and around impacted areas to prevent future contamination.	No	Not implementable. Would not sufficiently prevent receptor contact.
Removal	Excavation	Offsite Landfill Disposal	Physical removal of impacted soil with offsite disposal.	Yes	Potentially implementable for targeted areas. Significant excavation of subsurface material and disturbance of existing vegetation could create erosion issues and impact drainage areas downriver.
		Onsite Consolidation and Capping	Physical removal of impacted soil and consolidation at onsite capped location.	Yes	Potentially implementable for targeted areas. Significant excavation of subsurface material and disturbance of existing vegetation could create erosion issues and impact drainage areas downriver.
In-Situ Treatment	Physical/ Chemical	Monitored Natural Attenuation	Natural processes, such as volatilization, biodegradation, and chemical reactions are allowed to reduce contaminant concentrations to acceptable levels.	No	Not technically implementable due to limited effectiveness on the metals.
	Chemical Treatment	Chemical Oxidation	Use of chemical oxidant (Fenton's Reagent/hydrogen peroxide, permanganate, or persulfate) to oxidize contaminants in-situ.	No	Not technically implementable due to limited effectiveness on the constituents of concern (COCs) known to be present at the site.
	Physical Treatment	Thermal Desorption/Destruction	Use of in-situ electrodes or heater wells to desorb or destroy contaminants in-situ.	No	Not technically implementable due to areal extent of contamination and applicability to soil types and site conditions is questionable.
	Biological Treatment	Aerobic/Anaerobic Bioremediation	The injection of a substrate to stimulate native microorganisms and degrade contaminants.	No	Not technically implementable due to limited effectiveness on the COCs known to be present at the site.

Table 4-2
Initial Screening of Potentially Applicable Technologies and Process Options for Soil - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

General Response Action	Potential Remedial Technology	Process Option	Description	Retained? (Yes/No)	Initial Screening
Ex-Situ Treatment	Physical Treatment	Soil Washing	Contaminants are removed from the soil by washing and the soil can be reused.	No	Significant excavation of subsurface material and disturbance of existing vegetation could create erosion issues and impact drainage areas downriver. Additional costs for treatment in addition to excavation costs reduces this technology's implementability/cost-effectiveness.
		Stabilization/Soil Mixing	Contaminants are immobilized by mixing with cement or fly ash, and the mixture can be returned to an open excavation or used in concrete or asphalt construction.	No	Significant excavation of subsurface material and disturbance of existing vegetation could create erosion issues and impact drainage areas downriver. Additional costs for treatment in addition to excavation costs reduces this technology's implementability/cost-effectiveness.
		Incineration	Soils incinerated at high temperatures.	No	Significant excavation of subsurface material and disturbance of existing vegetation could create erosion issues and impact drainage areas downriver. Additional costs for treatment in addition to excavation costs reduces this technology's implementability/cost-effectiveness.
	Chemical Treatment	Chemical Oxidation	Involves destroying contaminants by changing the oxidation state using chemical oxidants.	No	Significant excavation of subsurface material and disturbance of existing vegetation could create erosion issues and impact drainage areas downriver. Additional costs for treatment in addition to excavation costs reduces this technology's implementability/cost-effectiveness.

Shading indicates that the process option was eliminated during the initial screening stage.

Table 4-3
Initial Screening of Potentially Applicable Technologies and Process Options for Sediment

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

General Response Action	Potential Remedial Technology	Process Option	Description	Retained? (Yes/No)	Initial Screening
No Further Action	None	None	No additional action.	Yes	Used as a baseline for comparison to other technologies.
Institutional Controls	Access Restrictions	Deed Restrictions	Deed restrictions issued for property in potentially contaminated areas to control land use or maintain a remedial action.	Yes	Potentially implementable to maintain the remedial action. Deed restrictions would not limit potential ecological receptor contact with sediments.
		Fencing	Fencing will minimize access to impacted sediments.	Yes	Not implementable, as fencing would not limit potential ecological receptor contact with sediments.
	Scheduled Monitoring	Sediment Sampling	Ongoing monitoring of sediment quality.	No	Sediment impacts not uniform and are constantly changing due to influence of river flooding. Monitoring changing impacts would yield inconsistent monitoring data from which no trends could be derived.
	Biota Management	Exclude Habitat from Any Impacts from Site Contaminants.	Exclude habitat from any impacts from site contaminants.	No	Not implementable. Infeasible to exclude benthic organisms.
		Habitat Modification	Modify habitat to minimize impacts from site contaminants (e.g., setting up barriers around selected areas).	No	Not implementable. Infeasible to exclude benthic organisms.
Containment	Capping/Burial	Geosynthetic Membrane	Impermeable manufactured geosynthetic membrane placed over impacted areas, then covered with riprap rock.	Yes	Potentially technically implementable. Placement of rirap would eliminate the substrate needed to maintain benthic organisms, which may not be administratively implementable.
		Clean Fill; potential Riprap Cover; potential use of amendments to stabilize contaminants	Burial of sediments under clean fill and potentially covered with riprap to prevent erosion. Amendments may be used to stabilize contaminants.	Yes	Potentially technically implementable. Placement of rirap would eliminate the substrate needed to maintain benthic organisms, which may not be administratively implementable. Recent studies show that there are potential amendments which could be used to stabilize contaminants such that erosion/migration is limited.
Removal	Excavation/Dredging	Offsite Landfill Disposal	Physical removal of impacted soil with offsite disposal.	Yes	Potentially implementable.
		Onsite Consolidation and Capping	Physical removal of impacted soil and consolidation at onsite capped location.	Yes	Potentially implementable.
In-Situ Treatment	Physical	Stabilization	Use of chemical oxidant (Fenton's Reagent/hydrogen peroxide, permanganate, or persulfate) to oxidize contaminants in-situ.	No	Not technically implementable due to limited effectiveness on the varied nature of constituents of concern (volatile organic compounds, polycyclic aromatic hydrocarbons, metals, polychlorinated biphenyls) known to be present at the site.
Ex-Situ Treatment	Physical	Stabilization/Soil Mixing	Contaminants are immobilized by mixing with cement or fly ash and the mixture can be returned to an open excavation or used in concrete or asphalt construction.	No	Significant excavation of subsurface material and disturbance of existing vegetation could create erosion issues and impact drainage areas downriver.
	Physical/Chemical	Incineration	Soils incinerated at high temperatures.	No	Excavation, treatment, and replacement of sediments would disturb existing habitat.
	Chemical Treatment	Chemical Oxidation	Involves destroying contaminants by changing the oxidation state using	No	Excavation, treatment, and replacement of sediments would disturb existing habitat.

Shading indicates that the process option was eliminated during the initial screening stage.

Table 5-1
Secondary Screening of Potentially Applicable Technologies and Process Options for Groundwater

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

General Response Action	Potential Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Comments
No Further Action	None	None	Not applicable	High	NA*	Retain.
Institutional Controls	Access Restrictions	Deed Restrictions	High	High	Low	Retain.
	Scheduled Monitoring	Water-Level Monitoring and Groundwater Sampling	Moderate	High	Low	Retain.
Removal	Hydraulic Control	Groundwater Extraction Wells	Low	Moderate	High	Eliminated as a removal option due to high cost and low effectiveness on a stable plume where containment is not required.
		Phytoremediation	Low	High	Moderate	Retained as a removal option. Existing plume is stable and containment not required.
In-Situ Treatment	Attenuation	Monitoring Natural Attenuation	High	High	Moderate	Eliminated; while there is some evidence of attenuation, there is not enough data to establish lines of evidence justifying the use of this technology to achieve RAOs
	Chemical Treatment	Chemical Oxidation	Moderate	Moderate	Moderate to Low	Retained as potential method to address VOCs.
	Physical Treatment	Air Sparging	Moderate	Low	Moderate	Eliminated as would only address VOCs and has limited implementability to areas downgradient of the cap.
Ex-Situ Treatment	Physical Treatment	Air Stripping	Moderate	Low	Moderate	Eliminated as the groundwater extraction wells required for ex-situ treatment have been eliminated, and would only address VOCs.

Notes:
Shading indicates that the process option was eliminated during the screening stage.
* Indicates costs associated with no further action are nill; however, there are costs associated with properly decommissioning existing monitoring wells.
NA = not applicable
PAH = polycyclic aromatic hydrocarbon
VOC = volatile organic compound

Table 5-2
Secondary Screening of Potentially Applicable Technologies and Process Options for Soils - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

General Response Action	Potential Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Comments
No Further Action	None	None	--	--	--	Retain. Required by NCP and USEPA guidance as a baseline for comparison to other process options.
Institutional Controls	Access Restrictions	Deed Restrictions	Moderate to high. Effective for protection of potential onsite receptors by reducing potential for exposure, but does not reduce environmental impacts or prevent leaching of contaminants from source areas.	High	Low. Negligible costs	Retain. Conventional technology to be considered in conjunction with other technologies if a deed and property owner can be identified.
		Fencing	Low to moderate. Effective for protection of potential onsite receptors by reducing potential for exposure, but does not reduce environmental impacts or prevent leaching of contaminants from source areas. Periodic flooding of the island will further reduce effectiveness of fencing.	High	Low	Eliminated due to periodic flooding of the island.
	Scheduled Monitoring	Soil Sampling	Low. Effective in identifying changing conditions but does not reduce potential for exposure or prevent leaching of contaminants from source areas.	High	Low to Moderate	Low effectiveness, as does not reduce potential for exposure or prevent leaching of contaminants.
Containment	Capping	Geosynthetic Membrane	High. Would prevent receptor contact and prevent leaching of contaminants from source areas.	Low to moderate. Will require mobilizing equipment to an areas with access limitations and floodplain compensation.	Moderate to high depending on access limitations.	Eliminated due to island access limitations and likely need for floodplain compensation
		Geotextile Fabric and Overburden Stone Material	Moderate to high. Effective for protection of potential onsite receptors by reducing potential for exposure, but does not reduce environmental impacts or prevent leaching of contaminants from source areas.	Moderate. Will require mobilizing equipment to an areas with access limitations.	Moderate	Retain. Conventional technology that would prevent receptor contact.
		Compacted Clay Cover	Low to moderate	Low	Moderate	Eliminated due to island access limitations and flooding.
Removal	Excavation	Offsite Landfill Disposal	High. Would prevent receptor contact and prevent leaching of contaminants from source areas.	Low to moderate. Will require mobilizing equipment to an areas with access limitations.	Moderate to high depending on access limitations.	Retain for targeted areas, may be considered in conjunction with other technologies. Conventional technology that would prevent receptor contact.
		Onsite Consolidation and Capping	Moderate to high. Would prevent receptor contact and depending on the cap type would prevent leaching of contaminants from source areas.	Low to moderate. Will require mobilizing equipment to an areas with access limitations.	Moderate to high depending on access limitations.	Retain for targeted areas, may be considered in conjunction with other technologies. Conventional technology that would prevent receptor contact.

Notes:
Shading indicates that the process option was eliminated during the screening stage.
NCP = National Contingency Plan
USEPA = United States Environmental Protection Agency

Table 5-3
Components of Remedial Alternatives for Soil/Waste - Nunes Parcel

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Alternative	Key Component
NP-SO-1: No Action	None
NP-SO-2: RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill; Consolidation; and Institutional Controls	Permitting Implement deed restrictions Demolition of building structures with potential recycling/reuse of select demolition material Removal and placement of other surface waste/Pond I sediments and surrounding soils Site grading Install Resource Conservation and Recovery Act (RCRA) Subtitle D cap; which meets state Solid Waste Regulations Implement landfill gas control system Evaluate leachate collection requirements Install fencing Long-term maintenance
NP-SO-3: RCRA Subtitle C Cap of Landfill; Consolidation; and Institutional Controls	Permitting Implement deed restrictions Demolition of building structures with potential recycling/reuse of select demolition material Removal and placement of other surface waste/Pond I sediments and surrounding soils Site grading Install RCRA Subtitle C Cap Implement landfill gas control system Evaluate leachate collection requirements Install fencing Long-term maintenance

Table 5-4
Components of Remedial Alternatives for Soil/Waste - J.M. Mills Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Alternative	Key Component
JM-SO-1: No Action	None
JM-SO-2: Full RCRA Subtitle C Cap of Landfill, Removal of Soil Exceeding Preliminary Remediation Goals (PRGs) from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	Permitting Implement deed restrictions Clear and grub landfill Site grading Install Resource Conservation and Recovery Act (RCRA) Subtitle C Cap Implement landfill gas control system Evaluate leachate collection requirements Clear and grub floodplain and riverbank Removal and placement of debris fields under site cap Excavate soil exceeding PRGs Transport soil and place under neighboring and/or Nunes Parcel cap(s) Restore floodplain and riverbank Install fencing Long-term maintenance
JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	Permitting Implement deed restrictions Clear and grub landfill Site grading Install combination RCRA Subtitle C Cap/perimeter soil cap Implement landfill gas control system Evaluate leachate collection requirements Clear and grub floodplain and riverbank Removal and placement of debris fields under site cap Excavate soil exceeding PRGs Transport soil and place under neighboring and/or Nunes Parcel cap(s) Restore floodplain and riverbank Install fencing Long-term maintenance

Table 5-5
Components of Remedial Alternatives for Soil/Waste - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Alternative	Key Component
UI-SO-1: No Action	None
UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls	Permitting Implement deed restrictions Clear and grub remediation area Removal and placement at J.M. Mills or Nunes Parcel of soil PRG exceedances, surface waste and debris Placement of geotextile fabric and stone cover where exceedances remain Long-term maintenance
UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs	Permitting Clear and grub remediation area Removal and placement at J.M. Mills or Nunes Parcel of soil exceedances and waste

Table 5-6
Secondary Screening of Potentially Applicable Technologies and Process Options for Sediments

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

General Response Action	Potential Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Comments
No Further Action	None	None	--	--	NA	Retain. Required by NCP and USEPA guidance as a baseline for comparison to other process options.
Institutional Controls	Access Restrictions	Deed Restrictions	Low. Does not limit potential ecological receptor contact with sediments. Would be used in maintenance of a remedial action.	High	Low. Negligible costs	Deed restrictions would not limit potential ecological receptor contact with sediments.
Containment	Capping/Burial	Geosynthetic Membrane and Riprap	High. Would prevent receptor contact and prevent leaching of contaminants from impacted sediments to surface water.	Moderate. Will require mobilizing equipment to areas with access limitations.	Moderate	Retain. Conventional technology that would prevent receptor contact and reduce leaching to surface water.
		Clean Fill; potential Riprap Cover; potential use of amendments to stabilize contaminants	Moderate to high. Effective for protection of potential onsite receptors by reducing potential for exposure, but clean fill alone does not reduce environmental impacts or prevent leaching of contaminants to surface water. Use of amendments may reduce leaching.	Moderate. Will require mobilizing equipment to an area with access limitations.	Moderate	Retain. Conventional technology that would prevent receptor contact.
		Compacted Clay Cover	High	Low	Moderate	Due to island access limitations and flooding, implementability is low.
Removal	Excavation/ Dredging	Offsite Landfill Disposal	High. Would prevent receptor contact and prevent leaching of contaminants from impacted sediments to surface water.	Moderate. Will require mobilizing equipment to areas with access limitations.	High	Eliminated due to additional costs for offsite disposal in comparison with onsite consolidation and capping.
		Onsite Consolidation and Capping	High. Would prevent receptor contact and prevent leaching of contaminants from impacted sediments to surface water.	Moderate. Will require mobilizing equipment to an area with access limitations.	Moderate	Retain. Conventional technology that would prevent receptor contact and reduce leaching to surface water.

Notes:
Shading indicates that the process option was eliminated during the screening stage.
NA = not applicable
NCP = National Contingency Plan
USEPA = United States Environmental Protection Agency

Table 6-1
Screening of Remedial Alternative for Groundwater GW-1: No Action

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, no further action would be taken to address groundwater impacts.

Effectiveness	Implementability	Cost
Advantages		
There is presently limited public access. Natural attenuation processes and groundwater flux through the site would continue to reduce groundwater concentrations.	Easily implemented.	Minimial costs to properly abandon existing monitoring wells and restore site.
Disadvantages		
Would not reduce contaminant mobility. Future use likely to be limited. It is not protective of human receptors.	May require future remedial action.	May defer eventual future capital and operation and maintenance expenditures if future remediation is required.

Conclusion: The No Action Alternative would not achieve the remedial action objectives;however, it is retained as a baseline for comparison to the remaining alternatives as is required by the National Contingency Plan.

Table 6-2
Screening of Remedial Alternative for Groundwater GW-2:
Institutional Controls and Long-Term Monitoring

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, the extent of groundwater impacts would be registered on the property deed to notify property owners that use of the groundwater is prohibited. Long-term monitoring would be conducted to confirm that groundwater quality remains within remedial action objectives.

Effectiveness	Implementability	Cost
Advantages		
Would prevent receptor access through institutional controls. Provides long-term protection. Current monitoring data indicates site-specific groundwater velocities are high and that attenuation processes are occurring.	Conventional technology.	Provides for long-term planning of predictable monitoring costs.
Disadvantages		
	May require additional monitoring wells to improve long-term data resolution.	Long-term operation and maintenance costs.

Conclusion: This alternative would be protective of human health by limiting exposure to impacted groundwater. This alternative is retained for detailed analysis.

Table 6-3
Screening of Remedial Alternative for Groundwater GW-3:
Institutional Controls, Long-Term Monitoring, and Phytoremediation

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, institutional controls and long-term monitoring would be combined with phytoremediation to control groundwater migration and reduce the overall time to achieve remedial action objectives.

Effectiveness	Implementability	Cost
Advantages		
Would prevent receptor access through institutional controls. Would reduce surface-water infiltration and contaminant mobility. Would reduce contaminant mass. Provides long-term protection.	Conventional technology.	Moderate installation costs.
Disadvantages		
Potential for phytoaccumulation of metals in plant material. Limited exceedances of Performance Standards (PSs) in zones potentially appropriate for the technology.	Life cycle duration requires long-term maintenance of phytobarrier Phytoremediation barrier is seasonally dormant. Phytoremediation depth will be limited to the depth of the tree roots.	Long-term maintenance costs.

Conclusion: This alternative would be protective of human health by limiting exposure to impacted groundwater, but due to limited exceedances of PSs in zones potentially appropriate for the technology, the effectiveness would be limited. This alternative is not retained for detailed analysis.

Table 6-4
Screening of Remedial Alternative for Groundwater GW-4:
Institutional Controls, Long-Term Monitoring, and Chemical Oxidation

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, institutional controls and long-term monitoring would be combined with active groundwater treatment using chemical oxidation to reduce the overall time to achieve remedial action objectives.

Effectiveness	Implementability	Cost
Advantages		
Would prevent receptor access through institutional controls. Would reduce contaminant mass. Provides long-term protection.	Conventional technology.	Moderate construction costs.
Disadvantages		
Recent groundwater sampling indicates long-term trends have reduced many contaminants in monitoring wells. Potential for mobilization of contaminants.	Multiple treatments events are typically required. Area to be treated is below the Nunes Parcel cap (proposed location) and will be inaccessible following implementation of source area remedy.	

Conclusion: This alternative would be protective of human health by limiting exposure to impacted groundwater, but appears to be unnecessary given the documented decline in contaminant concentrations. This alternative is not retained for detailed analysis.

Table 6-5
Screening of Remeidal Alternative JM-SO-1: No Action - J.M. Mills Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, no action would be taken to address soils in contact with buried waste.

Effectiveness	Implementability	Cost
Advantages		
There is presently limited public access. Natural attenuation processes would reduce soil concentrations.	Easily implemented.	No capital or operation and maintenance (O&M) costs would be required.
Disadvantages		
Would not reduce contaminant mobility. Future use may entail greater site access and use. It is not protective of ecological or human receptors.	May require future remedial action.	May require future capital and O&M expenditures if future remediation is required.

Conclusion: The No Action Alternative would not be protective of human health or the environment, but is retained as a baseline for comparison to the remaining alternatives as is required by the National Contingency Plan.

Table 6-6
Screenign of Remedial Alternative JM-SO-2:
Presumptive Approach: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, the existing landfill would be regraded to allow for construction of a RCRA Subtitle C Cap system. Soil exceedances on the floodplain and riverbank would be addressed by excavating and placing material under the proposed cap here or at the Nunes Parcel. Debris fields would be addressed. Deed restrictions and fencing would be used to control future land use and limit access.

Effectiveness	Implementability	Cost
Advantages		
Would prevent receptor access through institutional controls, fencing, and capping the waste. Significantly reduces surface-water infiltration Contamination consolidated. Provides long-term protection.	Conventional technology.	
Disadvantages		
Would not reduce contaminant toxicity.	Would require significant regrading of the existing slopes. The regrading efforts would likely create odors that may potentially be noticeable to nearby residential populations. Constructability issues given the restriction on the north (railroad) and south (floodplain). Space and access limitations are major constraints for the installation of the geosynthetic deployment. Traffic associated with delivery of construction material will be high and may pose complications with existing traffic conditions. Removal of mature trees on floodplain and along riverbank with larger footprint associated with increased cap thickness. Increased cap thickness associated with final cover profile requires larger amounts of soil/waste removal and landfill shaping and grading.	High capital costs. Long-term operation and maintenance costs.

Conclusion: This alternative would be protective of human health and the environment by limiting exposure to the waste materials. Contaminant mass and mobility would be reduced by soil removal and reducing surface-water infiltration. This alternative is retained for detailed analysis.

Table 6-7
Screening of Remedial Alternative JM-SO-3:

Presumptive Approach: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, the existing landfill would be regraded to allow for construction of a RCRA Subtitle C cap system over the flatter slopes (upper 33% of the landfill) and a perimeter soil cap over the steeper slopes (lower 67% of the landfill). Soil PRG exceedances on the floodplain and riverbank would be addressed by excavating and placing material under the proposed cover here or at the Nunes Parcel. Debris fields would be addressed. Deed restrictions and fencing would be used to control future land use and limit access.

Effectiveness	Implementability	Cost
Advantages		
Would prevent receptor access through institutional controls, fencing, and capping the waste (in the RCRA Subtitle C cap area). Would reduce surface water infiltration and contaminant mobility. Contamination consolidated. Provides long-term protection.	Conventional technology. Decreased cap thickness associated with final cover profile requires a lesser amount of soil/waste removal and landfill shaping and grading. Smaller regrading effort would create less odors to nearby populations. Reduced truck traffic relative to other active alternative.	Moderate construction costs
Disadvantages		
Would not reduce contaminant toxicity. Does not fully prevent exposure to receptor in soil cap area, nor does it meet hazardous waste closure standards.	Would require significant regrading of the existing slopes. Constructability issues given the restriction on the north (railroad) and south (floodplain). Removal of mature trees on floodplain and along riverbank.	Long-term operation and maintenance costs.

Conclusion: This alternative would not be effective in preventing exposure to receptors in the soil cap area, but is retained for detailed analysis for comparative purposes.

Table 6-8
Screening of Remedial Alternative NP-SO-1: No Action - Nunes Parcel

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, no action would be take to address soils in contact with buried waste or on the peninsula forming Pond I or near the Rhode Island Department of Environmental Management (RIDEM) Soil Removal Area. No management of the buried canal would be conducted.

Effectiveness	Implementability	Cost
Advantages		
There is presently limited public access. Natural attenuation processes would reduce soil concentrations.	Easily implemented.	No capital or operation and maintenance (O&M) costs would be required.
Disadvantages		
Would not reduce contaminant mobility. Future use may entail greater site access and use. It is not protective of ecological or human receptors.	May require future remedial action.	May require future capital and O&M expenditures if future remediation is required.

Conclusion: The No Action Alternative would not be protective of human health or the environment, but is retained as a baseline for comparison to the remaining alternatives as is required by the National Contingency Plan.

Table 6-9
Screening of Remedial Alternative NP-SO-2:
RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, the building structures would be demolished, building debris and surface waste would be removed for offsite disposal or placed below the cover, as would material from other areas, including the J.M. Mills floodplain and the Unnamed Island. A full RCRA Subtitle D cap, compliant with Rhode Island Deparment of Environmental Management (RIDEM) Solid Waste Regulations, would be constructed over the graded material. Soils from outside the waste area that exceed Preliminary Remediation Goals (PRGs) (the peninsula forming Pond I and the area near the RIDEM Soil Removal Area) would be consolidated under the cap. Deed restrictions and fencing would be used to control future land use and limit access.

Effectiveness	Implementability	Cost
Advantages		
Would prevent receptor access through institutional controls, and fencing. Would reduce surface water infiltration and contaminant mobility. Provides long-term protection.	Conventional technology.	Moderate construction costs.
Disadvantages		
Would not reduce contaminant toxicity. Reduction in contaminant mobility and surface water infiltration would not be reduced to levels that would meet hazardous waste closure standards. Would not prevent receptor exposure to hazardous waste closure standards.	Cap construction will extend to bank of river and will require armoring and elevated level of long-term maintenance. Flood storage mitigation will be required to account for landfill cover.	Long-term operation and maintenance costs.

Conclusion: This alternative would not be effective in preventing exposure to receptors to hazardous waste standards, but is retained for detailed analysis for comparative purposes.

Table 6-10
Screening of Remedial Alternative NP-SO-3:
RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, the building structures would be demolished, building debris and surface waste would be removed for offsite disposal or placed below the cover, as would material from other areas, including the J.M. Mills floodplain and the Unnamed Island. A full RCRA Subtitle C cap would be constructed over the graded material. Soils from outside the waste area that exceed Preliminary Remediation Goals (the peninsula forming Pond I and the area near the Rhode Island Department of Environmental Management Soil Removal Area) would be consolidated under the cap. Deed restrictions and fencing would be used to control future land use and limit access.

Effectiveness	Implementability	Cost
Advantages		
Would prevent receptor access through institutional controls, fencing, and capping the waste. Would reduce surface water infiltration and contaminant mobility. Provides long-term protection.	Conventional technology.	High construction costs.
Disadvantages		
Would not reduce contaminant toxicity.	Cap construction will extend to bank of river and will require armoring and elevated level of long-term maintenance. Flood storage mitigation will be required to account for landfill cover.	Long-term operation and maintenance costs.

Conclusion: This alternative would be protective of human health and the environment by limiting exposure to the waste materials. Contaminant mobility would be reduced by preventing surface water infiltration. This alternative is retained for detailed analysis.

Table 6-11
Screening of Remedial Alternative UI-SO-1: No Action - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, no action would be taken to address soils exceeding Preliminary Remediation Goals (PRGs) or in contact with buried waste.

Effectiveness	Implementability	Cost
Advantages		
There is presently limited public access. Natural attenuation processes would gradually reduce soil concentrations.	Easily implemented.	No capital or operation and maintenance (O&M) costs would be required.
Disadvantages		
Would not reduce contaminant mobility. Future use may entail greater site access and use. It is not protective of ecological or human receptors.	May require future remedial action.	May require future capital and O&M expenditures if future remediation is required.

Conclusion: The No Action Alternative would not be protective of human health or the environment, but is retained as a baseline for comparison to the remaining alternatives as is required by the National Contingency Plan.

Table 6-12
Screening of Remedial Alternative UI-SO-2:
Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, removal to a depth of 2 feet below ground surface of soil exceeding Preliminary Remediation Goals (PRGs), surface waste and debris would be performed and placed under the J.M. Mills and/or Nunes Parcel cap(s). Where remaining soils exceed PRGs, a geotextile and riprap cover would be constructed to eliiminate exposure. Deed restrictions would be used to control future land use and limit access.

Effectiveness	Implementability	Cost
Advantages		
Would prevent receptor access through institutional controls and removal of the soil and waste. Would reduce contaminant mass through targeted removal of soil and waste. Provides long-term protection.	Conventional technology.	Moderate construction costs.
Disadvantages		
Institutional controls would not be effective in limiting potential access by ecological receptors. Flooding conditions may release contaminants from below the rip rap cover and allow receptor exposure.	Limited access to the site creates significant issues with equipment mobilization and transport of materail. Placement of rirap would eliminate the substrate needed to maintain benthic organisms, which may not be administratively implementable.	Long-term operation and maintenance (O&M) costs where cover remains. Flooding conditions on the island may require frequent maintenance of the riprap cover.

Conclusion: This alternative would not be protective of human health and the environment, as receptor exposure may occur due to flooding conditions, but is retained for detailed analysis for comparison purposes.

Table 6-13
Screening of Remedial Alternative UI-SO-3:
Remove/Consolidate All Waste/Soil Exceeding PRGs

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, removal of soil exceeding the lead and bis(2-ethylhexyl)phthalate Preliminary Remediation Goals (PRGs) and all waste would be performed with consolidation at the Nunes Parcel and/or J.M. Mills cap(s). No institutional controls would be required

Effectiveness	Implementability	Cost
Advantages		
Would result in complete removal of the waste and would not require institutional controls Would reduce contaminant mass through removal of soil and waste. Provides long-term protection.	Conventional technology.	No operation and maintenance costs
Disadvantages		
	Limited access to the site creates significant issues with equipment mobilization and transport of materail. Depth of waste (up to 12 ft below ground surface) requires excavation below the water table.	High construction costs. Difficult to determine actual volume of waste. Actual volumes may be significantly higher than estimated volumes.

Conclusion: This alternative would be protective of human health and the environment by limiting exposure to the soil and waste materials. Excavating the soil and waste will be a significant challenge given the site access restrictions. This alternative is retained for detailed analysis.

Table 6-14
Screening of Remedial Alternative for Sediments SE-1: No Action - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, no action would be take to address sediments on the Unnamed Island.

Effectiveness	Implementability	Cost
Advantages		
Natural attenuation processes would reduce sediment concentrations over time.	Easily implemented.	No capital or operation and maintenance (O&M) costs would be required.
Disadvantages		
Would not reduce contaminant mobility. It is not protective of ecological receptors.	May require future remedial action.	May require future capital and O&M expenditures if future remediation is required.

Conclusion: The No Action Alternative would not be protective of human health and the environment, but is retained as a baseline for comparison to the remaining alternatives as is required by the National Contingency Plan.

Table 6-15
Screening of Remedial Alternative for Sediments SE-2:
Remove/Consolidate Sediment Exceeding PRGs

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, sediments exceeding Preliminary Remediation Goals (PRGs) would be removed, stabilized, and placed below the Nunes Parcel and/or J.M. Mills caps. No institutional controls would be implemented.

Effectiveness	Implementability	Cost
Advantages		
Would prevent potential receptor access and the elimination of impacts exceeding PRGs Provides long-term protection.	Conventional technology.	High construction costs. No operation and maintenance required.
Disadvantages		
	Would require disturbing existing habitat during construction. Limited access to the site creates significant issues with equipment mobilization. Best Management Practices would likely allow some sediment dispersal during excavation.	Difficult to determine actual volume of sediment impacts. Actual volumes may be significantly higher than estimated volumes.

Conclusion: This alternative would be protective of human health and the environment by eliminating impacted sediments. This alternative is retained for detailed analysis.

Table 6-16
Screening of Remedial Alternative for Sediments SE-3:
Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, the upper 1 foot of sediments exceeding Preliminary Remediation Goals (PRGs) would be removed, stabilized, and placed below the Nunes Parcel and/or J.M. Mills caps. Where PRG exceedances remain, a geotextile and clean fill would be placed to eliminate an exposure pathway. Deed restrictions would be used to maintain the remedy by controlling future land use and limiting access. Use of amendments to stabilize contaminants in sediment would be evaluated during design.

Effectiveness	Implementability	Cost
Advantages		
Would prevent receptor access through removal and/or covering of the sediment. Deed restrictions would help maintain the remedy. Provides long-term protection. Would reduce contaminant mass through targeted removal of sediment and waste.	Conventional technology.	Moderate construction costs. Readily identifiable extent of removal, allowing accurate estimation of costs prior to beginning removal activities in addition to actual field implementation.
Disadvantages		
Cover materials may be subject to erosion.	Would require disturbing existing habitat during construction. Limited access to the site creates significant issues with equipment mobilization and placement of the geotextile and clean fill cover. Best Management Practices would likely allow some sediment dispersal during excavation.	Long-term operation and maintenance to inspect and maintain cover. Flooding conditions may require frequent maintenance of the cover.

Conclusion: This alternative would be protective of human health and the environment by eliminating impacted sediments. This alternative is retained for detailed analysis.

Table 6-17
Screening of Remedial Alternative for Sediments SE-4:
Subaqueous Cover (No Sediment Removal) with Institutional Controls

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Synopsis: Under this alternative, placement of geotextile and clean fill over impacted sediments would eliminate ecological impacts. Deed restrictions would be used to maintain the remedy by controlling future land use and limiting access. Use of amendments to stabilize contaminants in sediment would be evaluated during design.

Effectiveness	Implementability	Cost
Advantages		
Would prevent receptor access through covering the sediment. Deed restrictions would help maintain the remedy. Provides long-term protection.	Conventional technology. Minimal sediment dispersal.	Moderate construction costs. Readily identifiable scope and estimation of costs prior to beginning implementation of the remedy in addition to actual field implementation.
Disadvantages		
Would not reduce contaminant toxicity. Would not reduce contaminant mass. Cover materials may be subject to erosion.	Would require disturbing existing habitat during construction. Limited access to the site creates significant issues with equipment mobilization and placement of the cover materials. The addition of cover materials may reduce flood storage capacities.	Long-term operation and maintenance to inspect and maintain cover. Flooding conditions may require frequent maintenance of the cover.

Conclusion: This alternative would be protective of human health and the environment by limiting direct exposure to the impacted sediments. Contaminant mass and mobility would not be reduced by the subaqueous cover. This alternative is retained for detailed analysis.

Table 7-1

Summary of Detailed and Comparative Analysis of Groundwater Remedial Action Alternatives

Feasibility Study

Peterson/Puritan, Inc. Superfund Site - Operable Unit 2

Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative GW-1 No Action	Alternative GW-2 Limited Action: Institutional Controls and Long-Term Monitoring
Threshold Criteria				
1)	Overall protection of human health and the environment	Human Health and Environmental Protection	Does not provide overall protection of human health or the environment. Does not minimize, reduce, or control contaminant impacts in groundwater or associated exposure risks.	Protection of human health and the environment achieved through institutional controls and monitoring.
2)	Compliance with ARARs	Chemical-Specific	Does not comply with chemical-specific ARARs.	Institutional controls within the compliance boundary of the waste management area established for the soil remedy will prevent use of contaminated groundwater that exceeds these standards.
		Location-Specific	No location-specific ARARs would apply to this alternative.	This alternative would comply with ARARs during installation of monitoring wells and sampling in and around wetlands.
		Action-Specific	No action-specific ARARs would apply to this alternative.	This alternative would comply with action-specific ARARs related to monitoring and ICs.
Balancing Criteria				
3)	Long-term effectiveness and permanence	Magnitude of Residual Risk	Natural attenuation processes may reduce contaminant concentrations to performance standards (PSs), at which point, residual risk would be below risk criteria within the compliance boundary. However, no long-term groundwater monitoring would be done to indicate where/when/if PSs are met.	Natural attenuation processes may reduce contaminant concentrations to PSs, at which point the residual risk would be below risk criteria within the compliance boundary. Groundwater monitoring would be conducted to confirm PS exceedances do not migrate beyond the compliance boundary.
		Adequacy and Reliability of Controls	There would be no controls to limit access to contaminated groundwater.	Institutional controls would be implemented to limit potential for exposure to impacted groundwater. Five-year reviews will be conducted to assess the effectiveness of the controls.

Table 7-1

Summary of Detailed and Comparative Analysis of Groundwater Remedial Action Alternatives

Feasibility Study

Peterson/Puritan, Inc. Superfund Site - Operable Unit 2

Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative GW-1 No Action	Alternative GW-2 Limited Action: Institutional Controls and Long-Term Monitoring
4)	Reduction of mobility, toxicity, or volume through treatment	Treatment Process Used and Materials Treated	None proposed.	None proposed.
		Amount of Hazardous Materials Destroyed or Treated	This alternative does not include treatment processes.	None, except by natural processes.
		Degree of Expected Reductions in Toxicity, Mobility, and Volume	This alternative does not include treatment processes.	This alternative does not include treatment processes.
		Degree to which Treatment is Irreversible	This alternative does not include treatment processes.	This alternative does not include treatment processes.
		Type and Quantity of Residuals Remaining After Treatment	There is no active treatment, thus no treatment residuals.	There is no active treatment, thus no treatment residuals.
5)	Short-term effectiveness	Protection of Community During Remedial Actions	Not applicable.	Minimal impacts during well installation/monitoring managed through engineering controls.
		Protection of Workers During Remedial Actions	Not applicable.	Minimal impacts during well installation/monitoring managed through engineering controls.
		Environmental Impacts	Not applicable.	Minimal impacts during well installation/monitoring managed through engineering controls.
		Time Until RAOs are Achieved	Insufficient data to estimate time for natural attenuation to achieve RAOs.	RAOs would be achieved upon implementation of institutional controls and a long-term monitoring plan.

Table 7-1

Summary of Detailed and Comparative Analysis of Groundwater Remedial Action Alternatives

Feasibility Study

Peterson/Puritan, Inc. Superfund Site - Operable Unit 2

Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative GW-1 No Action	Alternative GW-2 Limited Action: Institutional Controls and Long-Term Monitoring
6)	Implementability	Ability to Construct and Operate the Technology	Not applicable.	Establishment of institutional controls and a monitoring program is simple.
		Reliability of the Technology	Not applicable.	Institutional controls and monitoring are both reliable technologies.
		Ease of Undertaking Additional Remedial Actions, if Necessary	Will not interfere with the ability to undertake additional remedial actions.	Will not interfere with the ability to undertake additional remedial actions.
		Ability to Monitor Effectiveness of Remedy	Not applicable. Monitoring is not part of this remedy.	Long-term groundwater monitoring would verify the continued protection of human health and the progress of contaminant reduction within the compliance boundary.
		Ability to Obtain Approvals From Other Agencies	Not applicable.	Establishment of institutional controls and a monitoring program would require input from other agencies, but is administratively feasible.
		Coordination with Other Agencies	Not applicable.	Establishment of institutional controls and a monitoring program would require input from other agencies, but is administratively feasible.
		Availability of Offsite Treatment, Storage, and Disposal Services and Capacity	Not applicable.	Not applicable.
		Availability of Necessary Equipment and Specialists	Not applicable.	All necessary equipment and specialists are readily available.
		Availability of Prospective Technologies	Not applicable.	Not applicable.

Table 7-1

Summary of Detailed and Comparative Analysis of Groundwater Remedial Action Alternatives

Feasibility Study

Peterson/Puritan, Inc. Superfund Site - Operable Unit 2

Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative GW-1 No Action	Alternative GW-2 Limited Action: Institutional Controls and Long-Term Monitoring
7)	Cost	Capital Costs	$0	$166,000
		Operating and Maintenance	$0	$505,000
		Present Worth Costs	$0	$671,000
Modifying Criteria				
8)	State Acceptance		Likely not acceptable.	Assessed in the ROD following comment on the FS.
9)	Community Acceptance		Likely not acceptable.	Assessed in the ROD following comment on the FS.

Notes:

All costs are estimated to an accuracy of +50% to -30% (EPA, 2000).

ARAR = applicable or relevant and appropriate requirement

EPA = United States Environmental Protection Agency

FS = Feasibility Study

RAO = remedial action objectives

ROD = Record of Decision

Table 7-2

Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - J.M. Mills Landfill

Feasibility Study

Peterson/Puritan, Inc. Superfund Site - Operable Unit 2

Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative JM-SO-1 No Action	Alternative JM-SO-2 RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	Alternative JM-SO-3 Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls
Threshold Criteria					
1)	Overall protection of human health and the environment	Human Health and Environmental Protection	Does not provide overall protection of human health or the environment. Does not minimize, reduce, or control contaminant impacts in soil or associated exposure risks.	Protection of human health and the environment achieved through removal and/or capping of impacted soils and/or waste that pose risk to humans and the environment.	Does not establish a completely protective physical barrier between potential receptors and contaminated materials in soil and waste. The perimeter soil cap does not fully reduce the infiltration and the potential for leaching of contaminants in soil to groundwater and does not ensure that contamination is not released in the event of a flood.
2)	Compliance with ARARs	Chemical-Specific	Does not comply with chemical-specific ARARs.	Landfill cap will meet ARARs by eliminating exposure to any waste/soil exceeding PRGs. Targeted removal of riverbank and floodplain soils would be conducted to attain ARARs.	The perimeter soil cap may not prevent the release of contaminated material in the event of a flood so this alternative will not fully address chemical-specific ARARs.
		Location-Specific	No location-specific ARARs.	Appropriate planning and all practical means necessary would be used to minimize harm to wetlands, floodplains, adjacent stream, fish, and wildlife.	While appropriate planning and all practical means necessary would be used to minimize harm to wetlands, floodplains, adjacent stream, fish, and wildlife, the proposed combination RCRA C and perimeter soil cap will not meet required standards for withstanding flooding, up to a 500-year storm event, that would alter areas of floodplain and federal jurisdictional wetlands.
		Action-Specific	No action-specific ARARs.	Excavated soils would be handled and disposed of appropriately. Remedy would comply with RCRA C closure requirements and other action-specific ARARs.	Excavated soils would be handled and disposed of appropriately. This alternative would not comply with RCRA closure requirements.

Table 7-2
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - J.M. Mills Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative JM-SO-1 No Action	Alternative JM-SO-2 RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	Alternative JM-SO-3 Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls
Balancing Criteria					
3)	Long-term effectiveness and permanence	Magnitude of Residual Risk	It is not known how effective natural attenuation processes would be in reducing risk, and no long-term monitoring would be done to indicate whether remedial goals are met.	The alternative would address waste and soils that pose a risk to human health and the environment.	The alternative would address waste and soils that pose a risk to human health and the environment.
		Adequacy and Reliability of Controls	There would be no controls to limit access to contaminants in waste or soil.	Removal and/or capping of waste and contaminant-impacted soils provide assurance that this alternative is effective in preventing direct contact and limiting infiltration in the long-term. Five-year reviews will be conducted to assess the effectiveness of the remedy and the institutional controls.	Stormwater percolation through the cover system will be reduced and aerobic conditions will be maintained. Effectiveness and permanence in question with respect to the perimeter soil cap relative to TSCA protectiveness standards, RCRA closure standards, and potential for release of contaminants during flooding scenarios. Five-year reviews will be conducted to assess the effectiveness of the remedy and the institutional controls.
4)	Reduction of mobility, toxicity, or volume through treatment	Treatment Process Used and Materials Treated	None proposed.	No treatment processes involved.	No treatment processes involved.
		Amount of Hazardous Materials Destroyed or Treated	None, except by natural processes.	No treatment processes involved.	No treatment processes involved.
		Degree of Expected Reductions in Toxicity, Mobility, and Volume	Natural processes would be expected to reduce toxicity, mobility, and volume. However, no monitoring would be done to assess expected changes.	No treatment processes involved. It is expected that all identified soils that exceed PRGs would be removed and/or buried/capped.	No treatment processes involved. It is expected that all identified soils that exceed PRGs would be removed and/or buried/capped.

Table 7-2
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - J.M. Mills Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative JM-SO-1 No Action	Alternative JM-SO-2 RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	Alternative JM-SO-3 Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls
4)	Reduction of mobility, toxicity, or volume through treatment	Degree to which Treatment is Irreversible	Not applicable.	No treatment processes involved.	No treatment processes involved.
		Type and Quantity of Residuals Remaining After Treatment	There is no active treatment, thus no treatment residuals.	No treatment processes involved.	No treatment processes involved.
5)	Short-term effectiveness	Protection of Community During Remedial Actions	Not applicable.	Normal construction-related access prohibitions would be in place during site activities. Additional controls will be required along the Blackstone River to restrict public access during construction activities. Truck traffic for hauling a large amount of capping materials will impact the community. May be able to use railroad to reduce truck traffic.	Normal construction-related access prohibitions would be in place during site activities. Additional controls will be required along the Blackstone River to restrict public access during construction activities. Truck traffic for hauling a large amount of capping materials will impact the community. May be able to use railroad to reduce truck traffic.
		Protection of Workers During Remedial Actions	Not applicable.	Normal construction Health and Safety Plans will be in place during site activities.	Normal construction Health and Safety Plans will be in place during site activities.
		Environmental Impacts	Not applicable.	Impacts to environmental receptors are anticipated to be significant. Activities will require removal of all trees on the landfill cap and areas of the riverbank and floodplain where PRGs are exceeded. Armor will be required where riverbank is excavated, and restoration to pre-remedy conditions will not be feasible.	Impacts to environmental receptors are anticipated to be significant. Activities will require removal of all trees on the landfill cap and areas of the riverbank and floodplain where PRGs are exceeded. Armor will be required where riverbank is excavated, and restoration to pre-remedy conditions will not be feasible.
		Time Until RAOs are Achieved	Insufficient data to estimate time for natural attenuation to achieve RAOs.	RAOs are achieved immediately upon completion of capping/excavation/restoration.	RAOs are achieved immediately upon completion of capping/excavation/restoration.

Table 7-2
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - J.M. Mills Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative JM-SO-1 No Action	Alternative JM-SO-2 RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	Alternative JM-SO-3 Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls
6)	Implementability	Ability to Construct and Operate the Technology	Not applicable.	Types of planned activities are not uncommon but are difficult to implement while minimizing environmental impacts to sensitive receptors (Blackstone River and associated wetlands). Large volume of landfill waste requires reshaping to allow for the cap thickness. Approximately 36,000 cy will be transferred to the Nunes Parcel. Physical space restrictions on the north (railroad) and south (floodplain) are major constraints for the installation of the geosynthetic liner. Large amount of cover materials and supplies increases truck traffic through local roads.	Types of planned activities are not uncommon but are difficult to implement while minimizing environmental impacts to sensitive receptors (Blackstone River and associated wetlands). Landfill waste requires reshaping to allow for the cap thickness. Approximately 20,000 cy of waste will be transferred to the Nunes Parcel. Cover materials and supplies requires truck traffic through local roads.
		Reliability of the Technology	Not applicable.	Capping, excavation, and burial technologies are reliable. Maintenance/protection of a competed cover along riverbank is difficult in high-energy fluvial environments where it is necessary to balance reliability with aesthetic concerns.	Capping, excavation, and burial technologies are reliable. Maintenance/protection of a competed cover along riverbank is difficult in high-energy fluvial environments where it is necessary to balance reliability with aesthetic concerns.
		Ease of Undertaking Additional Remedial Actions, if Necessary	Will not interfere with the ability to undertake additional remedial actions.	Upon completion of the capping, it will be difficult to undertake additional remedial actions.	Upon completion of the capping, it will be difficult to undertake additional remedial actions.
		Ability to Monitor Effectiveness of Remedy	Not applicable. Monitoring is not part of this remedy.	Monitoring of surrounding media (i.e., groundwater, surface water, and air) will allow for evaluation of remedy effectiveness. Five-year reviews will be conducted to confirm effectiveness.	Monitoring of surrounding media (i.e., groundwater, surface water, and air) will allow for evaluation of remedy effectiveness. Five-year reviews will be conducted to confirm effectiveness.

Table 7-2

Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - J.M. Mills Landfill

Feasibility Study

Peterson/Puritan, Inc. Superfund Site - Operable Unit 2

Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative JM-SO-1 No Action	Alternative JM-SO-2 RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	Alternative JM-SO-3 Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls
6)	Implementability	Ability to Obtain Approvals From Other Agencies	Not applicable.	The technologies used are widely accepted and should not pose significant approval or coordination hurdles. However, the cap could encroach significantly (due to the need for stability benches) into the river buffer zone and require state wetland evaluations for wildlife, wildlife habitat, recreation and aesthetics, flood protection, suface and groundwater protection, and water quality impacts.	The technologies used are widely accepted and should not pose significant approval or coordination hurdles. However, the cap could encroach into the river buffer zone and require state wetland evaluations for wildlife, wildlife habitat, recreation and aesthetics, flood protection, suface and groundwater protection, and water quality impacts.
		Coordination with Other Agencies	Not applicable.	The technologies used are widely accepted and should not pose significant approval or coordination hurdles.	The technologies used are widely accepted and should not pose significant approval or coordination hurdles.
		Availability of Offsite Treatment, Storage, and Disposal Services and Capacity	Not applicable.	Excavated soils will be largely consolidated onsite. If capacity of landfills does not allow for complete onsite consolidation, volumes are not expected to pose problems for offsite disposal.	Excavated soils will be largely consolidated onsite. If capacity of landfills does not allow for complete onsite consolidation, volumes are not expected to pose problems for offsite disposal.
		Availability of Necessary Equipment and Specialists	Not applicable.	All necessary equipment and specialists are readily available.	All necessary equipment and specialists are readily available.
		Availability of Prospective Technologies	Not applicable.	All necessary technologies are readily available.	All necessary technologies are readily available.
7)	Cost	Capital Costs	$0	$21,063,000	$13,225,000
		Operating and Maintenance	$0	$496,000	$496,000
		Present Worth Costs	$0	$21,559,000	$13,721,000

Table 7-2
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - J.M. Mills Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative JM-SO-1 No Action	Alternative JM-SO-2 RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	Alternative JM-SO-3 Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls
Modifying Criteria					
8)	State Acceptance		Likely not acceptable.	Assessed in the ROD following comment of the FS.	Assessed in the ROD following comment of the FS.
9)	Community Acceptance		Likely not acceptable.	Assessed in the ROD following comment of the FS.	Assessed in the ROD following comment of the FS.

Notes:
All costs are estimated to an accuracy of +50% to -30% (EPA, 2000).
ARAR = applicable or relevant and appropriate requirement
cy = cubic yard
EPA = United States Environmental Protection Agency
FS = Feasibility Study
PRG = Preliminary Remediation Goal
RAO = Remedial Action Objective
RCRA = Resource Conservation and Recovery Act
ROD = Record of Decision
TSCA = Toxic Substances Control Act

Table 7-3
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Nunes Parcel Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative NP-SO-1 No Action	Alternative NP-SO-2 RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls	Alternative NP-SO-3 RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls
Threshold Criteria					
1)	Overall protection of human health and the environment	Human Health and Environmental Protection	Does not provide overall protection of human health or the environment. Does not minimize, reduce, or control contaminant impacts in soil or associated exposure risks.	Protection of human health and the environment achieved through capping of impacted soils and/or waste that pose risk to humans and the environment, although long-term protectiveness is questionable with respect to materials in the landfill. Therefore, not fully protective.	Protection of human health and the environment achieved through capping of impacted soils and/or waste that pose risk to humans and the environment.
2)	Compliance with ARARs	Chemical-Specific	Does not comply with chemical-specific ARARs.	Landfill cap will meet ARARs by eliminating exposure to any waste/soil exceeding PRGs.	Landfill cap will meet ARARs by eliminating exposure to any waste/soil exceeding PRGs.
		Location-Specific	No location-specific ARARs.	Appropriate planning and all practical means necessary would be used to minimize harm to wetlands, floodplains, adjacent stream, fish, and wildlife.	Appropriate planning and all practical means necessary would be used to minimize harm to wetlands, floodplains, adjacent stream, fish, and wildlife.
		Action-Specific	No action-specific ARARs.	This alternative would not comply with RCRA C closure requirements.	This alternative would comply with RCRA C closure requirements and other action-specific ARARs.
Balancing Criteria					
3)	Long-term effectiveness and permanence	Magnitude of Residual Risk	It is not known how effective natural attenuation processes would be in reducing risk, and no long-term monitoring would be done to indicate whether remedial goals are met.	The alternative would address waste and soils that pose a risk to human health and the environment.	The alternative would address waste and soils that pose a risk to human health and the environment.
		Adequacy and Reliability of Controls	There would be no controls to limit access to contaminants in waste or soil.	Capping of waste and contaminant-impacted soils provide assurance that this alternative is effective in preventing direct contact and limiting infiltration in the long-term. Effectiveness and permanence in question with respect to RCRA closure standards and potential for release of contaminants during flooding scenarios. Five-year review will be conducted to assess the effectiveness of the remedy and the institutional controls.	Capping of waste and contaminant-impacted soils provide assurance that this alternative is effective in preventing direct contact and limiting infiltration in the long-term. Five-year review will be conducted to assess the effectiveness of the remedy and the institutional controls.

Table 7-3
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Nunes Parcel Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative NP-SO-1 No Action	Alternative NP-SO-2 RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls	Alternative NP-SO-3 RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls
4)	Reduction of mobility, toxicity, or volume through treatment	Treatment Process Used and Materials Treated	None proposed.	No treatment processes involved.	No treatment processes involved.
		Amount of Hazardous Materials Destroyed or Treated	None, except by natural processes.	No treatment processes involved.	No treatment processes involved.
		Degree of Expected Reductions in Toxicity, Mobility, and Volume	Natural processes would be expected to reduce toxicity, mobility, and volume. However, no monitoring would be done to assess expected changes.	No treatment processes involved. It is expected that all identified soils that exceed PRGs would be capped.	No treatment processes involved. It is expected that all identified soils that exceed PRGs would be capped.
		Degree to Which Treatment is Irreversible	Not applicable.	There is no active treatment.	There is no active treatment.
		Type and Quantity of Residuals Remaining After Treatment	There is no active treatment, thus no treatment residuals.	There is no active treatment, thus no treatment residuals.	There is no active treatment, thus no treatment residuals.
5)	Short-term effectiveness	Protection of Community During Remedial Actions	Not applicable.	Normal construction-related access prohibitions would be in place during site activities. Additional controls will be required along the Blackstone River to restrict public access during construction activities. Truck traffic for hauling a large amount of capping materials will impact the community. May be able to use railroad to reduce truck traffic.	Normal construction-related access prohibitions would be in place during site activities. Additional controls will be required along the Blackstone River to restrict public access during construction activities. Truck traffic for hauling a large amount of capping materials will impact the community. May be able to use railroad to reduce truck traffic.
		Protection of Workers During Remedial Actions	Not applicable.	Normal construction Health and Safety Plans will be in place during site activities.	Normal construction Health and Safety Plans will be in place during site activities.
		Environmental Impacts	Not applicable.	Impacts to environmental receptors are anticipated to be significant. Activities will require removal of all trees on the work area. Armor may be required where the cap approaches the riverbank or is within the floodplain at finish grade.	Impacts to environmental receptors are anticipated to be significant. Activities will require removal of all trees on the work area. Armor may be required where the cap approaches the riverbank or is within the floodplain at finish grade.
		Time Until RAOs are Achieved	Insufficient data to estimate time for natural attenuation to achieve RAOs.	RAOs are achieved immediately upon completion of capping.	RAOs are achieved immediately upon completion of capping.

Table 7-3
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Nunes Parcel Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative NP-SO-1 No Action	Alternative NP-SO-2 RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls	Alternative NP-SO-3 RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls
6)	Implementability	Ability to Construct and Operate the Technology	Not applicable.	Types of planned activities are not uncommon, but are difficult to implement while minimizing environmental impacts to sensitive receptors (Blackstone River).	Types of planned activities are not uncommon, but are difficult to implement while minimizing environmental impacts to sensitive receptors (Blackstone River).
		Reliability of the Technology	Not applicable.	Capping technologies are reliable when implemented correctly. Maintenance/protection of a completed cap adjacent to the riverbank may be difficult depending on finish grade.	Capping technologies are reliable when implemented correctly. Maintenance/protection of a completed cap adjacent to the riverbank may be difficult depending on finish grade.
		Ease of Undertaking Additional Remedial Actions, if necessary	Will not interfere with the ability to undertake additional remedial actions.	Upon completion of the capping, it will be difficult to undertake additional remedial actions.	Upon completion of the capping, it will be difficult to undertake additional remedial actions.
		Ability to Monitor Effectiveness of Remedy	Not applicable. Monitoring is not part of this remedy.	Monitoring of surrounding media (i.e., groundwater, surface water, and air) will allow for evaluation of remedy effectiveness. Five-year reviews will be conducted to confirm effectiveness.	Monitoring of surrounding media (i.e., groundwater, surface water, and air) will allow for evaluation of remedy effectiveness. Five-year reviews will be conducted to confirm effectiveness.
		Ability to Obtain Approvals From Other Agencies	Not applicable.	The technologies used are widely accepted and should not pose significant approval or coordination hurdles. However, the cap could encroach into the river buffer zone and require state wetland evaluations for wildlife, wildlife habitat, recreation and aesthetics, flood protection, suface and groundwater protection, and water quality impacts.	The technologies used are widely accepted and should not pose significant approval or coordination hurdles. However, the cap could encroach into the river buffer zone and require state wetland evaluations for wildlife, wildlife habitat, recreation and aesthetics, flood protection, suface and groundwater protection, and water quality impacts.
		Coordination With Other Agencies	Not applicable.	The technologies used are widely accepted and should not pose significant approval or coordination hurdles.	The technologies used are widely accepted and should not pose significant approval or coordination hurdles.

Table 7-3
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Nunes Parcel Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative NP-SO-1 No Action	Alternative NP-SO-2 RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls	Alternative NP-SO-3 RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls
6)	Implementability	Availability of Offsite Treatment, Storage, and Disposal Services and Capacity	Not applicable.	Contaminated soils will be consolidated onsite. If capacity of landfill does not allow for complete onsite consolidation, volumes are not expected to pose problems for offsite disposal.	Contaminated soils will be consolidated onsite. If capacity of landfill does not allow for complete onsite consolidation, volumes are not expected to pose problems for offsite disposal.
		Availability of Necessary Equipment and Specialists	Not applicable.	All necessary equipment and specialists are readily available.	All necessary equipment and specialists are readily available.
		Availability of Prospective Technologies	Not applicable.	All necessary technologies are readily available.	All necessary technologies are readily available.
7)	Cost	Capital Costs	$0	$4,808,000	$5,956,000
		Operating and Maintenance	$0	$124,000	$124,000
		Present Worth Costs	$0	$4,932,000	$6,080,000
Modifying Criteria					
8)	State Acceptance		Likely not acceptable.	Assessed in the ROD following comment of the FS.	Assessed in the ROD following comment of the FS.
9)	Community Acceptance		Likely not acceptable.	Assessed in the ROD following comment of the FS.	Assessed in the ROD following comment of the FS.

Notes:
All costs are estimated to an accuracy of +50% to -30% (EPA, 2000).
ARAR = applicable or relevant and appropriate requirement
EPA = United States Environmental Protection Agency
FS = Feasibility Study
PRG = Preliminary Remediation Goal
RAO = Remedial Action Objective
ROD = Record of Decision

Table 7-4
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative UI-SO-1 No Action	Alternative UI-SO-2 Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls	Alternative UI-SO-3 Remove/Consolidate All Waste/Soil Exceeding PRGs
Threshold Criteria					
1)	Overall protection of human health and the environment	Human Health and Environmental Protection	Does not provide overall protection of human health or the environment. Does not minimize, reduce, or control contaminant impacts in soil or associated exposure risks.	Protection achieved through removal and/or capping of waste amd impacted soils that pose risk to humans and the environment, although long-term protectiveness is questionable with respect to residual materials. Therefore, not fully protective.	Protection achieved through removal of waste and impacted soils that pose risk to humans and the environment.
2)	Compliance with ARARs	Chemical-Specific	Does not comply with chemical-specific ARARs.	As there is no impermeable layer in the cover, the remedy will not prevent contaminant release during a flood event. Therefore, it does not meet chemical-specific ARARs.	The remedy will meet chemical-specific ARARs by eliminating exposure to any waste/soil exceeding PRGs.
		Location-Specific	No location-specific ARARs.	As there is no impermeable layer in the cover, the remedy will not prevent contaminant release during a flood event. Therefore, it does not meet location-specific ARARs.	Appropriate planning and all practical means necessary would be used to minimize harm to wetlands, floodplains, adjacent stream, fish, and wildlife.
		Action-Specific	No action-specific ARARs.	This alternative would not comply with RCRA C closure requirements.	The remedy would comply with action-specific ARARs.
Balancing Criteria					
3)	Long-term effectiveness and permanence	Magnitude of Residual Risk	It is not known how effective natural attenuation processes would be in reducing risk, and no long-term monitoring would be done to indicate whether remedial goals are met.	The alternative would address waste and soils that pose a risk to human health and the environment.	The alternative would address waste and soils that pose a risk to human health and the environment.
		Adequacy and Reliability of Controls	There would be no controls to limit access to contaminants in soil.	Removal and/or capping of waste and contaminant-impacted soils provide assurance that this alternative is effective in preventing direct contact in the long-term. Effectiveness and permanence in question with respect to RCRA closure standards and potential for release of contaminants during flooding scenarios. Five-year review will be conducted to assess the effectiveness of the remedy and the institutional controls.	Removal of waste and contaminant-impacted soils provide assurance that this alternative is effective in the long-term.

Table 7-4
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative UI-SO-1 No Action	Alternative UI-SO-2 Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls	Alternative UI-SO-3 Remove/Consolidate All Waste/Soil Exceeding PRGs
4)	Reduction of mobility, toxicity, or volume through treatment	Treatment Process Used and Materials Treated	None proposed.	No treatment processes involved.	No treatment processes involved, except to the extent that water generated from the remedial action (i.e, from dewatering processes) may be treated.
		Amount of Hazardous Materials Destroyed or Treated	None, except by natural processes.	No treatment processes involved.	No treatment processes involved, except to the extent that water generated from the remedial action (i.e, from dewatering processes) may be treated.
		Degree of Expected Reductions in Toxicity, Mobility, and Volume	Natural processes would be expected to reduce toxicity, mobility, and volume. However, no monitoring would be done to assess expected changes.	No treatment processes involved. It is expected that all identified soils that exceed PRGs would be removed and/or buried/capped.	No treatment processes involved, except to the extent that water generated from the remedial action (i.e, from dewatering processes) may be treated. It is expected that all identified soils that exceed PRGs would be removed and consolidated below a landfill cap.
		Degree to Which Treatment is Irreversible	Not applicable.	There is no active treatment.	There is no active treatment on the soil/waste.
		Type and Quantity of Residuals Remaining After Treatment	There is no active treatment, thus no treatment residuals.	There is no active treatment, thus no treatment residuals.	There is no active treatment on the soil/waste. There may be minor residuals for any water treatment performed (i.e., from dewatering processes).
5)	Short-term effectiveness	Protection of Community During Remedial Actions	Not applicable.	Normal construction-related access prohibitions would be in place during site activities. Additional controls will be required along the Blackstone River to restrict public access during construction activities. Truck traffic for hauling capping materials will impact the community.	Normal construction-related access prohibitions would be in place during site activities. Additional controls will be required along the Blackstone River to restrict public access during construction activities.
		Protection of Workers During Remedial Actions	Not applicable.	Normal construction Health and Safety Plans will be in place during site activities.	Normal construction Health and Safety Plans will be in place during site activities. Risks increased due to depth of excavation.

Table 7-4
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative UI-SO-1 No Action	Alternative UI-SO-2 Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls	Alternative UI-SO-3 Remove/Consolidate All Waste/Soil Exceeding PRGs
5)	Short-term effectiveness	Environmental Impacts	Not applicable.	Impacts to environmental receptors are anticipated to be significant. Activities will require removal of all trees on the work area where PRGs are exceeded. Erosion control/capping will have an impact on the substrate for environmental receptors.	Impacts to environmental receptors are anticipated to be significant. Activities will require removal of all trees on the work area where PRGs are exceeded.
		Time Until RAOs are Achieved	Insufficient data to estimate time for natural attenuation to achieve RAOs.	RAOs are achieved immediately upon completion of capping/excavation/restoration.	RAOs are achieved immediately upon completion of excavation/restoration.
6)	Implementability	Ability to Construct and Operate the Technology	Not applicable.	Types of planned activities are not uncommon, but are difficult to implement while minimizing environmental impacts to sensitive receptors (Blackstone River). Transportation of soils off the Unnamed Island will require crossing the flood-prone river with heavy equipment and haul trucks.	Types of planned activities are not uncommon, but are difficult to implement while minimizing environmental impacts to sensitive receptors (Blackstone River). Transportation of soils off the Unnamed Island will require crossing the flood-prone river with heavy equipment and haul trucks. Excavation of waste will extend up to 12 feet below the water table, potentially requiring shoring and/or water handling/treatment. Significant potential for disruption of activities due to location in flood-prone area.
		Reliability of the Technology	Not applicable.	Capping, excavation, and burial technologies are reliable. Maintenance of completed geotextile cover and riprap on Unnamed Island in a high-energy fluvial environment may be challenging.	Excavation is reliable.

Table 7-4
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative UI-SO-1 No Action	Alternative UI-SO-2 Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls	Alternative UI-SO-3 Remove/Consolidate All Waste/Soil Exceeding PRGs
6)	Implementability	Ease of Undertaking Additional Remedial Actions, if necessary	Will not interfere with the ability to undertake additional remedial actions.	Additional remedial actions will require the removal or penetration of cap.	Will not interfere with the ability to undertake additional remedial actions.
		Ability to Monitor Effectiveness of Remedy	Not applicable. Monitoring is not part of this remedy.	Monitoring of surrounding media (i.e., groundwater, surface water, and air) will allow for evaluation of remedy effectiveness. Five-year reviews will be conducted to confirm effectiveness.	As the source material will be removed, there will be no need to further monitor the remedy.
		Ability to Obtain Approvals From Other Agencies	Not applicable.	The technologies used are widely accepted and should not pose significant approval hurdles. However, the work would be in the middle of the river and would require state wetland evaluations for wildlife, wildlife habitat, recreation and aesthetics, flood protection, suface and groundwater protection, and water quality impacts.	The technologies used are widely accepted and should not pose significant approval hurdles. However, the work would be in the middle of the river and would require state wetland evaluations for wildlife, wildlife habitat, recreation and aesthetics, flood protection, suface and groundwater protection, and water quality impacts.
		Coordination With Other Agencies	Not applicable.	The technologies used are widely accepted and should not pose significant coordination hurdles.	The technologies used are widely accepted and should not pose significant coordination hurdles.
		Availability of Offsite Treatment, Storage, and Disposal Services and Capacity	Not applicable.	Excavated soils will be consolidated onsite below the J.M. Mills Landfill and/or Nunes Parcel cap(s). If capacity of landfill does not allow for complete onsite consolidation, volumes are not expected to pose problems for offsite disposal.	Excavated soils will be consolidated onsite below the J.M. Mills Landfill and/or Nunes Parcel cap(s). If capacity of landfill does not allow for complete onsite consolidation, volumes are not expected to pose problems for offsite disposal.

Table 7-4
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative UI-SO-1 No Action	Alternative UI-SO-2 Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls	Alternative UI-SO-3 Remove/Consolidate All Waste/Soil Exceeding PRGs
6)	Implementability	Availability of Necessary Equipment and Specialists	Not applicable.	All necessary equipment and specialists are readily available.	All necessary equipment and specialists are readily available.
		Availability of Prospective Technologies	Not applicable.	All necessary technologies are readily available.	All necessary technologies are readily available.
7)	Cost	Capital Costs	$0	$4,312,000	$6,136,000
		Operating and Maintenance	$0	$62,000	$0
		Present Worth Costs	$0	$4,374,000	$6,136,000
Modifying Criteria					
8)	State Acceptance		Likely not acceptable.	Assessed in the ROD following comment of the FS.	Assessed in the ROD following comment of the FS.
9)	Community Acceptance		Likely not acceptable.	Assessed in the ROD following comment of the FS.	Assessed in the ROD following comment of the FS.

Notes:
All costs are estimated to an accuracy of +50% to -30% (EPA, 2000).
ARAR = applicable or relevant and appropriate requirement
EPA = United States Environmental Protection Agency
FS = Feasibility Study
PRG = Preliminary Remediation Goal
RAO = Remedial Action Objective
ROD = Record of Decision

Table 7-5
Summary of Detailed and Comparative Analysis of Pond Sediment Remedial Action Alternatives

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative SE-1 No Action	Alternative SE-2 Remove/Consolidate Sediment Exceeding PRGs	Alternative SE-3 Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls	Alternative SE-4 Subaqueous Cover (No Sediment Removal) with Institutional Controls
Threshold Criteria						
1)	Overall protection of human health and the environment	Human Health and Environmental Protection	Does not provide overall protection of human health and the environment. Does not minimize, reduce, or control contaminant impacts in sediment or associated exposure risks.	Protection of human health and the environment achieved through removal of impacted sediments that pose risk to the environment.	Protection of human health and the environment achieved through removal and/or covering impacted sediments that pose risk to the environment.	Protection of human health and the environment achieved through covering impacted sediments that pose risk to the environment.
2)	Compliance with ARARs	Chemical-Specific	Does not comply with chemical-specific ARARs	The remedy would eliminate exposures to contaminants exceeding PRGs.	The remedy would eliminate exposures to contaminants exceeding PRGs.	The remedy would eliminate exposures to contaminants exceeding PRGs.
		Location-Specific	No location-specific ARARs.	The remedy would be designed/implemented to comply with applicable requirements.	The remedy would be designed/implemented to comply with applicable requirements.	The remedy would be designed/implemented to comply with applicable requirements.
		Action-Specific	No action-specific ARARs.	The remedy would be designed/implemented to comply with applicable requirements.	The remedy would be designed/implemented to comply with applicable requirements.	The remedy would be designed/implemented to comply with applicable requirements.
Balancing Criteria						
3)	Long-term effectiveness and permanence	Magnitude of Residual Risk	It is not known how effective natural attenuation processes would be in reducing risk, and no long-term monitoring would be done to indicate whether remedial goals are met.	The alternative would address sediments that pose a risk to the environment.	The alternative would address sediments that pose a risk to the environment.	The alternative would address sediments that pose a risk to the environment.
		Adequacy and Reliability of Controls	There would be no controls to limit access to contaminants in sediments.	Removal of contaminant-impacted sediments provide assurance that this alternative is effective in the long-term.	Removal and/or covering of contaminant-impacted sediments provide assurance that this alternative is effective in the long-term. Five-year review will be conducted to assess the effectiveness of the remedy and the institutional controls.	Covering of contaminant-impacted sediments provide assurance that this alternative is effective. Five-year review will be conducted to assess the effectiveness of the subaqueous cover and the institutional controls.

Table 7-5
Summary of Detailed and Comparative Analysis of Pond Sediment Remedial Action Alternatives

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative SE-1 No Action	Alternative SE-2 Remove/Consolidate Sediment Exceeding PRGs	Alternative SE-3 Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls	Alternative SE-4 Subaqueous Cover (No Sediment Removal) with Institutional Controls
4)	Reduction of mobility, toxicity, or volume through treatment	Treatment Process Used and Materials Treated	None proposed.	No treatment processes involved, except for the potential treatment of water generated by dewatering prior to discharge and any potential addition of bulking agents to the sediments prior to consolidation under the landfill cap(s).	No treatment processes involved, except for the potential treatment of water generated by dewatering prior to discharge and any potential addition of bulking agents to the sediments prior to consolidation under the landfill cap(s).	No treatment processes involved.
		Amount of Hazardous Materials Destroyed or Treated	None, except by natural processes.	No treatment processes involved, except for the potential treatment of water generated by dewatering prior to discharge and any potential addition of bulking agents to the sediments prior to consolidation under the landfill cap(s).	No treatment processes involved. Sediments exceeding PRGs will be either excavated and consolidated below a landfill cap or will be covered in place. No material will be destroyed.	No treatment processes involved.
		Degree of Expected Reductions in Toxicity, Mobility, and Volume	Natural processes would be expected to reduce toxicity, mobility, and volume. However, no monitoring would be done to assess expected changes.	No treatment processes involved, except for the potential treatment of water generated by dewatering prior to discharge and any potential addition of bulking agents to the sediments prior to consolidation under the landfill cap(s).	No treatment processes involved, except for the potential treatment of water generated by dewatering prior to discharge and any potential addition of bulking agents to the sediments prior to consolidation under the landfill cap(s).	No treatment processes involved.
		Degree to which Treatment is Irreversible	Not applicable.	There is no active treatment on the sediment, except for the potential addition of bulking agents prior to consolidation under the landfill cap(s).	There is no active treatment on the sediment, except for the potential addition of bulking agents prior to consolidation under the landfill cap(s).	There is no active treatment.
		Type and Quantity of Residuals Remaining After Treatment	There is no active treatment, thus no treatment residuals.	There is no active treatment on the sediment. There may be minor residuals for any water treatment performed (i.e., from dewatering processes).	There is no active treatment on the sediment. There may be minor residuals for any water treatment performed (i.e., from dewatering processes).	There is no active treatment, thus no treatment residuals.

Table 7-5
Summary of Detailed and Comparative Analysis of Pond Sediment Remedial Action Alternatives

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative SE-1 No Action	Alternative SE-2 Remove/Consolidate Sediment Exceeding PRGs	Alternative SE-3 Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls	Alternative SE-4 Subaqueous Cover (No Sediment Removal) with Institutional Controls
5)	Short-term effectiveness	Protection of Community During Remedial Actions	Not applicable.	Normal construction-related access prohibitions would be in place during site activities. Additional controls will be required along the Blackstone River to restrict public access during construction activities.	Normal construction-related access prohibitions would be in place during site activities. Additional controls will be required along the Blackstone River to restrict public access during construction activities. Truck traffic for hauling cover materials will impact the community.	Normal construction-related access prohibitions would be in place during site activities. Additional controls will be required along the Blackstone River to restrict public access during construction activities. Truck traffic for hauling cover materials will impact the community.
		Protection of Workers During Remedial Actions	Not applicable.	Normal construction Health and Safety Plans will be in place during site activities.	Normal construction Health and Safety Plans will be in place during site activities.	Normal construction Health and Safety Plans will be in place during site activities.
		Environmental Impacts	Not applicable.	Potential for impacts to environmental receptors during excavation/dredging activities. Suspension of sediment is likely to occur within ponds and potentially within the Blackstone River. Trees and brush will be cleared near areas of activities.	Potential for impacts to environmental receptors during excavation/dredging activities. Suspension of sediment is likely to occur within ponds and potentially within the Blackstone River. Trees and brush will be cleared near areas of activities.	Potential for impacts to environmental receptors during remedial activities. Suspension of sediment may occur within ponds and potentially within the Blackstone River. Trees and brush will be cleared near areas of activities. Covering will impact depths of ponds, notably in shallow zones, where the cover may extend above the waterline and reduce flood storage capacity.
		Time Until RAOs are Achieved	Insufficient data to estimate time for natural attenuation to achieve RAOs.	RAOs are achieved immediately upon completion of excavation.	RAOs are achieved immediately upon completion of covering/excavation/restoration.	RAOs are achieved immediately upon completion of covering/restoration.

Table 7-5
Summary of Detailed and Comparative Analysis of Pond Sediment Remedial Action Alternatives

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative SE-1 No Action	Alternative SE-2 Remove/Consolidate Sediment Exceeding PRGs	Alternative SE-3 Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls	Alternative SE-4 Subaqueous Cover (No Sediment Removal) with Institutional Controls
6)	Implementability	Ability to Construct and Operate the Technology	Not applicable.	Types of planned activities are not uncommon, but are difficult to implement while minimizing environmental impacts to sensitive receptors (Blackstone River). Sediment removal may become impractical if PRG exceedances exceed anticipated depths. Significant potential for disruption of activities due to location in flood-prone area.	Types of planned activities are not uncommon, but are difficult to implement while minimizing environmental impacts to sensitive receptors (Blackstone River). Significant potential for disruption of activities due to location in flood-prone area.	Types of planned activities are not uncommon, but are difficult to implement while minimizing environmental impacts to sensitive receptors (Blackstone River). Significant potential for disruption of activities due to location in flood-prone area.
		Reliability of the Technology	Not applicable.	Sediment excavation technologies are reliable.	Sediment excavation and covering technologies are reliable. Maintenance of completed cover within ponds adjacent to a high energy fluvial environment may be challenging. However, use of amendments may reduce maintenance challenges.	Subaqueous cover technologies are reliable. Maintenance of completed cover within ponds adjacent to a high energy fluvial environment may be challenging. However, use of amendments may reduce maintenance challenges.
		Ease of Undertaking Additional Remedial Actions, if necessary	Will not interfere with the ability to undertake additional remedial actions.	Will not interfere with the ability to undertake additional remedial actions.	Upon completion of the cover, it will be difficult to undertake additional remedial actions.	Upon completion of the cover, it will be difficult to undertake additional remedial actions.

Table 7-5
Summary of Detailed and Comparative Analysis of Pond Sediment Remedial Action Alternatives

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative SE-1 No Action	Alternative SE-2 Remove/Consolidate Sediment Exceeding PRGs	Alternative SE-3 Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls	Alternative SE-4 Subaqueous Cover (No Sediment Removal) with Institutional Controls
6)	Implementability	Ability to Monitor Effectiveness of Remedy	Not applicable. Monitoring is not part of this remedy.	As the source material will be removed, there will be no need to further monitor the remedy.	Monitoring of the cover thickness will provide determination of effectiveness. Five-year reviews will be conducted to confirm effective maintenance of cover. Use of amendments may reduce maintenance challenges.	Monitoring of the cover thickness will provide determination of effectiveness. Five-year reviews will be conducted to confirm effective maintenance of cover. Use of amendments may reduce maintenance challenges.
		Ability to Obtain Approvals From Other Agencies	Not applicable.	The technologies used are widely accepted and should not pose significant approval hurdles. However, the work would be in the middle of the river and may require further evaluations during the design phase.	The technologies used are widely accepted and should not pose significant approval hurdles. However, the work would be in the middle of the river and may require further evaluations during the design phase.	The technologies used are widely accepted and should not pose significant approval hurdles. However, the work would be in the middle of the river and may require further evaluations during the design phase.
		Coordination With Other Agencies	Not applicable.	The technologies used are widely accepted and should not pose significant coordination hurdles.	The technologies used are widely accepted and should not pose significant coordination hurdles.	The technologies used are widely accepted and should not pose significant coordination hurdles.
		Availability of Offsite Treatment, Storage, and Disposal Services and Capacity	Not applicable.	Excavated sediments will be stabilized and largely consolidated onsite below J.M. Mills and/or Nunes Parcel landfill cap(s). If capacity of landfills does not allow for complete onsite consolidation, volumes are not expected to pose problems for offsite disposal.	Excavated sediments will be stabilized and largely consolidated onsite below J.M. Mills and/or Nunes Parcel landfill cap(s). If capacity of landfills does not allow for complete onsite consolidation, volumes are not expected to pose problems for offsite disposal.	Not applicable.
		Availability of Necessary Equipment and Specialists	Not applicable.	All necessary equipment and specialists are readily available.	All necessary equipment and specialists are readily available.	All necessary equipment and specialists are readily available.

Table 7-5
Summary of Detailed and Comparative Analysis of Pond Sediment Remedial Action Alternatives

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Specific Factors	Alternative SE-1 No Action	Alternative SE-2 Remove/Consolidate Sediment Exceeding PRGs	Alternative SE-3 Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls	Alternative SE-4 Subaqueous Cover (No Sediment Removal) with Institutional Controls
7)	Cost	Availability of Prospective Technologies	Not applicable.	All necessary technologies are readily available.	All necessary technologies are readily available.	All necessary technologies are readily available.
		Capital Costs	$0	$8,120,000	$5,103,000	$2,883,000
		Operating and Maintenance	$0	$0	$701,000	$701,000
		Present Worth Costs	$0	$8,120,000	$5,804,000	$3,584,000
Modifying Criteria						
8)	State Acceptance		Likely not acceptable.	Assessed in the ROD following comment of the FS.	Assessed in the ROD following comment of the FS.	Assessed in the ROD following comment of the FS.
9)	Community Acceptance		Likely not acceptable.	Assessed in the ROD following comment of the FS.	Assessed in the ROD following comment of the FS.	Assessed in the ROD following comment of the FS.

Notes:
All costs are estimated to an accuracy of +50% to -30% (EPA, 2000).
ARAR = applicable or relevant and appropriate requirement
EPA = United States Environmental Protection Agency
FS = Feasibility Study
ft = feet
PRG = Preliminary Remediation Goal
RAO = remedial action objective
RCRA = Resource Conservation and Recovery Act
ROD = Record of Decision

Table 8-1
Summary of Detailed and Comparative Analysis of Groundwater Remedial Action Alternatives

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Alternative GW-1 No Action		Alternative GW-2 Limited Action Institutional Controls and Long-Term Monitoring	
Threshold Criteria					
1)	Overall protection of human health and the environment	**0**	Does not provide overall protection of human health. Does not minimize, reduce, or control contaminant impacts in groundwater or associated exposure risks. Groundwater RAOs would not be met.	**4**	Protective of human health by eliminating potential exposure to contaminants in groundwater. Institutional controls eliminate exposure pathways. Groundwater RAOs would be met.
2)	Compliance with ARARs	**0**	Does not comply with chemical-specific ARARs. No action- or location-specific ARARs.	**4**	Complies with ARARs.
Balancing Criteria					
3)	Long-term effectiveness and permanence	**0**	Not effective or permanent. Potential exposure risks associated with contaminants in groundwater would remain with no controls or long-term management plan.	**4**	Institutional controls are effective at limiting potential exposure inside a compliance boundary. Long-term monitoring is effective at documenting if migration of contaminants beyond the compliance boundary is occurring.
4)	Reduction of mobility, toxicity, or volume through treatment	**0**	No treatment processes involved.	**0**	No treatment processes involved.
5)	Short-term effectiveness	**0**	No activities would be implemented that would present potential short-term exposure risks to human health or the environment.	**5**	Limited activities (well installation/monitoring) result in minimal short-term exposure risks and impacts to workers, adjacent populations, or the environment that would be managed through engineering controls. Potential risks would be limited to onsite populations.

Table 8-1
Summary of Detailed and Comparative Analysis of Groundwater Remedial Action Alternatives

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Alternative GW-1 No Action		Alternative GW-2 Limited Action Institutional Controls and Long-Term Monitoring	
6)	Implementability	**3**	Technically feasible due to lack of technical components.	**5**	Simple to implement. Administratively feasible. Involves long-term O&M.
7)	Cost	**5**	Capital Costs: $0 Total O&M and Periodic Costs:$0 Total Present Value Cost: $0	**5**	Capital Costs: $166,000 Total O&M and Periodic Costs:$505,000 Total Present Value Cost: $671,000
Modifying Criteria					
8)	State Acceptance	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.
9)	Community Acceptance	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.
Screening Totals					
		8		**27**	

Notes:

All costs are estimated to an accuracy of +50% to -30% (USEPA, 2000).

ARAR = applicable or relevant and appropriate requirement
FS = Feasibility Study
MNA = monitored natural attenuation
O&M = operation and maintenance
RAO = remedial action objective
ROD = Record of Decision
USEPA = United States Environmental Protection Agency
VOC = volatile organic compound

Ratings categories for Threshold and Balancing Criteria (Excluding Cost):

(0) None
(1) Low
(2) Low to moderate
(3) Moderate
(4) Moderate to high
(5) High

Table 8-2
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - J.M. Mills Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Alternative JM-SO-1 No Action		Alternative JM-SO-2 RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls		Alternative JM-SO-3 Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	
Threshold Criteria							
1)	Overall protection of human health and the environment	**0**	Does not provide overall protection of human health or the environment. Does not minimize, reduce, or control contaminant impacts in waste and soil or associated exposure risks. Soil RAOs would not be met.	**5**	Protective of human health and the environment by eliminating potential exposure to contaminants in waste and soil. There are no offsite impacts, and institutional controls eliminate exposure pathways. RAOs would be met.	**0**	Does not establish a completely protective physical barrier between potential receptors and contaminated materials in soil and waste. Does not fully reduce the infiltration and the potential for leaching of contaminants in soil to groundwater. Does not fully address potential landfill gas releases and does not ensure that contamination is not eroded or washed out of the landfill during any flood, up to a 500-year event.
2)	Compliance with ARARs	**0**	Does not comply with chemical-specific ARARs. No action- or location-specific ARARs.	**5**	Complies with ARARs.	**0**	Complies with ARARs for impacted soils. Does not comply with hazardous waste landfill closure requirements, landfill gas emission requirements, and floodplains management requirements.
Balancing Criteria							
3)	Long-term effectiveness and permanence	**0**	Not effective or permanent. Potential exposure risks associated with contaminants in soil and waste would remain with no controls or long-term management plan.	**5**	Effective and permanent for removal of impacted soil. Effective and permanent for soil and waste below landfill cap.	**4**	Effective and permanent for removal of impacted soil. Effective and permanent for eliminating direct contact with soil and waste below landfill cap. Not as effective as whole RCRA Subtitle C cap for minimizing infiltration or protecting against flooding.
4)	Reduction of mobility, toxicity, or volume through treatment	**0**	No treatment processes involved.	**0**	No treatment processes involved.	**0**	No treatment processes involved.
5)	Short-term effectiveness	**0**	No activities would be implemented that would present potential short-term exposure risks to human health or the environment.	**3**	Meets RAOs in short period of time at relatively low risk to community and site workers. Construction activities will have a significant impact on the environment, through both removal of mature trees on riverbank and floodplain and through erosion controls along the riverbank. Greater impacts to the community due to the additional volume of cap materials which need to be brought on site.	**4**	Meets RAOs in short period of time at relatively low risk to community and site workers. Construction activities will have a significant impact on the environment, through both removal of mature trees on riverbank and floodplain and through erosion controls along the riverbank.
6)	Implementability	**3**	Technically feasible due to lack of technical components. However, not administratively feasible due to a lack of monitoring or protection of human health or the environment.	**2**	Landfill boundaries on the northeast (railroad) and southwest (floodplain) will interfere with construction of the cap. Space and access limitations (specifically on the northeast slope) for geosynthetic deployment and installation will be major constraints. Large volume of cover material increases truck traffic on local roads.	**3**	Landfill boundaries on the northeast (railroad) and southwest (floodplain) will interfere with regrading of the cap and may require consolidation of waste.
7)	Cost	**5**	Capital Costs: $0 Total O&M and Periodic Costs:$0 Total Present Value Cost: $0	**2**	Capital Costs: $21,063,000 Total O&M and Periodic Costs:$496,000 Total Present Value Cost: $21,559,000	**4**	Capital Costs: $13,225,000 Total O&M and Periodic Costs:$496,000 Total Present Value Cost: $13,721,000

Table 8-2
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - J.M. Mills Landfill

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Alternative JM-SO-1 No Action		Alternative JM-SO-2 RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls		Alternative JM-SO-3 Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	
Modifying Criteria							
8)	State Acceptance	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.
9)	Community Acceptance	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.
Screening Totals							
		8		**22**		**15**	

Notes:

All costs are estimated to an accuracy of +50% to -30% (USEPA, 2000).
ARAR = applicable or relevant and appropriate requirement
FS = Feasibility Study
O&M = operation and maintenance
PRG = Preliminary Remediation Goal
RAO = remedial action objective
RCRA = Resource Conservation and Recovery Act

Ratings categories for Threshold and Balancing Criteria (Excluding Cost):
(0) None
(1) Low
(2) Low to moderate
(3) Moderate
(4) Moderate to high
(5) High

Table 8-3
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Nunes Parcel

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Alternative NP-SO-1 No Action		Alternative NP-SO-2 RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls		Alternative NP-SO-3 RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls	
Threshold Criteria							
1)	Overall protection of human health and the environment	**0**	Does not provide overall protection of human health or the environment. Does not minimize, reduce, or control contaminant impacts in waste and soil or associated exposure risks. Soil RAOs would not be met.	**4**	Protective of human health and the environment by eliminating potential exposure to contaminants in waste and soil, although long-term protectiveness in question. There are no offsite impacts, and institutional controls eliminate exposure pathways. RAOs would be met.	**5**	Protective of human health and the environment by eliminating potential exposure to contaminants in waste and soil. There are no offsite impacts, and institutional controls eliminate exposure pathways. RAOs would be met.
2)	Compliance with ARARs	**0**	Does not comply with chemical-specific ARARs. No action- or location-specific ARARs.	**0**	Does not comply with RCRA closure standards.	**5**	Complies with ARARs for municipal and hazardous waste landfills.
Balancing Criteria							
3)	Long-term effectiveness and permanence	**0**	Not effective or permanent. Potential exposure risks associated with contaminants in soil and waste would remain with no controls or long-term management plan.	**4**	Generally effective and permanent for soil and waste below landfill cap, although long-term protectiveness in question based on waste in landfill. Allows more infiltration to occur than the Subtitle C cap.	**5**	Effective and permanent for soil and waste below landfill cap.
4)	Reduction of mobility, toxicity, or volume through treatment	**0**	No treatment processes involved.	**0**	No treatment processes involved.	**0**	No treatment processes involved.
5)	Short-term effectiveness	**0**	No activities would be implemented that would present potential short-term exposure risks to human health or the environment.	**4**	Meets RAOs in short period of time at relatively low risk to community and site workers. Construction activities will have a significant impact on the environment, through both removal of mature trees on riverbank and floodplain and through erosion controls along the riverbank.	**3**	Meets RAOs in short period of time at relatively low risk to community and site workers. Construction activities will have a significant impact on the environment, through both removal of mature trees on riverbank and floodplain and through erosion controls along the riverbank. Greater impacts to the community due to the additional volume of cap materials which need to brought on site.
6)	Implementability	**3**	Technically feasible due to lack of technical components. However, not administratively feasible due to a lack of monitoring or protection of human health or the environment.	**4**	Landfill boundaries on the west and south (Blackstone River) will interfere with completion of the cover and will require armor to prevent washout.	**4**	Landfill boundaries on the west and south (Blackstone River) will interfere with completion of the cover and anchoring of liner and will require armor to prevent washout.
7)	Cost	**5**	Capital Costs: $0 Total O&M and Periodic Costs:$0 Total Present Value Cost: $0	**4**	Capital Costs: $4,808,000 Total O&M and Periodic Costs:$124,000 Total Present Value Cost: $4,932,000	**3**	Capital Costs: $5,956,000 Total O&M and Periodic Costs:$124,000 Total Present Value Cost: $6,080,000

Table 8-3
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Nunes Parcel

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Alternative NP-SO-1 No Action		Alternative NP-SO-2 RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls		Alternative NP-SO-3 RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls	
Modifying Criteria							
8)	State Acceptance	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.
9)	Community Acceptance	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.
Screening Totals							
		8		**20**		**25**	

Notes:

All costs are estimated to an accuracy of +50% to -30% (USEPA, 2000).

AOC = area of concern
ARAR = applicable or relevant and appropriate requirement
FS = Feasibility Study
O&M = operation and maintenance
RAO = remedial action objective
RCRA = Resource Conservation and Recovery Act
ROD = Record of Decision
USEPA = United States Environmental Protection Agency

Ratings categories for Threshold and Balancing Criteria (Excluding Cost)

(0) None
(1) Low
(2) Low to moderate
(3) Moderate
(4) Moderate to high
(5) High

Table 8-4
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Alternative UI-SO-1 No Action		Alternative UI-SO-2 Remove/consolidate surface waste/soil (0-2 ft) exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls		Alternative UI-SO-3 Remove/consolidate all waste/soil exceeding PRGs	
Threshold Criteria							
1)	Overall protection of human health and the environment	**0**	Does not provide overall protection of human health or the environment. Does not minimize, reduce, or control contaminant impacts in waste and soil or associated exposure risks. Soil RAOs would not be met.	**0**	While partially protective of human health and the environment by eliminating potential exposure to waste and contaminants in soil, not fully protective because it will not meet protectiveness standards for the landfilling of hazardous waste	**5**	Protective of human health and the environment by eliminating potential exposure to waste and contaminants in soil. RAOs would be met.
2)	Compliance with ARARs	**0**	Does not comply with chemical-specific ARARs. No action- or location-specific ARARs.	**0**	Any remaining contaminants below 2 feet would not meet chemical- and location-specific ARARs, as the cover design does not protect against the release of contaminants through continued leaching or during a flood event, because there is no impermeable barrier layer in the cover. Does not comply with RCRA C closure standards.	**5**	Complies with ARARs.
Balancing Criteria							
3)	Long-term effectiveness and permanence	**0**	Not effective or permanent. Potential exposure risks associated with contaminants in soil would remain with no controls or long-term management plan.	**3**	Effective and permanent for removal of waste and impacted soil. May not achieve long-term effectiveness and permanence, because there is no impermeable barrier layer in the cover making it likely that a release from continued leaching, further erosion over time, and/or during a 100-year or 500-year storm event would occur.	**5**	Effective and permanent due to removal of waste and impacted soil.
4)	Reduction of mobility, toxicity, or volume through treatment	**0**	No treatment processes involved.	**0**	No treatment processes involved.	**0**	No treatment processes involved, except to the extent that water generated from the remedial action (i.e, from dewatering processes) may be treated.
5)	Short-term effectiveness	**0**	No activities would be implemented that would present potential short-term exposure risks to human health or the environment.	**4**	Meets RAOs in short period of time at relatively low risk to community and site workers. Construction activities will have a significant impact on the environment, through both removal of mature trees and through erosion controls/capping established as part of the remedy.	**3**	Meets RAOs in short period of time at relatively low risk to community and site workers. Construction activities will have a significant impact on the environment, through both removal of mature trees and through erosion controls along the riverbank. Increased risks due to larger and deeper excavation area and increased volume for transportation off of the island.
6)	Implementability	**4**	Technically feasible due to lack of technical components.	**3**	Activities will require temporary bridge to move heavy equipment and haul trucks across river. Flooding has potential to disrupt work and damage equipment.	**2**	Activities will require temporary bridge to move heavy equipment and haul trucks across river. Flooding has potential to disrupt work and damage equipment. Portions of the waste are located as much as 12 ft below the water table.
7)	Cost	**5**	Capital Costs: $0 Total O&M and Periodic Costs:$0 Total Present Value Cost: $0	**4**	Capital Costs: $4,312,000 Total O&M and Periodic Costs:$62,000 Total Present Value Cost: $4,374,000	**2**	Capital Costs: $6,136,000 Total O&M and Periodic Costs:$0 Total Present Value Cost: $6,136,000

Table 8-4
Summary of Detailed and Comparative Analysis of Source Area Remedial Action Alternatives - Unnamed Island

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Alternative UI-SO-1 No Action		Alternative UI-SO-2 Remove/consolidate surface waste/soil (0-2 ft) exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls		Alternative UI-SO-3 Remove/consolidate all waste/soil exceeding PRGs	
Modifying Criteria							
8)	State Acceptance	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.
9)	Community Acceptance	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.
Screening Totals							
		9		**14**		**22**	

Notes:

All costs are estimated to an accuracy of +50% to -30% (USEPA, 2000).
ARAR = applicable or relevant and appropriate requirement
FS = Feasibility Study
ft = feet
O&M = operation and maintenance
PRG = Preliminary Remediation Goal
RAO = remedial action objective
ROD = Record of Decision
USEPA = United States Environmental Protection Agency

Ratings categories for Threshold and Balancing Criteria (Excluding Cost)
(0) None
(1) Low
(2) Low to moderate
(3) Moderate
(4) Moderate to high
(5) High

Table 8-5
Summary of Detailed and Comparative Analysis of Pond Sediment Remedial Action Alternatives

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Alternative SE-1 No Action		Alternative SE-2 Remove/Consolidate Sediment Exceeding PRGs		Alternative SE-3 Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls		Alternative SE-4 Subaqueous Cover (No Sediment Removal) with Institutional Controls	
Threshold Criteria									
1)	Overall protection of human health and the environment	**0**	Does not provide overall protection of human health and the environment. Does not minimize, reduce, or control contaminant impacts in sediments or associated exposure risks. RAOs would not be met.	**5**	Protective of human health and the environment by eliminating potential exposure to contaminants in sediment. RAOs would be met.	**5**	Protective of human health and the environment by eliminating potential exposure to contaminants in sediment by removal and/or covering. There are no offsite impacts and institutional controls would assist in maintaining the remedy. RAOs would be met.	**4**	Protective of human health and the environment by covering potential exposure to contaminants in sediments. There are no offsite impacts and institutional controls would assist in maintaining the remedy. RAOs would be met. Contaminants not removed at all.
2)	Compliance with ARARs	**0**	Does not comply with chemical-specific ARARs. No action- or location-specific ARARs.	**5**	Complies with ARARs.	**5**	Complies with ARARs.	**5**	Complies with ARARs.
Balancing Criteria									
3)	Long-term effectiveness and permanence	**0**	Not effective or permanent. Potential exposure risks associated with contaminants in sediment would remain with no controls or long-term management plan.	**5**	Effective and permanent for removal of impacted sediment.	**5**	Effective and permanent for removal of impacted sediment. Effective and permanent for sediment below cover.	**4**	Effective and permanent for sediment below cover. Not as effective as alternatives which remove impacted sediment.
4)	Reduction of mobility, toxicity, or volume through treatment	**0**	No treatment processes involved.	**0**	No treatment processes involved, except for the potential treatment of water generated by dewatering prior to discharge and any potential addition of bulking agents to the sediments prior to consolidation under the landfill cap(s).	**0**	No treatment processes involved, except for the potential treatment of water generated by dewatering prior to discharge and any potential addition of bulking agents to the sediments prior to consolidation under the landfill cap(s).	**0**	No treatment processes involved.
5)	Short-term effectiveness	**0**	No activities would be implemented that would present potential short-term exposure risks to human health or the environment.	**3**	Meets RAOs in short period of time at relatively low risk to community and site workers, although the highest short-term exposure risks to the environment and community due to the largest volume of sediment to be transported off of Unnamed Island.	**4**	Meets RAOs in short period of time at relatively low risk to community and site workers, although increased short-term exposure risks compared to covering only, due to sediments being excavated and transported off of Unnamed Island.	**4**	Meets RAOs in short period of time at relatively low risk to community and site workers. However, potential loss of habitat in shallower zones when placing cover with no excavation.
6)	Implementability	**3**	Technically feasible due to lack of technical components.	**2**	Activities will require temporary bridge to move heavy equipment and haul trucks across river. Flooding has potential to disrupt work and damage equipment. Total volume of sediment requiring removal unknown.	**3**	Activities will require temporary bridge to move heavy equipment and haul trucks across river. Flooding has potential to disrupt work and damage equipment. Total volume of sediment requiring removal unknown.	**3**	Activities will require temporary bridge to move heavy equipment and haul trucks across river. Flooding has potential to disrupt work and damage equipment.
7)	Cost	**5**	Capital Costs: $0 Total O&M and Periodic Costs:$0 Total Present Value Cost: $0	**2**	Capital Costs: $8,120,000 Total O&M and Periodic Costs:$0 Total Present Value Cost: $8,120,000	**3**	Capital Costs: $5,103,000 Total O&M and Periodic Costs:$701,000 Total Present Value Cost: $5,804,000	**4**	Capital Costs: $2,883,000 Total O&M and Periodic Costs:$701,000 Total Present Value Cost: $3,584,000

Table 8-5
Summary of Detailed and Comparative Analysis of Pond Sediment Remedial Action Alternatives

Feasibility Study
Peterson/Puritan, Inc. Superfund Site - Operable Unit 2
Cumberland and Lincoln, Rhode Island

Evaluation Criteria		Alternative SE-1 No Action		Alternative SE-2 Remove/Consolidate Sediment Exceeding PRGs		Alternative SE-3 Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls		Alternative SE-4 Subaqueous Cover (No Sediment Removal) with Institutional Controls	
Modifying Criteria									
8)	State Acceptance	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.
9)	Community Acceptance	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.	**0**	Assessed in the ROD following comment of the FS.
Screening Totals									
		8		**22**		**25**		**24**	

Notes:

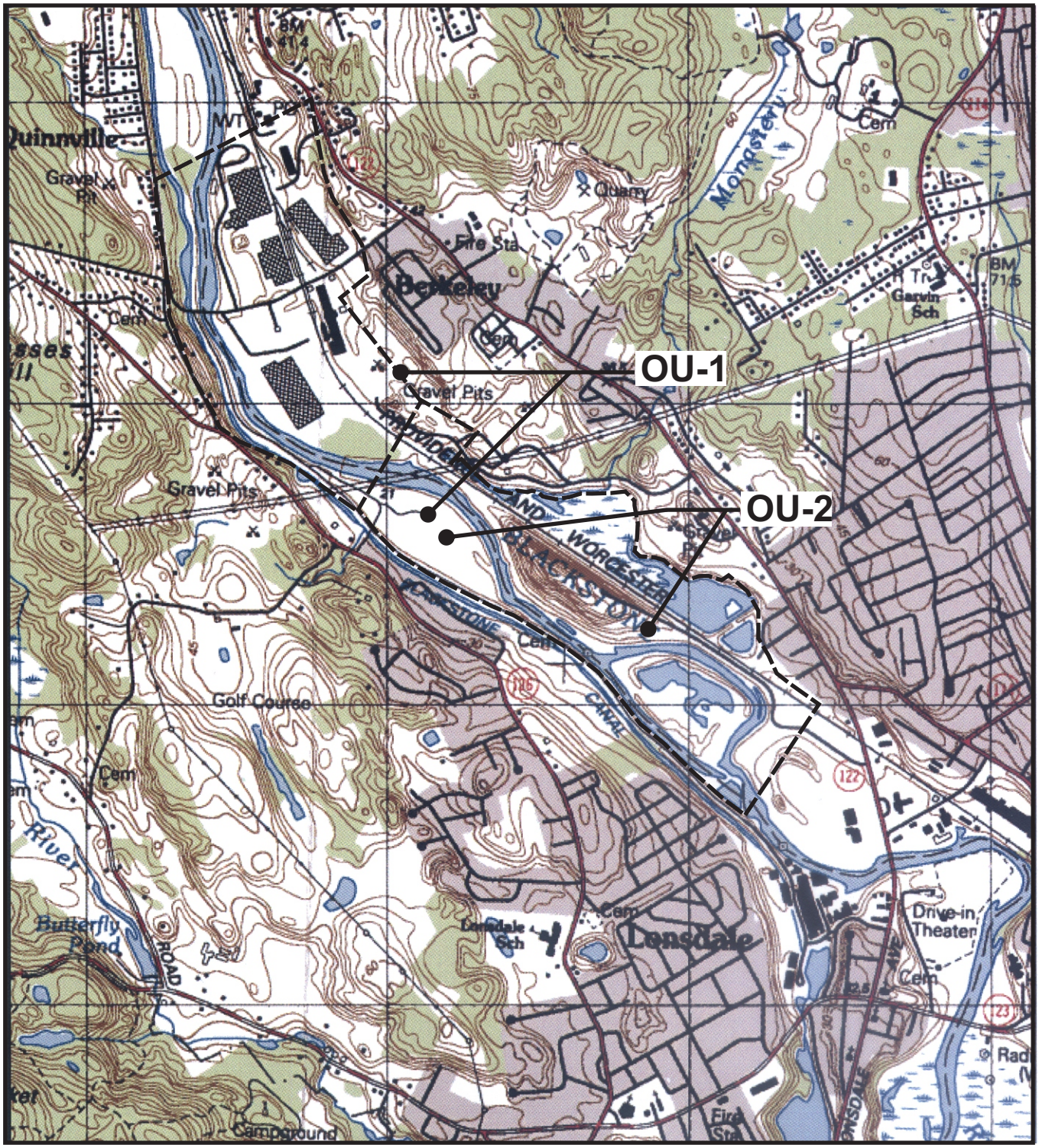
All costs are estimated to an accuracy of +50% to -30% (USEPA, 2000).

ARAR = applicable or relevant and appropriate requirement
ft = feet
FS = Feasibility Study
O&M = Operation and Maintenance
PRG = Preliminary Remediation Goal
RAO = remedial action objective
ROD = Record of Decision
USEPA = United States Environmental Protection Agency

Ratings categories for Threshold and Balancing Criteria (Excluding Cost):

(0) None
(1) Low
(2) Low to moderate
(3) Moderate
(4) Moderate to high
(5) High

FIGURES

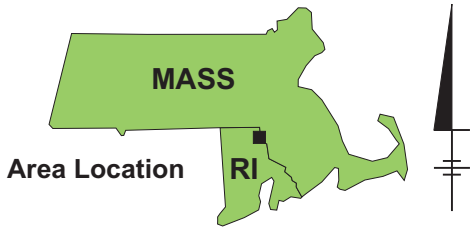


REFERENCE: BASE MAP USGS 7.5 MIN. QUAD., ATTLEBORO, MASS.

0 0.25 0.5

Approximate Scale in Miles

DRAFT



PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

SITE LOCATION MAP

ARCADIS

FIGURE
2-1

01/08/2013 SYRACUSE, NY-ENV/CAD DJHOWES
B0037902/0000/00500/CDR/37902N01.CDR

ASHTON DAM

MACKLAND FARM/KELLY HOUSE PROPERTY

WETLAND C

WETLAND D

WETLAND B

WETLAND A

NUNES PARCEL

PRATT DAM

DF-4

J.M. MILLS LANDFILL

QUINNVILLE WELL FIELD

DF-1 TO DF-3

UNNAMED ISLAND

NOTE:

1. 2002 AERIAL PHOTO OBTAINED FROM RHODE ISLAND GEOGRAPHIC INFORMATION SYSTEM: HTTP://WWW.EDC.URI.EDU/RIGIS/

LEGEND:

OU2 BOUNDARY (RI Site Study Area)

DEBRIS FIELDS

0 1,200 2,400 Feet

GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

SITE LAYOUT

ARCADIS

FIGURE 2-2

7/7/06 SYR-85 SAB
P:\Peterson/Puritan (376021012)
GQ\Peterson_Puritan\Cumberland_RI\Remedialinvestigation\Report\mxd\Site Layout.mxd

DEBRIS FIELDS 1-3

LENOX STREET MUNICIPAL WELL

WETLAND A

WETLAND B

WETLAND C

WETLAND D

HW-02

POND I

POND H

DEBRIS FIELD 4

POND A

POND E

POND D

POND C

POND B

POND P

BLACKSTONE RIVER

BLACKSTONE CANAL

(BACKWATER)

POND F

PRATT DAM

LEGEND:

- RESIDENTIAL WATER SUPPLY WELL
- Culvert
- RAILROAD EASEMENT
- DEBRIS FIELDS
- OU2 BOUNDARY (RI Site Study Area)
- RAILROAD
- HISTORICAL ACCESS ROAD
- DIRECTION OF SURFACE WATER FLOW
- WATER
- HISTORICAL POND
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOUTHERN BANK AREA
- SOLID WASTE TRANSFER STATION

(NFO NUNES DISPOSAL, INC.)

NOTE:
1. NFO - NOW OR FORMERLY OWNED BY

0 500 1,000 Feet
GRAPHIC SCALE

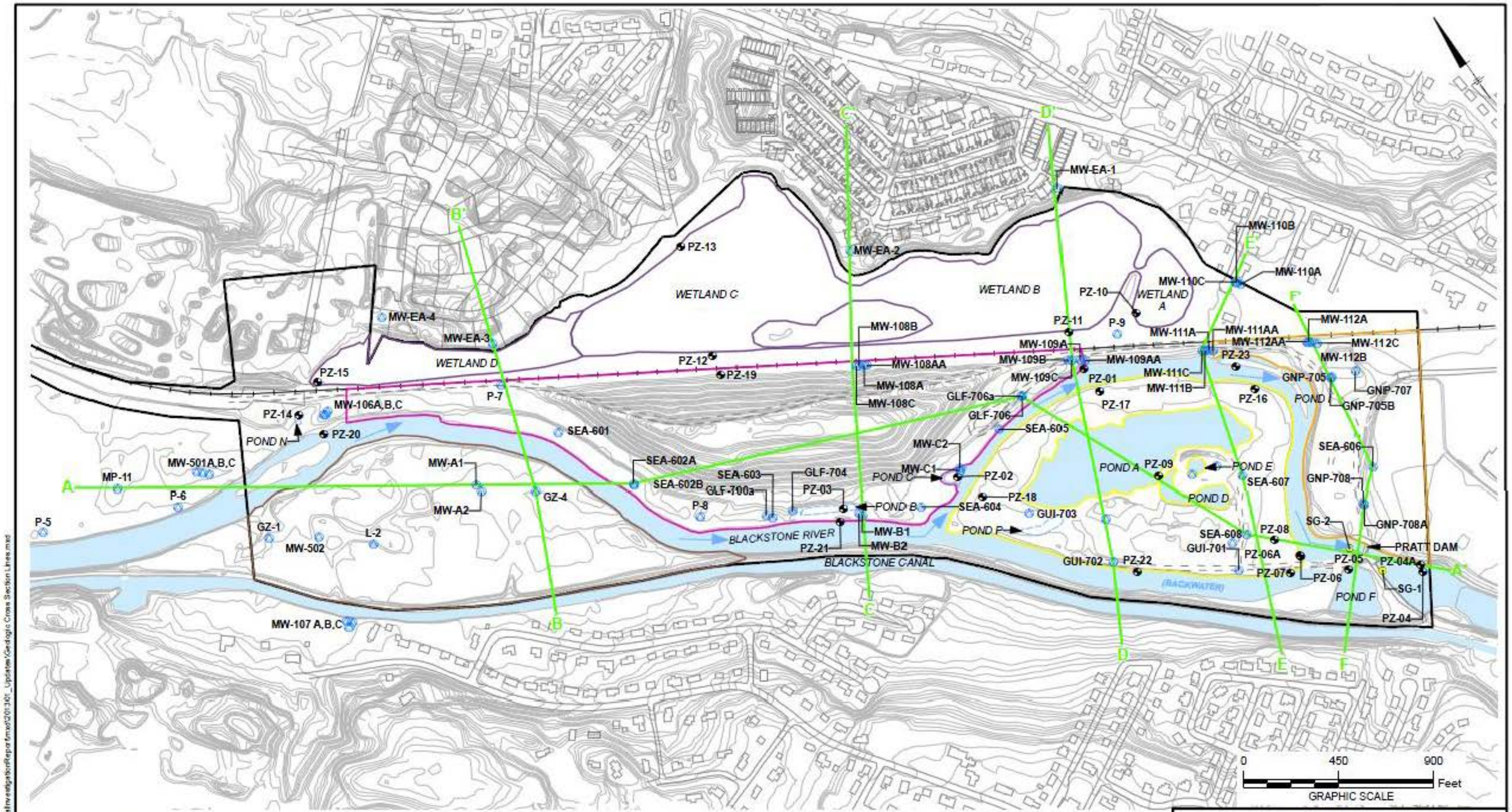
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

SUB AREA DEFINITION

ARCADIS

FIGURE **2-3**

CITY:(COLE) DIVISION:(BWORKS) DB:(LOREEWE) LD:() PIC:() PM:() TM:(JROBERTS)
PROJECT:PETERSON PURITAN PATH:\\Petersson_Puritan\Cumberland_RI\Mxds\FeasibilityStudyReport\fig02130131_UpdatedStudyArea.mxd



LEGEND:

GROUNDWATER LOCATIONS:
- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- GEOLOGIC CROSS SECTION

- OU2 BOUNDARY (RI Site Study Area)
- RAILROAD
- HISTORICAL ACCESS ROAD
- WATER
- DIRECTION OF SURFACE WATER FLOW

- HISTORICAL POND
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NFO NUNES DISPOSAL, INC.)

NOTES:

1. SAMPLE LOCATIONS AND BASEMAPPING ARE IN THE COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD 83 FEET. LOCATIONS RECORDED IN THE FIELD USING GPS.
2. NFO - NOW OR FORMERLY OWNED BY

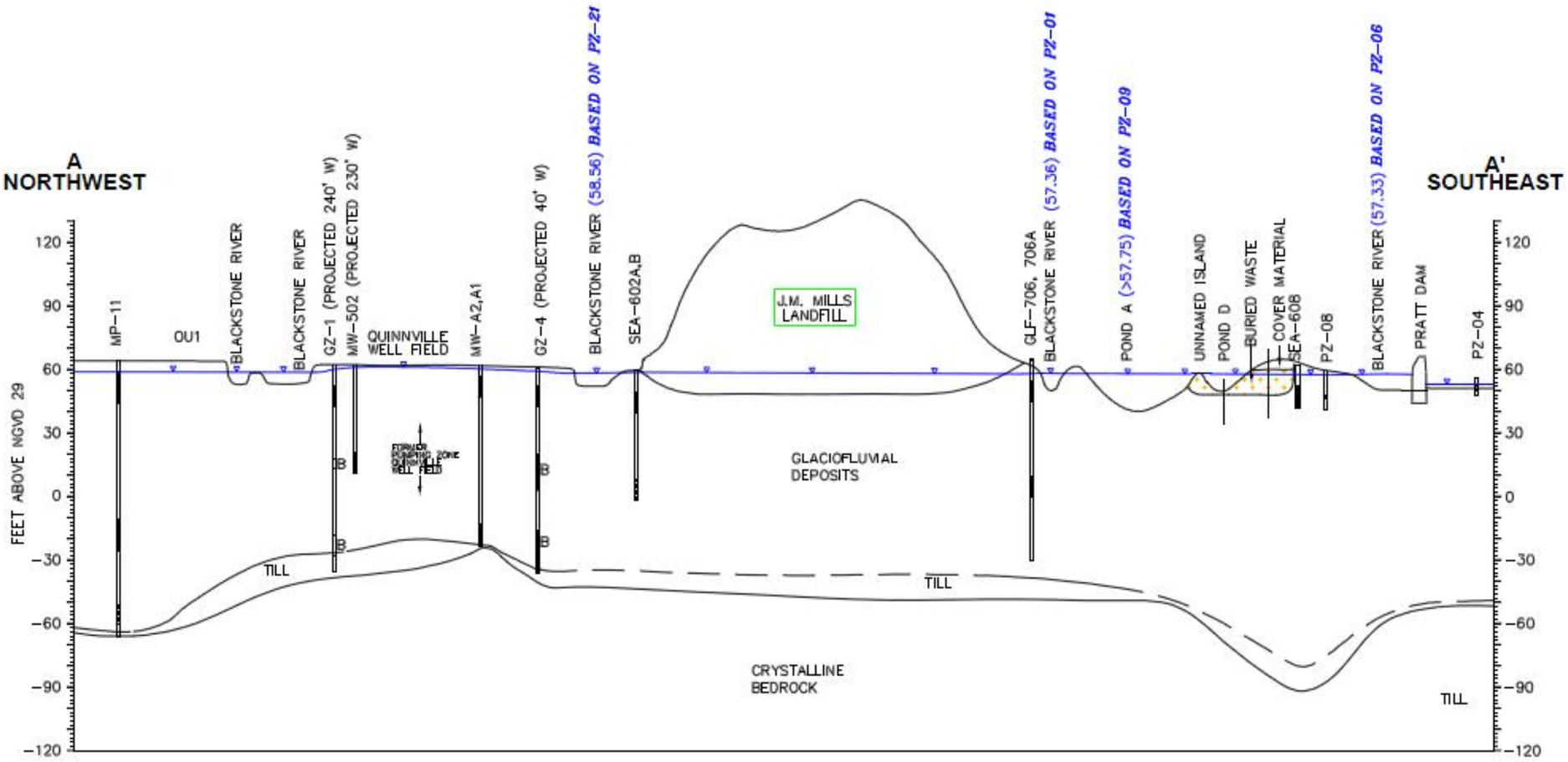
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

GEOLOGIC CROSS SECTION LOCATOR MAP

ARCADIS

FIGURE 2-4

CITY: SYR DIV/GROUP: IT DB: KES LD: PIC: PM: TM: TR
Peterson Puritan (B0037902.0000.00500)
Q:\Peterson_Puritan\Cumberland_RI\Remedialinvestigation\Report\mxd\20130[...]_UpdatesWGeologic Cross Section Lines.mxd



LEGEND

APPROXIMATE WATER TABLE

WASTE/REFUSE

MONITORING WELL (SINGLE) OR MULTIPLE WELL CLUSTER

RISER

SCREENED INTERVAL

B — BARCAD INTERVAL (GZA WELLS ONLY)

NOTES:

1. GEOLOGIC CONTACTS DASHED WHERE INFERRED.
2. CROSS SECTION MODIFIED FROM THE CROSS SECTION PREPARED BY SHIELD ENVIRONMENTAL ASSOCIATES INC., INITIAL SITE CHARACTERIZATION REPORT FEBRUARY 2004.

0 60' 120'
VERTICAL SCALE

0 600' 1200'
HORIZONTAL SCALE

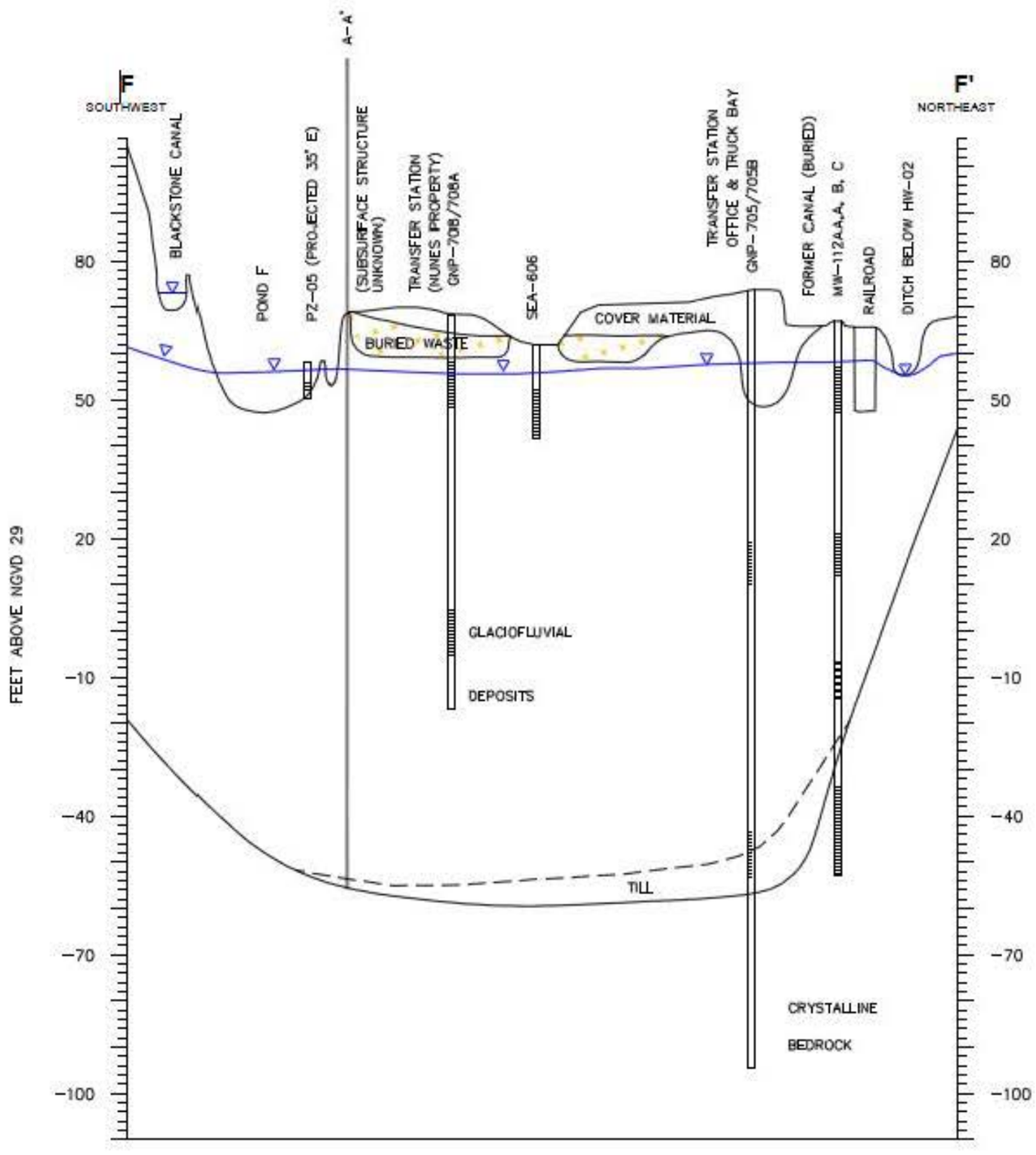
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

CROSS SECTION A-A'

ARCADIS

FIGURE 2-5

CITY:BRADSBERY DIVISION/GROUP:RVCAD DBA:SCHLUNG LD: RC PM: TM LYR:(Opt)On=*;Off=REF
G:\ENCAD\Landfill\ACT\380760\cadd\mxd\Fig2-5xsA-A'.dwg LAYOUT: 2-5 SAVED: 6/23/2010 1:30PM ACADVER: 18.1S (LMS TECH) PAGESETUP: — PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 6/23/2010 2:36 PM BY ANDRUSKO
XREFS: IMAGES: PROJECTNAME: —



LEGEND

APPROXIMATE WATER TABLE NOVEMBER 8, 2005

WASTE/REFUSE

MONITORING WELL (SINGLE) OR MULTIPLE WELL CLUSTER

RISER

SCREENED INTERVAL

B — BARCAD INTERVAL (GZA WELLS ONLY)

NOTES:

1. GEOLOGIC CONTACTS DASHED WHERE INFERRED.
2. CROSS SECTION MODIFIED FROM THE CROSS SECTION PREPARED BY SHIELD ENVIRONMENTAL ASSOCIATES INC., INITIAL SITE CHARACTERIZATION REPORT FEBRUARY 2004.

0 30' 60'
VERTICAL SCALE

0 300' 600'
HORIZONTAL SCALE

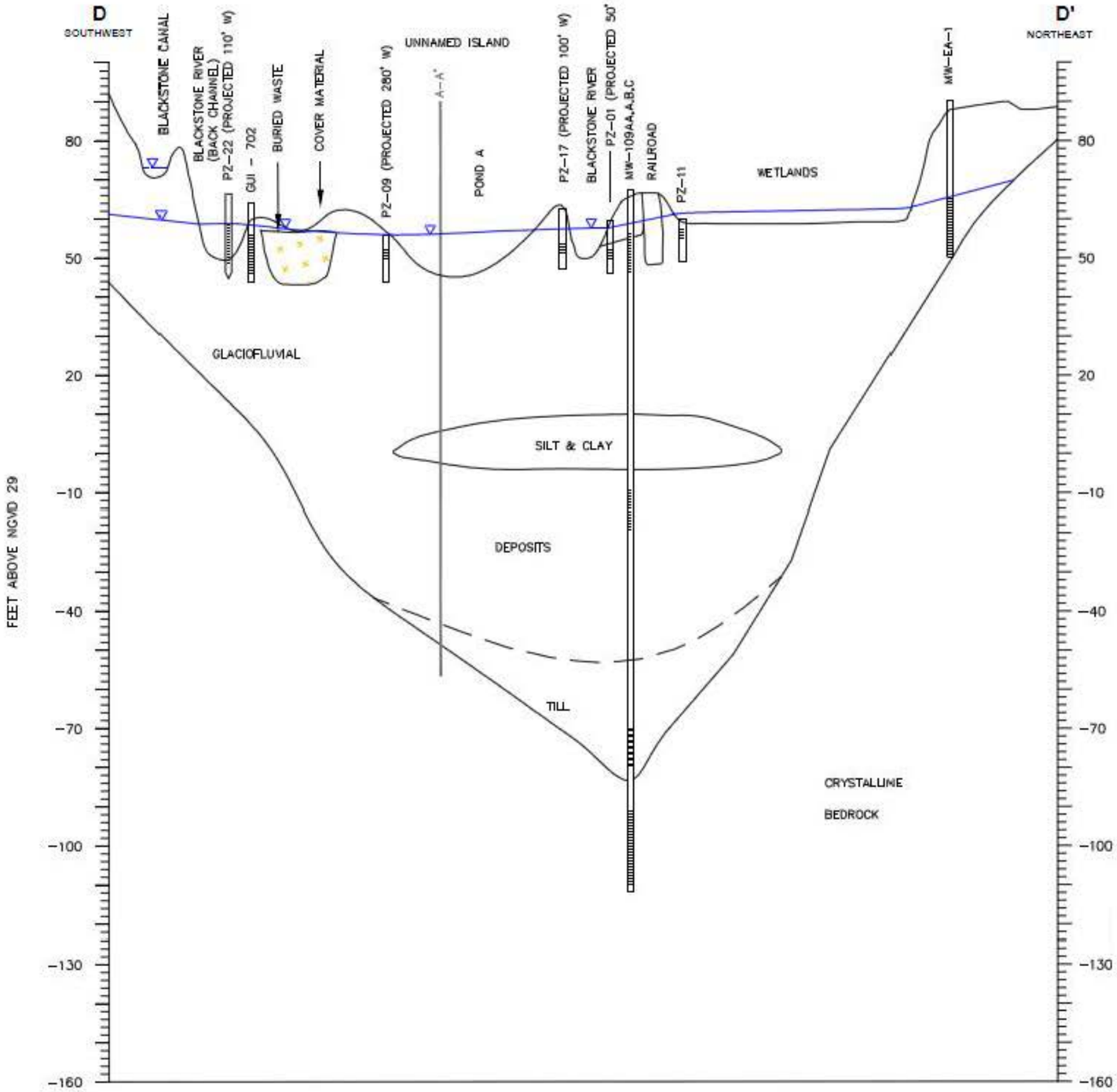
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

CROSS SECTION F - F'

ARCADIS

FIGURE 2-6

CITY:SYRACUSE,NY DIV/GROUP:ENVCAD DB:A.SCHLUNG LD: PIC: PM: TM: LYR:ON=*;OFF=REF*
G:\ENVCAD\Jobs\gis\MXD\ACT\2003TASC\000000000\CAD\MXD_ACT2003TASC_000000000_LAYOUT 2-6.mxd LAYOUT: 2-6 SAVED: 10/2/2013 3:59 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: —
XREFS: IMAGES PROJECTNAME: —



LEGEND

APPROXIMATE WATER TABLE NOVEMBER 8, 2005

WASTE/REFUSE

MONITORING WELL (SINGLE) OR MULTIPLE WELL CLUSTER

RISER

SCREENED INTERVAL

B — BARCAD INTERVAL (GZA WELLS ONLY)

NOTES:

1. GEOLOGIC CONTACTS DASHED WHERE INFERRED.
2. CROSS SECTION MODIFIED FROM THE CROSS SECTION PREPARED BY SHIELD ENVIRONMENTAL ASSOCIATES INC., INITIAL SITE CHARACTERIZATION REPORT FEBRUARY 2004.

0 30' 60'
VERTICAL SCALE

0 300' 600'
HORIZONTAL SCALE

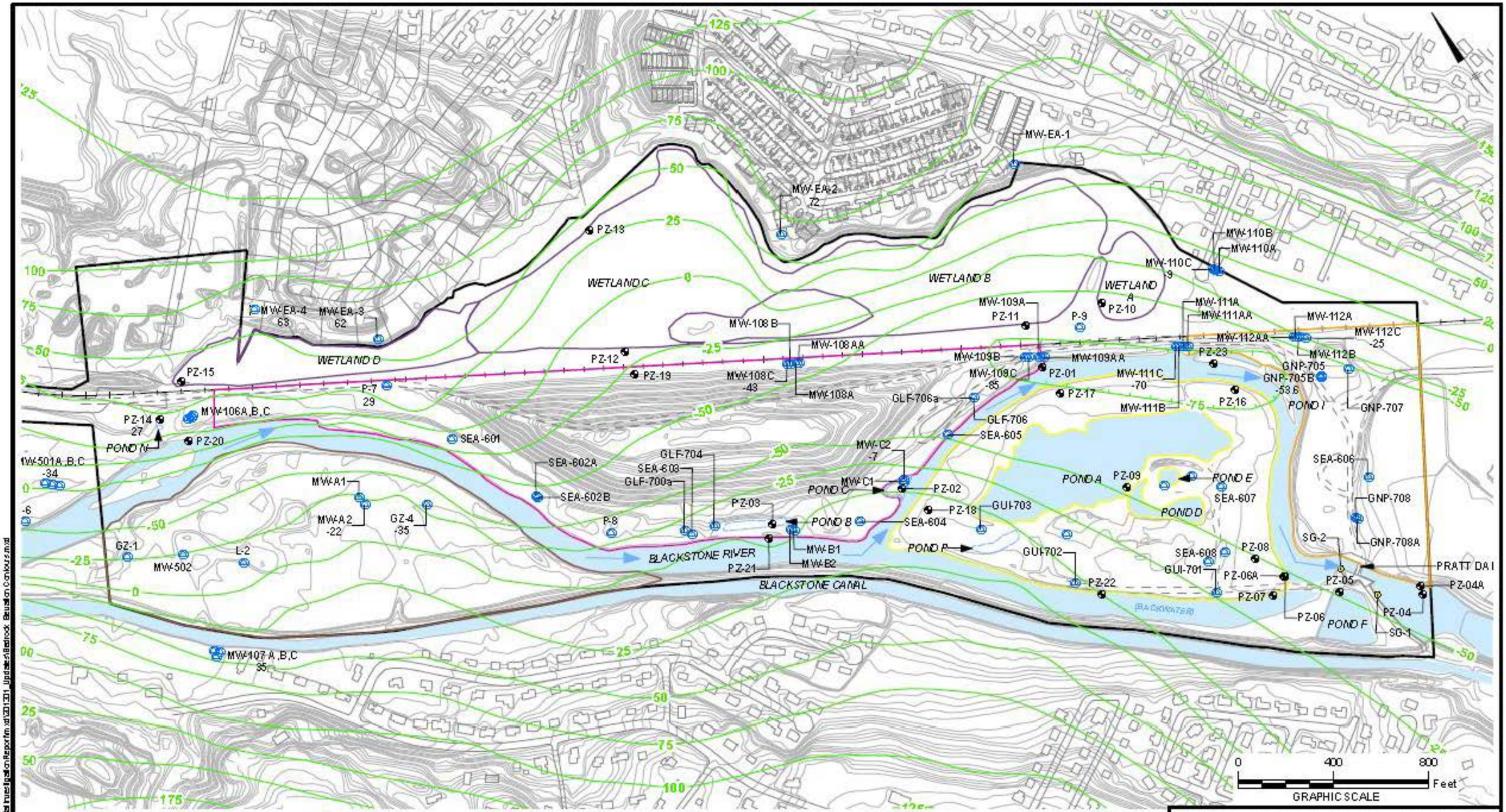
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

CROSS SECTION D -D'

ARCADIS

FIGURE 2-7

CITY:BRAUSBY DIVISION:GROUP:BVD:CAD DBA:SCHLUNG LD: RC: PM: TM: LYR:(OPT)=OFF;REF
G:\ENVCAD\Landfill\ACT\2007\Decommissioning\Figures\Fig2-7SEC402.dwg LAYOUT: 2-7 SAVED: 10/30/2007 3:57 PM ACADVER: 16.1S (LMS TECH) PAGESETUP: --- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 10/30/2007 3:57 PM BY: AVENS, DAVID
XREFS: IMAGES: PROJECTNAME: —



LEGEND:

- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- BEDROCK ELEVATION CONTOUR
- 25 ELEVATION ABOVE MEAN SEA LEVEL
- -30 ELEVATION BELOW MEAN SEALEVEL
- OU2 BOUNDARY (RI Site Study Area)
- RAILROAD
- HISTORICAL ACCESS ROAD
- WATER
- DIRECTION OF SURFACE WATER FLOW
- HISTORICAL POND
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NFO NUNES DISPOSAL, INC.)

NOTES:

1. SAMPLE LOCATIONS AND BASEMAPPING ARE IN THE COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD 83 FEET. LOCATIONS RECORDED IN THE FIELD USING GPS.
2. NFO - NOW OR FORMERLY OWNED BY

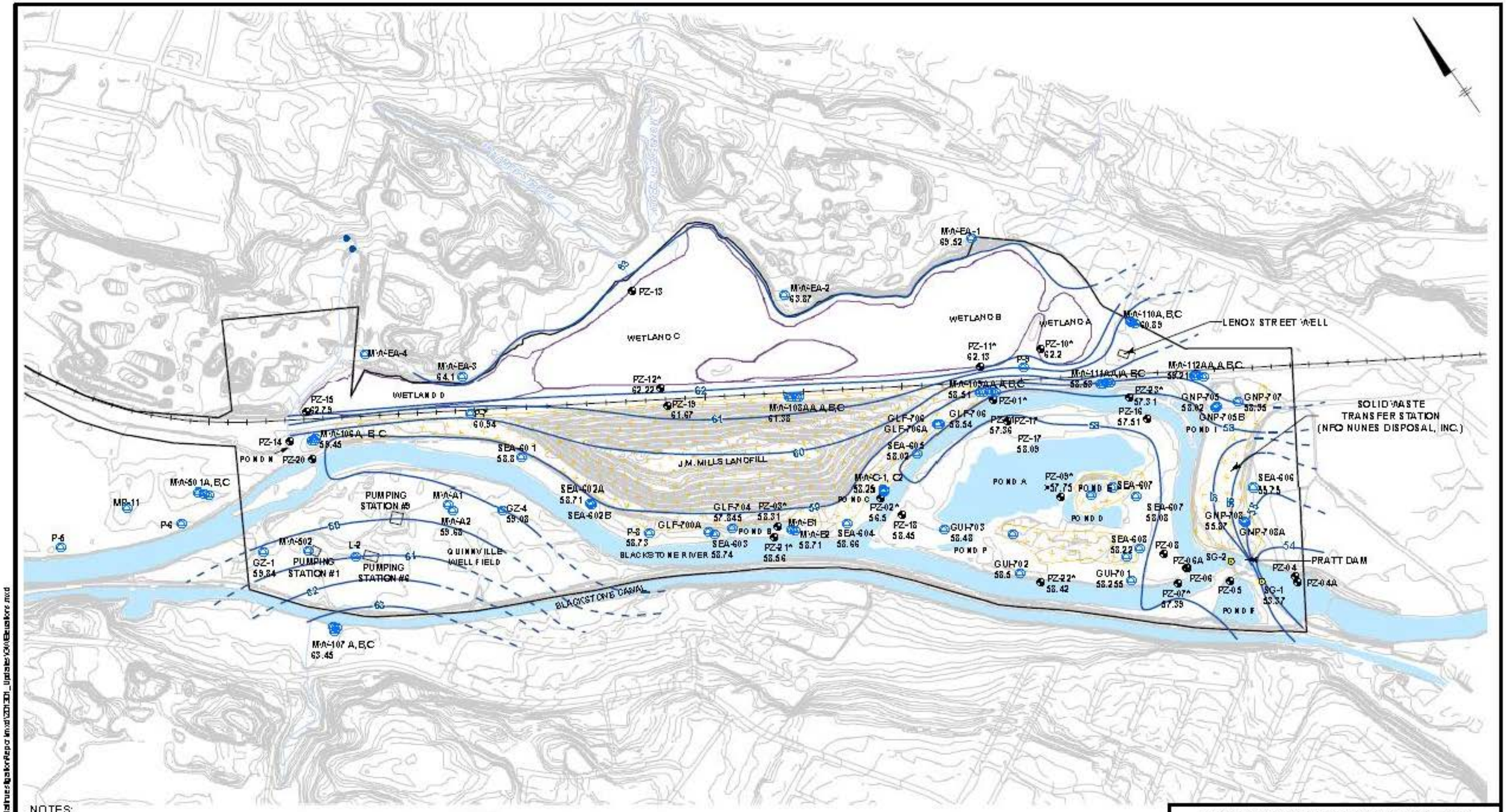
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

BEDROCK ELEVATION CONTOUR MAP

ARCADIS

FIGURE
2-8

CITY:SYR, DIVGROUP: IT DB: KBS LD: PIC: PM: TM: TR:
Peterson Puritan (80037502.0000DR00)
G:\Peterson_Puritan\Cumberland_RI\Remedial Investigation\Report\mxd\20131031_Updated Bedrock Elevation Contours.mxd



NOTES:

1) NFO - NOW OR FORMERLY OWNED BY
2) GROUNDWATER ELEVATIONS OBTAINED ON 11/28/05.
3) * WATER ELEVATION REPRESENTS THE SURFACE WATER ELEVATION. THE MEASURMENTS WERE TAKEN FROM OUTSIDE THE PIEZOMETER CASING.
4) PZ-2 WAS NOT USED IN CONTOURING DUE TO AN ANOMALOUS READING.
5) STANDING WATER AT PZ-15 IS INTERPRETED TO BE PERCHED (67.17'). VALUE SHOWN IS LEVEL INSIDE PIEZOMETER.

LEGEND:

- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- SEEPS
- GROUNDWATER CONTOUR
- INFERRED GROUNDWATER CONTOUR
- OU2 BOUNDARY (RI Site Study Area)
- BURIED WASTE
- WETLAND
- SURFACE WATER

0 500 1,000 Feet
GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

GROUNDWATER CONTOUR MAP

ARCADIS

FIGURE
2-9

CITY: SYR DIV/GROUP: IT DB: KBS LD: PD: PM: TM: TR:
Peterson Puritan (GENERAL)
G:\Peterson_Puritan\Cumberland_RI\Remedial\ries\Baker\Report\mxd\2D\2D01_UpdatedGWElevsBaker.mxd

DEBRIS FIELDS 1-3

LENOX STREET MUNICIPAL WELL

WETLAND B

WETLAND A

SO-048-DF
Cadmium 5.3

SO-023-LF
Cadmium 8.7

SO-026-LF
Cadmium 16.3

SO-028-LF
Cadmium 23.5

SO-W07-DF
Cadmium 2.3

POND N

SO-025-LF
Cadmium 3.1

SO-027-LF
Cadmium 4.6

SO-030-LF
Cadmium 10.6

SO-032-LF
Cadmium 8.1

SO-041-LF
Cadmium 8

J.M. MILLS LANDFILL

SO-W06-DF
Cadmium 8.7

SO-018-LF
Cadmium 1.4

SO-W05-DF
Cadmium 10.6

DEBRIS FIELD 4

SO-019-LF
Cadmium 4

POND I

POND A

POND E

POND C

SO-021-LF
Cadmium 3.7

POND D

SO-020-LF
Cadmium 12.4

POND B

SO-029-LF
Cadmium 12.2

BLACKSTONE RIVER

SO-022-LF
Cadmium 3.6

POND P

PRATT DAM

SO-042-LF
Cadmium 5

SO-024-LF
Cadmium 5.4

BLACKSTONE CANAL

POND F

Legend

- OU2 BOUNDARY (RI Site Study Area)
- APPROXIMATE EXTENT OF CADMIUM EXCEEDING PRGs IN JM MILLS LANDFILL SOIL
- BURIED WASTE
- SURFACE WATER
- RAILROAD
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NOW OR FORMERLY OWNED BY NUNES DISPOSAL, INC.)
- SOIL SAMPLE LOCATIONS
- SEEP

0 500 1,000

SCALE IN FEET

NOTES:
1) SAMPLE LOCATIONS ARE IN THE COORDINATE SYSTEM STATE PLANE RHODE ISLAND NAD 83 FEET. LOCATIONS RECORDED IN THE FIELD USING GPS.
2) RESULTS REPRESENT THE CUMULATIVE SURFACE SOIL (0-1' INTERVAL DEPTHS ONLY) SAMPLES COLLECTED FROM THE BEGINNING OF PHASE 1A IN 2003 THROUGH THE SUPPLEMENTAL UNNAMED ISLAND INVESTIGATION IN 2009.
3) ALL RESULTS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG).
4) WHILE CADMIUM RESULTS ARE PRESENTED AS A COMPARISON TO THE ECOLOGICAL PRG (3.93 PPM), THE EXTENT OF EXCEEDANCES IS ALSO BASED ON COMPARISON TO HUMAN HEALTH PRGS FOR THE RECREATIONAL USER.

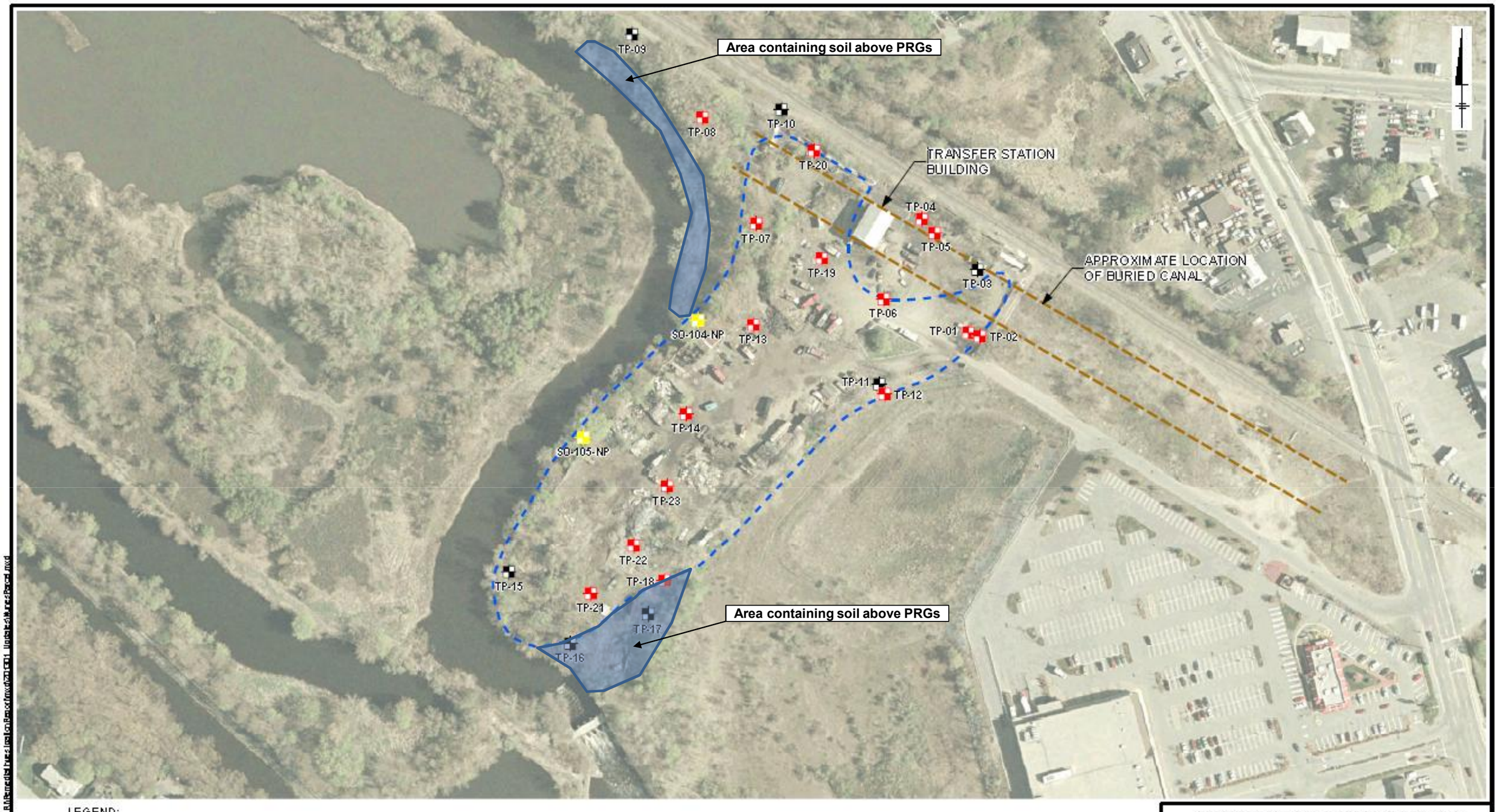
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

AREAS EXCEEDING REMEDIAL GOALS - J.M. MILLS LANDFILL

ARCADIS

FIGURE
3-1

CITY: LAKEWOOD DIV/GROUP:(ENV) DB: M. MALLO PIC:() PM:() APM:()
PROJECT: PETERSON PURITAN PATH: Y:\Peterson_Puritan\Cumberland_RI\RemedialInvestigationReport\mxd\20130301_Updates\metals_SOIL_SURFACE_black_JMMills_v2.mxd Date Saved: 3/4/2013 9:37:41 AM



LEGEND:

- TEST PIT LOCATION - SAMPLE(S) COLLECTED
- TEST PIT LOCATION - NO SAMPLES COLLECTED
- SOIL BORING LOCATION - HAND AUGERED (UNABLE TO EXCAVATE TEST PIT)
- REVISED PHASE 1B PROJECTED BOUNDARY OF BURIED SOLID WASTE
- BURIED CANAL

NOTE:

1) 2002 AERIAL PHOTO OBTAINED FROM RHODE ISLAND GEOGRAPHIC INFORMATION SYSTEM: http://www.edc.uri.edu/rigis/
2) REMEDIAL GOALS PRESENTED ARE BURIED WASTE AREAS

0 150 300 Feet

GRAPHIC SCALE

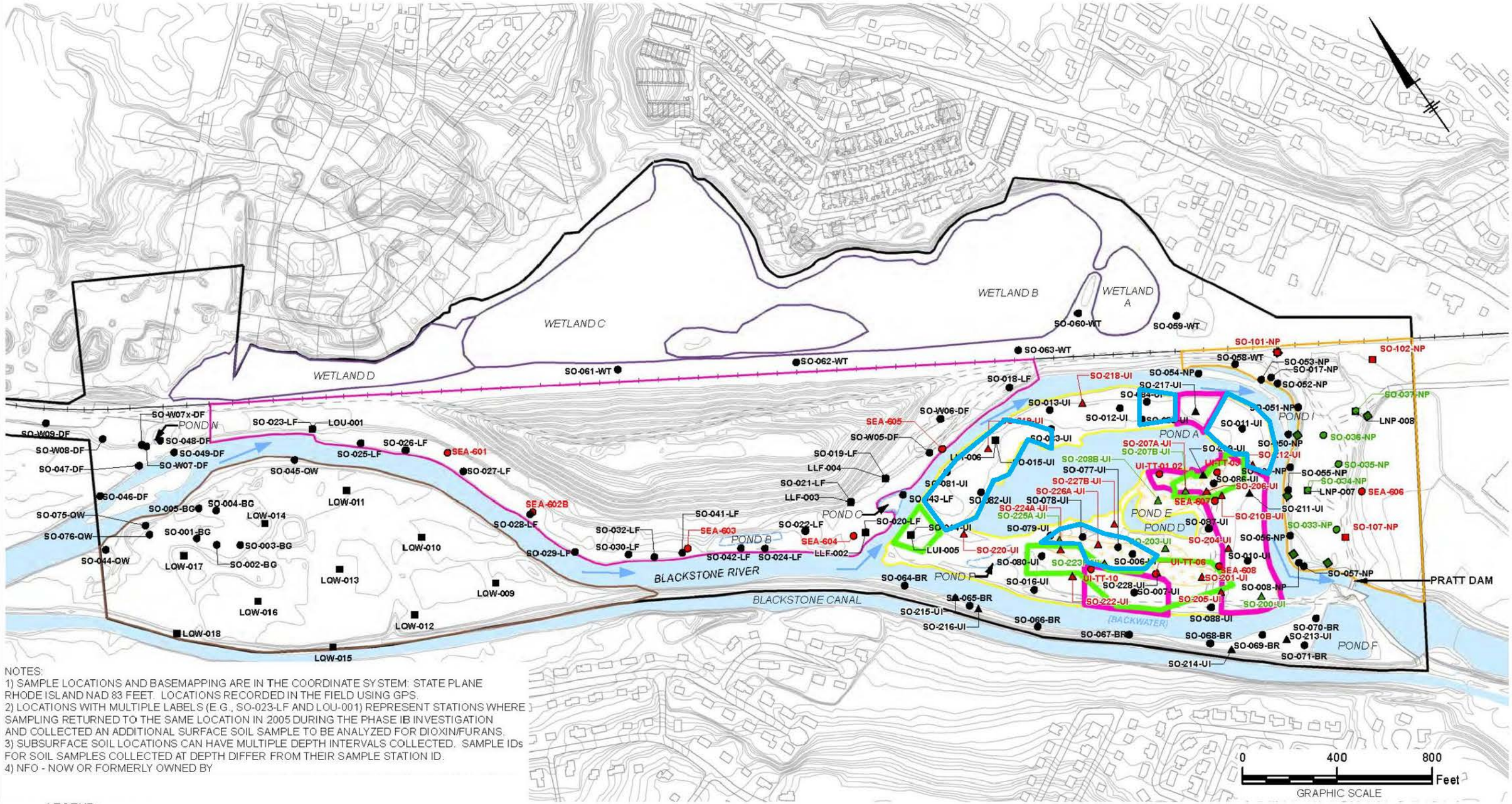
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

AREAS EXCEEDING REMEDIAL GOALS - NUNES PARCEL

ARCADIS

FIGURE 3-2

G:\1407 ROCHESTER\PETERSON PURITAN [ROCHESTER]\Work\GIS\Peterson_Puritan\Cumberland_RI\Remedial Investigation\Report\mxd\20120911_Updated\Nunes Parcel.mxd



NOTES:
1) SAMPLE LOCATIONS AND BASEMAPPING ARE IN THE COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD 83 FEET. LOCATIONS RECORDED IN THE FIELD USING GPS.
2) LOCATIONS WITH MULTIPLE LABELS (E.G., SO-023-LF AND LOU-001) REPRESENT STATIONS WHERE SAMPLING RETURNED TO THE SAME LOCATION IN 2005 DURING THE PHASE IB INVESTIGATION AND COLLECTED AN ADDITIONAL SURFACE SOIL SAMPLE TO BE ANALYZED FOR DIOXIN/FURANS.
3) SUBSURFACE SOIL LOCATIONS CAN HAVE MULTIPLE DEPTH INTERVALS COLLECTED. SAMPLE IDs FOR SOIL SAMPLES COLLECTED AT DEPTH DIFFER FROM THEIR SAMPLE STATION ID.
4) NFO - NOW OR FORMERLY OWNED BY

LEGEND:

- SO-029-LF — PHASE 1B SURFACE SOIL SAMPLE LOCATION
- SEA-602B — PHASE 1A SURFACE SOIL SAMPLE LOCATION
- SO-033-NP — PHASE 1A SUBSURFACE SOIL SAMPLE LOCATION
- LQW-009 — PHASE 1A SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- SO-105-NP — PHASE 1B SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- SO-101-NP — SUPPLEMENTAL INVESTIGATION SURFACE SOIL SAMPLE LOCATION
- SO-209-UI — SUPPLEMENTAL INVESTIGATION SUBSURFACE SOIL SAMPLE LOCATION
- SO-227B-UI — SUPPLEMENTAL INVESTIGATION SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- SO-200-UI — PHASE 1B SUBSURFACE SOIL SAMPLE LOCATION

- BURIED WASTE
- HISTORICAL POND
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NFO NUNES DISPOSAL, INC.)
- RAILROAD
- OU2 BOUNDARY **(RI Site Study Area)**
- HISTORICAL ACCESS ROAD
- WATER
- APPROXIMATE EXTENT OF BIS(2-ETHYLHEXYL)PHTHALATE EXCEEDING 6 MG/KG **(ECOLOGICAL PRG)**
- APPROXIMATE EXTENT OF LEAD EXCEEDING 161 MG/KG **(ECOLOGICAL PRG)**
- **ESTIMATE OF ADDITIONAL AREA EXCEEDING HUMAN HEALTH PRGS (NOTE THAT SOME LOCATIONS ENCOMPASSED EVEN IF NO DETECTION ABOVE PRGS FOR CONSERVATIVE ESTIMATE IN AREA WITH LIMITED SAMPLE RESULTS)**

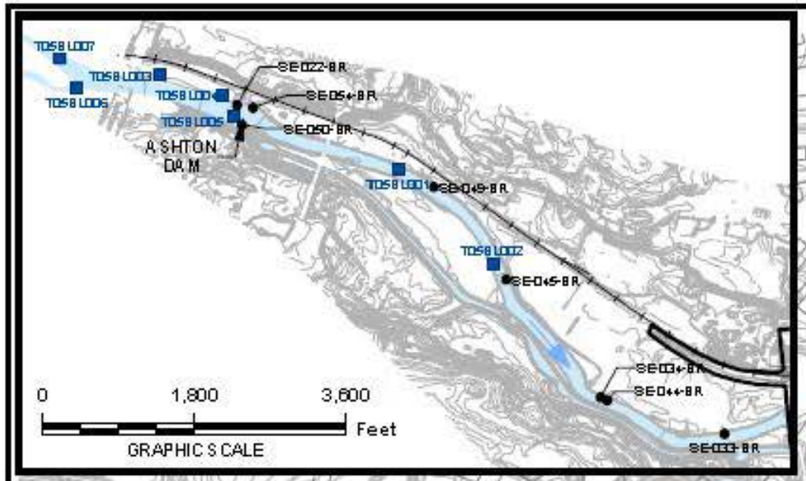
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

AREAS EXCEEDING REMEDIAL GOALS - UNNAMED ISLAND

ARCADIS

FIGURE 3-3

CITY: (CLE) DIV/GROUP: (ENV/GIS) DB: (LGREENE) LD: 0 PIC: 0 PM: 0 TM: (J.ROBERTS)
PROJECT: PETERSON PURITAN PATH: Y:\Peterson_Puritan\Cumberland_RI\Remedial Investigation Report\mxd\201301_Updates\SoilSampPhase1aand1b-topobasemap_update_v5.mxd



LEGEND:

- BE-001-UI ■ PHASE 1B SEDIMENT SAMPLE LOCATION
- TDSBR004 ● PHASE 1A SEDIMENT SAMPLE LOCATION
- HISTORICAL POND
- OU2 BOUNDARY (RI Site Study Area)
- RAILROAD
- HISTORICAL ACCESS ROAD
- DIRECTION OF SURFACE WATER FLOW
- WATER
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NFO NUNES DISPOSAL, INC.)
- APPROXIMATE EXTENT OF SEDIMENT EXCEEDING A PRG
- CADMIUM EXCEEDING 9.8 MG/KG
- CHROMIUM EXCEEDING 120 MG/KG
- COPPPER EXCEEDING 160 MG/KG
- LEAD EXCEEDING 300 MG/KG
- ZINC EXCEEDING 490 MG/KG
- TOTAL PAHs EXCEEDING 18 MG/KG

NOTES:
1) SAMPLE LOCATIONS AND BASEMAPPING ARE IN THE COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD83 FEET. LOCATIONS RECORDED IN THE FIELD USING GPS.
2) NFO - NOW OR FORMERLY OWNED BY
3) THE REMEDIAL GOALS PRESENTED ARE FOR SEDIMENTS EXCEEDING ECOLOGICAL REMEDIAL GOALS.
4) THE APPROXIMATE AREA EXCEEDING REMEDIAL GOALS IS 5.6 ACRES.

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

AREAS EXCEEDING REMEDIAL GOALS - SEDIMENTS

ARCADIS

FIGURE 3-4

CITY:(COLE) DIV/GROUP:(ENVGIS) DB:(LOREEM) LOG:(RIO) PIC:(RIO) TM:(JARO BERTS)
PROJECT:PETERSON PURITAN PATH:V:\Peterson_Puritan\Submitted_Final\Remedial Investigation\Report\Fig3-4_UpdatedSedSampPhase1and1b.mxd

UNNAMED STREAM
MONASTERY BROOK
WETLAND C
WETLAND D
WETLAND B
WETLAND A
MW-EA-1
MW-EA-2
PZ-13
PZ-10
PZ-11
PZ-12
PZ-19
PZ-15
PZ-14
MW-106A,B,C
PZ-20
P-7
MW-108A,AA,B,C
MW-109A,AA,B,C
MW-110A,B,C
MW-111A,AA,B,C
MW-112A,AA,B,C
PZ-01
PZ-17
PZ-23
PZ-16
GNP-705
GNP-707
GNP-705B
POND I
GLF-706
GLF-706a
SEA-605
SEA-601
J.M. MILLS LANDFILL
POND N
SOLID WASTE
TRANSFER STATION
(NFO NUNES DISPOSAL, INC.)
MW-C2
MW-C1
POND C
PZ-02
SEA-604
PZ-18
GUI-703
POND A
PZ-09
POND E
GW-207B-UI
GW-208B-UI
SEA-607
SEA-606
GNP-708
GNP-708A
POND D
GW-224A-UI
SEA-602A
SEA-602B
MW-A2
GZ-4
SEA-603
GLF-704
PZ-03
MW-B2
MW-B1
PZ-21
P-8
GLF-700a
BLACKSTONE RIVER
QUINNVILLE
WELL FIELD
MW-502
POND B
POND P
SEA-608
PZ-08
PZ-06
SG-2
PRATT DAM
PZ-04A
GW-201-UI
GUI-702
PZ-06A
PZ-22
GUI-701
PZ-07
PZ-05
SG-1
PZ-04
POND F
BLACKSTONE CANAL

LEGEND:

- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- SEEPS

FORMATION

- SHALLOW UNCONSOLIDATED UNIT
- INTERMEDIATE UNCONSOLIDATED UNIT
- TILL
- DEEPER UNCONSOLIDATED UNIT
- BEDROCK

- OU2 BOUNDARY (RI Site Study Area)
- BURIED WASTE
- SURFACE WATER
- UNNAMED ISLAND
- J.M. MILLS LANDFILL
- SOLID WASTE TRANSFER STATION (NOW OR FORMELY OWNED BY NUNES DISPOSAL, INC.)
- QUINNVILLE WELL FIELD
- WETLAND

0 500 1,000 Feet
GRAPHIC SCALE

NOTES:
1) ONLY WELLS SAMPLED AS PART OF THE OU2 RI ARE SHOWN ON THIS FIGURE.

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

MONITORING WELLS, PIEZOMETER AND STAFF GAUGES

ARCADIS

FIGURE 3-5

CITY: (CLE) DIV/GROUP:(ENV/GIS) DB:(LGREENE) LD:() PIC:() PM:() TM:(J.ROBERTS)
PROJECT: PETERSON PURITAN PATH: W:\env\GIS\Peterson Puritan\Cumberland RI\Revised\InvestigationReport\mxd\2013\1 Updates\Wells_v2.mxd

LENOX STREET MUNICIPAL WELL

LENOX STREET WELL

SOLID WASTE TRANSFER STATION (NFO NUNES DISPOSAL, INC.)

PRATT DAM

NOTES:

1) NFO - NOW OR FORMERLY OWNED BY
2) GROUNDWATER ELEVATIONS OBTAINED ON 11/28/05.
3) * WATER ELEVATION REPRESENTS THE SURFACE WATER ELEVATION. THE MEASURMENTS WERE TAKEN FROM OUTSIDE THE PIEZOMETER CASING.
4) PZ-2 WAS NOT USED IN CONTOURING DUE TO AN ANOMALOUS READING.
5) STANDING WATER AT PZ-15 IS INTERPRETED TO BE PERCHED (67.17'). VALUE SHOWN IS LEVEL INSIDE PIEZOMETER.

LEGEND:

- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- SEEPS
- GROUNDWATER CONTOUR
- INFERRED GROUNDWATER CONTOUR
- OU2 BOUNDARY (RI Site Study Area)
- RESIDENTIAL WATER SUPPLY WELL
- BURIED WASTE
- WETLAND
- SURFACE WATER
- Proposed Groundwater Compliance Boundary

0 500 1,000 Feet

GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

PROPOSED GROUNDWATER COMPLIANCE BOUNDARY

ARCADIS

FIGURE **3-6**

CITY/SYR: DIV/GROUP: IT: DB: KBS LD: PD: PM: TM: TR:
Peterson Puritan\ (EDS\SCD\2005)
G:\Peterson_Puritan\Cumberland_RI\Arcmedia\Figures\SpatialRep\mxd\3D\3D01_UpdatedGWBoundary.mxd

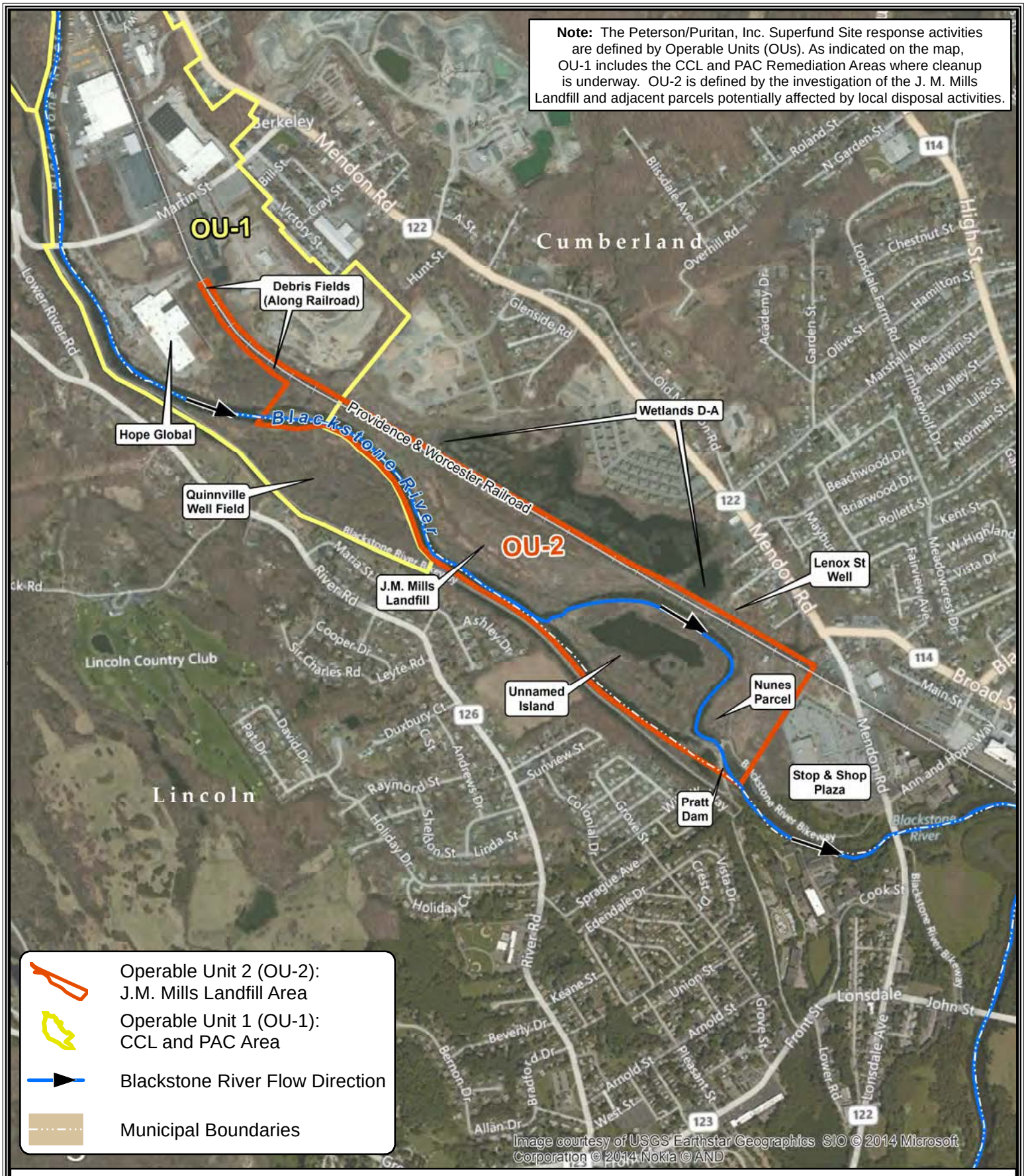


Figure 3-7. Revised Site Boundary

Peterson/Puritan, Inc. Superfund Site
Operable Unit 2 (OU-2)

Cumberland & Lincoln, Rhode Island

EPA

EPA Region 1 GIS Center Map Tracker ID 8590 June 29, 2012 Data Sources: Aerial Photo Base Map - Bing Maps; Municipal Boundary, Railroad - USGS/RIGIS, 1989; River & Flow Direction - National Hydrography Dataset, 2007;

JM-SO-2

DEBRIS FIELDS 1-3

LENOX STREET MUNICIPAL WELL

WETLAND B

WETLAND A

POND N

J.M. MILLS LANDFILL

DEBRIS FIELD 4

POND C

POND B

POND A

POND E

POND D

POND I

POND P

PRATT DAM

POND F

BLACKSTONE RIVER

BLACKSTONE CANAL

Legend

- OU2 BOUNDARY (RI Site Study Area)
- SURFACE WATER
- APPROXIMATE EXTENT OF SOIL EXCAVATION
- APPROXIMATE EXTENT OF RCRA SUBTITLE C CAP
- BURIED WASTE
- RAILROAD
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NOW OR FORMERLY OWNED BY NUNES DISPOSAL, INC.)
- SEEP

0 500 1,000

SCALE IN FEET

NOTES:
1) BURIED WASTE AND DEBRIS FIELDS CURRENTLY OUTSIDE THE BOUNDARY OF THE PROPOSED COVER WILL BE CONSOLIDATED UNDER THE PROPOSED COVER.
2) THE APPROXIMATE AREA OF THE LANDFILL COVER IS 21 ACRES.

Soils to be excavated – approximately 10 acres at a depth of 2 ft, resulting in approximately 33,000 cy

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

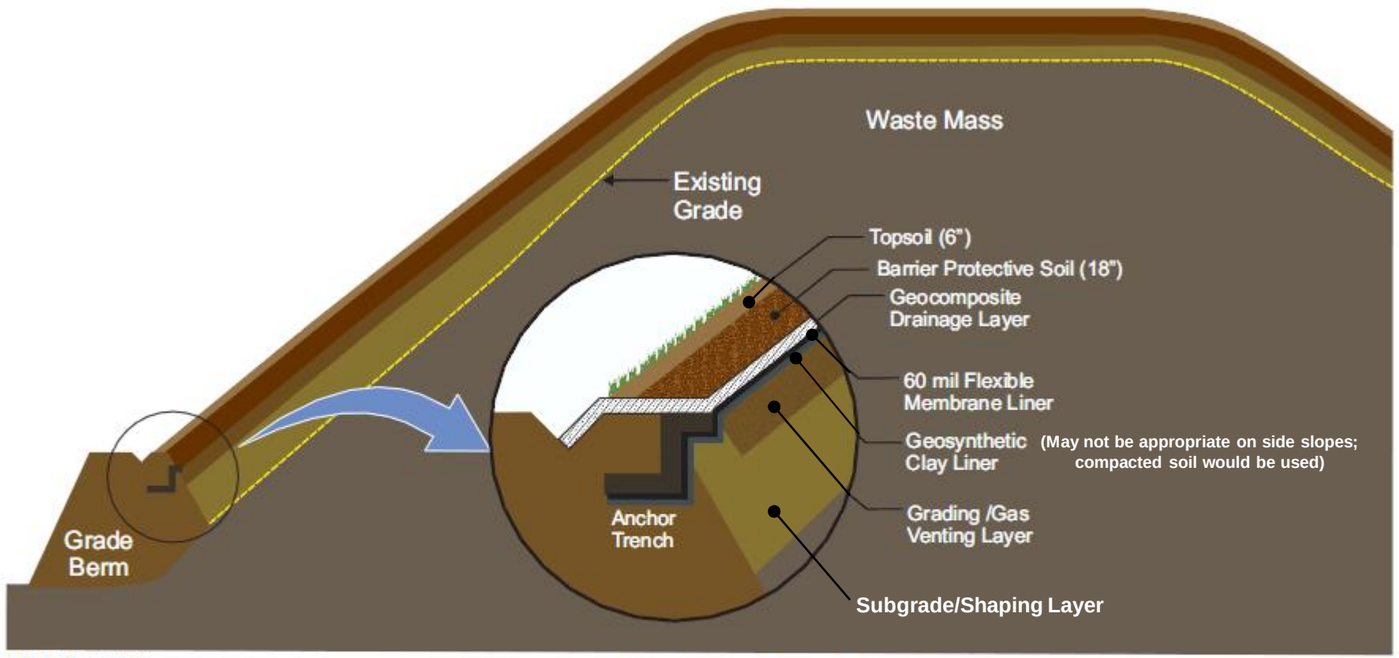
J.M. MILLS LANDFILL SOIL REMOVAL AND RCRA SUBTITLE C CAP

ARCADIS

FIGURE
7-1

JM-SO-2

03/01/2013 SYRACUSE, NY-ENV/CAD-DJHOWES
B0037902/0001/00500/CDR/37902G07.CDR



NOT TO SCALE

ALTERNATIVE JM SO-2

NOTES:
1. Grade berm/regrading of existing slopes to achieve 3V: 1H maximum sideslope.

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

CONCEPTUAL CROSS-SECTION
REGION 1 SUBTITLE C ALTERNATE CAP

ARCADIS

FIGURE
7-2

JM-SO-3

DEBRIS FIELDS 1-3

APPROXIMATE LOCATION OF RCRA SUBTITLE C CAP AND SOIL COVER SYSTEM TIE IN

WETLAND C

WETLAND B

WETLAND A

LENOX STREET MUNICIPAL WELL

WETLAND D

DEBRIS FIELD 4

POND I

POND N

J.M. MILLS LANDFILL

POND A

POND E

POND C

POND D

POND B

POND P

PRATT DAM

BLACKSTONE RIVER

BLACKSTONE CANAL

POND F

Legend

- OU2 BOUNDARY (RI Site Study Area)
- SURFACE WATER
- APPROXIMATE EXTENT OF SOIL EXCAVATION
- BURIED WASTE
- SEEP
- RAILROAD
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NOW OR FORMERLY OWNED BY NUNES DISPOSAL, INC.)
- APPROXIMATE EXTENT OF SOIL COVER SYSTEM
- APPROXIMATE EXTENT OF RCRA SUBTITLE C CAP
- APPROXIMATE EXTENT OF LANDFILL GRADING/COVER SYSTEM

0 500 1,000

SCALE IN FEET

NOTES:

1) BURIED WASTE AND DEBRIS FIELDS CURRENTLY OUTSIDE THE BOUNDARY OF THE PROPOSED COVER WILL BE CONSOLIDATED UNDER THE PROPOSED COVER.

2) THE APPROXIMATE AREA OF THE SOIL COVER SYSTEM IS 15.7 ACRES AND THE RCRA SUBTITLE C CAP IS 5.3 ACRES.

Soils to be excavated – approximately 10 acres at a depth of 2 ft, resulting in approximately 33,000 cy

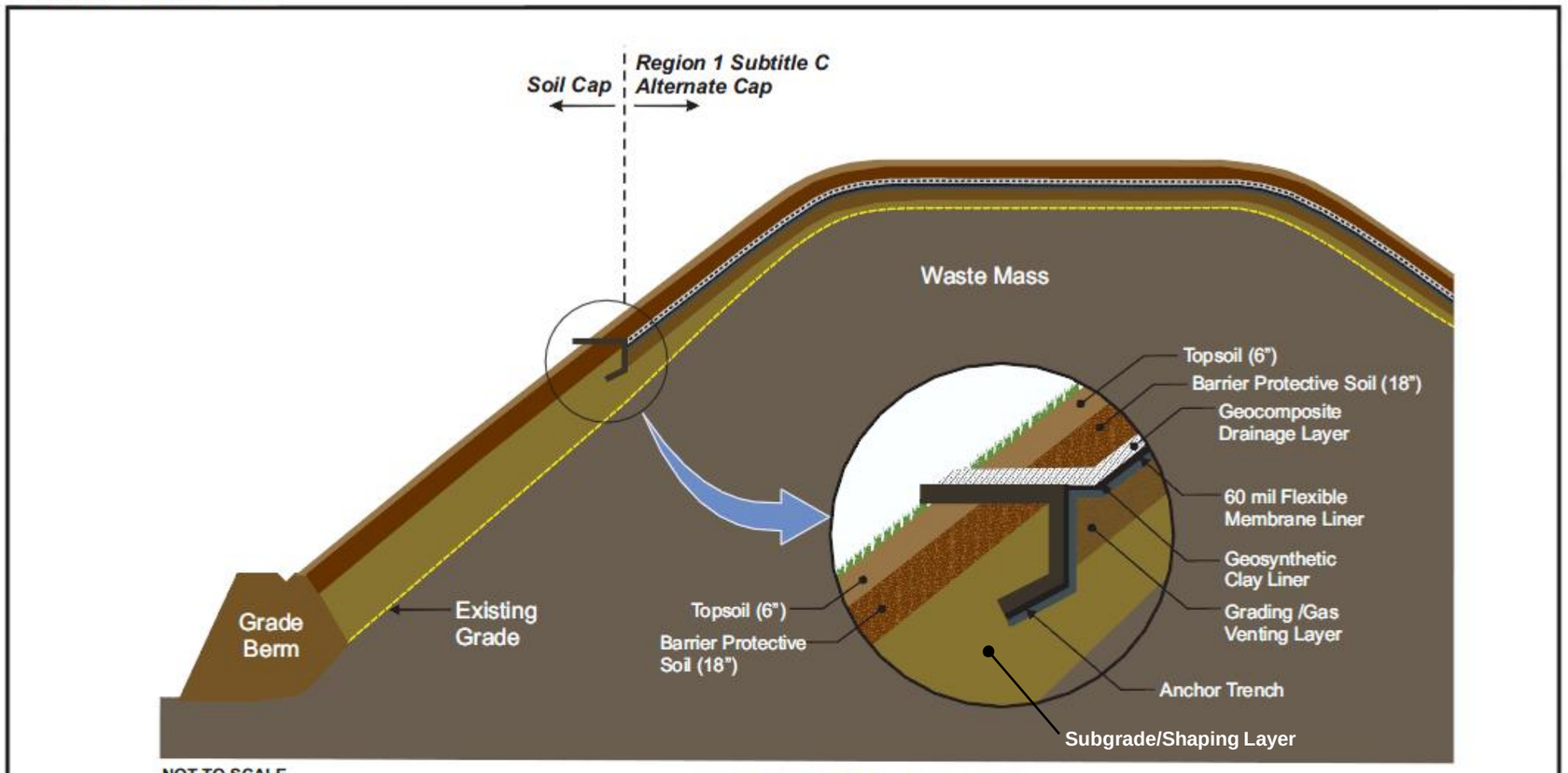
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

J.M. MILLS LANDFILL SOIL REMOVAL AND COMBINATION RCRA SUBTITLE C CAP AND SOIL COVER SYSTEM LOCATION

ARCADIS

FIGURE 7-3

03/01/2013 SYRACUSE, NY-ENVICAD-DJHOWES
B0037902/0001/00500/CDR/37902G06.CDR



NOT TO SCALE

ALTERNATIVE JM SO-3

NOTES:

1. Grade berm/regrading of existing slopes to achieve 3V: 1H maximum sideslope.
2. Upper 1/3 of JM Mills Landfill to receive alternate Subtitle C cap and lower 2/3 to receive soil cap.

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

CONCEPTUAL CROSS-SECTION COMBINATION REGION 1 SUBTITLE C ALTERNATE SOIL CAP

ARCADIS

FIGURE
7-4

NP-SO-2 & NP-SO-3

Area containing soil above PRGs to be consolidated under the cover

Approximate location of buried canal which may contain waste requiring consolidation under the cover

Area containing soil above PRGs to be consolidated under the cover

POND I

TP-09
TP-08
TP-10
TP-20
TP-04
TP-05
TP-07
TP-19
TP-03
TP-06
SO-104-NP
TP-13
TP-01
TP-02
TP-11
TP-12
TP-14
SO-105-NP
TP-23
TP-22
TP-18
TP-15
TP-21
TP-17
TP-16

LEGEND:

- TEST PIT LOCATION - SAMPLE(S) COLLECTED
- TEST PIT LOCATION - NO SAMPLES COLLECTED
- SOIL BORING LOCATION - HAND AUGERED (UNABLE TO EXCAVATE TEST PIT)
- APPROXIMATE EXTENT OF LANDFILL COVER

Additional soil/sediment to be excavated – approximately 1 acre at a depth of 2 ft, resulting in approximately 3,500 cy

NOTE:
1) 2002 AERIAL PHOTO OBTAINED FROM RHODE ISLAND GEOGRAPHIC INFORMATION SYSTEM: http://www.edc.uri.edu/rigis/
2) THE APPROXIMATE AREA OF THE PROPOSED COVER IS 6.28 ACRES.
3) SEDIMENT FROM POND I MAY BE CONSOLIDATED UNDER THE COVER.

0 150 300 Feet
GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

NUNES PARCEL LANDFILL CAP LOCATION

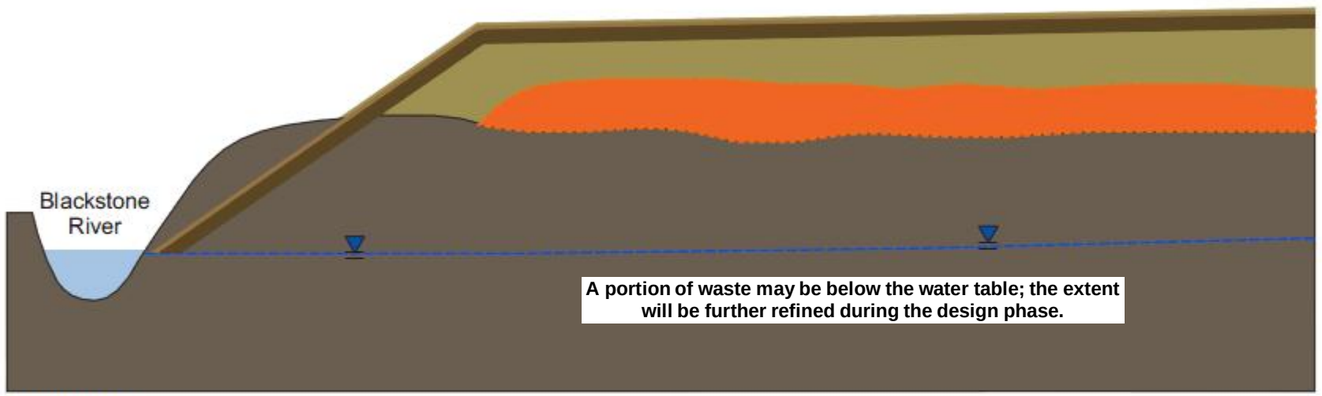
ARCADIS

FIGURE 7-5

614407 ROCH-85 EAB
PETERSON PURITAN (ROCH-85 EAB)
W:\c2p1\GIS\Peterson_Puritan\Cumberland_RI\Remedialinvestigation\Report\mxd\20130131_Updated\NunesParcel_LandfillCap.mxd

NP-SO-2

03/01/2013 SYRACUSE, NY-ENV/CAD-DJHOWES
B0037902/0001/00500/CDR/37902G02.CDR



NOT-TO-SCALE

ALTERNATIVE NP-SO-2

NOTES:

1. **Landfill cover to be designed to meet RCRA Subtitle D and RI Solid Waste Regulations. See Note 3 for details.**

2. Landfill slope will be a maximum of 3:1; slope will be armored to 100-year flood levels.

3. Proposed cover construction (top to bottom):
12" vegetative cover
Geocomposite drainage layer
60 mil Flexible Membrane Liner
[gas venting layer TBD in design]
6" bedding layer (minimum)

LEGEND:

- Consolidated Waste and/or Soil
- Surface Water
- Water Table
- Fill Material
- Current Ground Surface

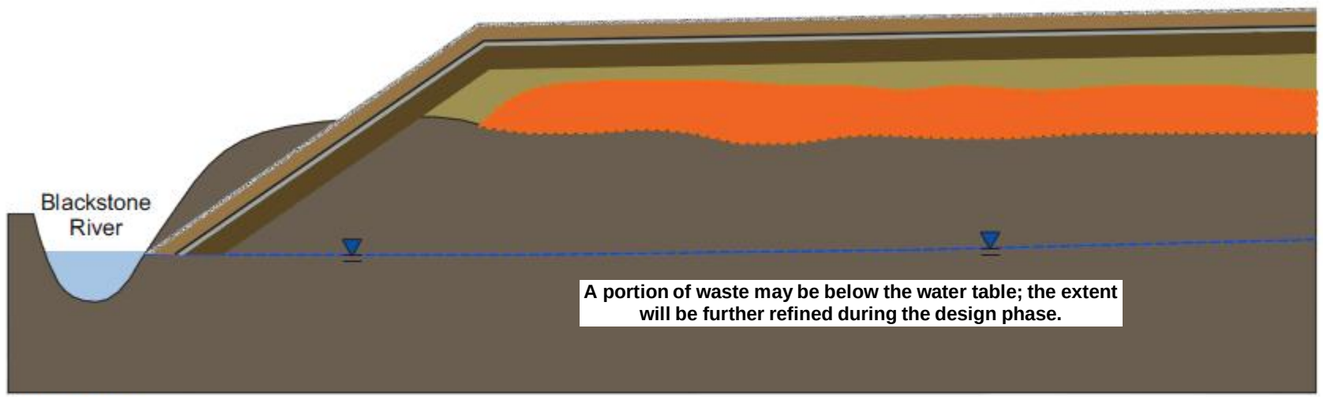
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

CONCEPTUAL CROSS-SECTION ALTERNATIVE NP-SO-2

ARCADIS

FIGURE 7-6

03/01/2013 SYRACUSE, NY-ENV/CAD-DJHOWES
B0037902/0001/00500/CDR/37902G05.CDR



NOT-TO-SCALE

ALTERNATIVE NP-SO-3

NOTES:

1. **Landfill cover proposed for costing purposes is a Region 1 Subtitle C Alternate Cap. Refer to Figure 7-2 for cap construction detail.**
2. Landfill slope will be a maximum of 3:1; slope will be armored to 100-year flood levels.

LEGEND:

- Consolidated Waste and/or Soil
- Surface Water
- Water Table
- Fill Material
- Current Ground Surface

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

CONCEPTUAL CROSS-SECTION ALTERNATIVE NP-SO-3

ARCADIS

FIGURE 7-7

UI-SO-2

WETLAND D
WETLAND C
WETLAND B
WETLAND A
POND N
POND C
POND B
POND P
POND A
POND E
POND D
POND I
POND F
BLACKSTONE RIVER
BLACKSTONE CANAL
PRATT DAM
SO-218-UI
SO-217-UI
SO-207A-UI
SO-207B-UI
SO-208B-UI
SO-227B-UI
SO-228A-UI
SO-224A-UI
SO-226A-UI
SO-220-UI
SO-206-UI
SO-211-UI
SO-210B-UI
SO-203-UI
SO-204-UI
SO-228-UI
SO-201-UI
SO-222-UI
SO-205-UI
SO-209-UI
SO-216-UI
SO-215-UI
SO-213-UI
SO-214-UI

LEGEND:

- SUPPLEMENTAL INVESTIGATION SURFACE SOIL SAMPLE LOCATION
- SUPPLEMENTAL INVESTIGATION SUBSURFACE SOIL SAMPLE LOCATION
- SUPPLEMENTAL INVESTIGATION SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- APPROXIMATE EXTENT OF SOIL EXCAVATION AND CAPPING AS NEEDED
- BURIED WASTE
- HISTORICAL POND
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NFO NUNES DISPOSAL, INC.)
- RAILROAD
- OU2 BOUNDARY (RI Site Study Area)
- HISTORICAL ACCESS ROAD
- WATER

0 400 800 Feet
GRAPHIC SCALE

NOTES:
1) BURIED WASTE AREAS OUTSIDE OF THE APPROXIMATE CAPPING AREA WILL BE CONSOLIDATED USDER THE J.M. MILLS OR NUNES PARCEL COVER.

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

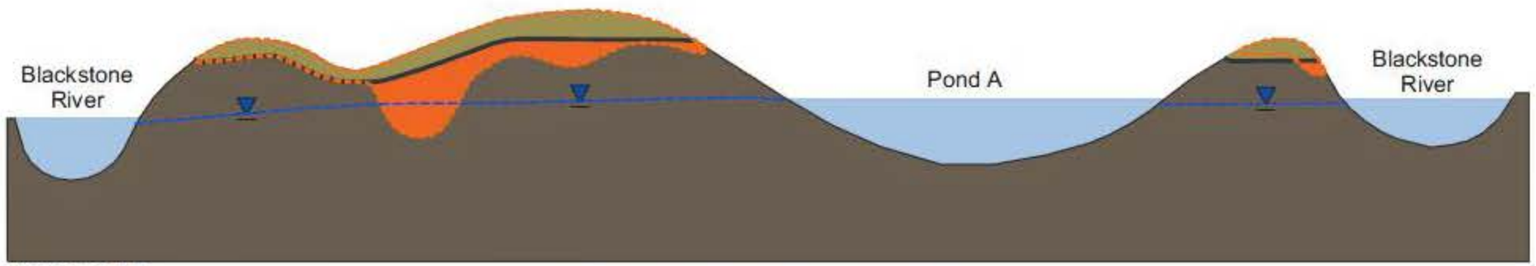
UNNAMED ISLAND SOIL EXCAVATION AND CAPPING LOCATION

ARCADIS

FIGURE 7-8

QTY: (CLE) DWGROUP (ENWGS) DB: (LGREENE) LD: () PC: () PM: () TM: (J ROBERTS)
PROJECT: PETERSON PURITAN PATH: Y:\Peterson_Puritan\Cumberland_RI\Remedialinvestigation\Report\mxd\20130130_Updates\Unnamedisland_CappingExcavation.mxd

02/27/2013 SYRACUSE, NY-ENV/CAD-DJHOWES
B0037902/0001/00500/CDR/37902G01.CDR



NOT-TO-SCALE

ALTERNATIVE UI-SO-2

NOTES:

1. Waste and/or soil exceeding remedial goals will be excavated to a depth of 2 ft below ground surface. Excavated materials will be consolidated under the landfill cover at the J.M. Mills Landfill or Nunes Parcel.
2. Areas where waste or PRG exceedances remain will have a geotextile liner installed with a fill material cover.

LEGEND:

- Waste and/or Soil Exceeding Remedial Goals
- Surface Water
- Water Table
- Geotextile Liner
- Fill Material (rip rap)

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

CONCEPTUAL CROSS-SECTION ALTERNATIVE UI-SO-2

ARCADIS

FIGURE 7-9

UI-SO-3

WETLAND D
WETLAND C
WETLAND B
WETLAND A
POND N
POND I
POND A
POND C
POND E
POND D
POND B
POND P
BLACKSTONE RIVER
BLACKSTONE CANAL
(BACKWATER)
POND F
PRATT DAM

LEGEND:

- APPROXIMATE EXTENT OF SOIL EXCAVATION AND WASTE REMOVAL
- HISTORICAL POND
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NFO NUNES DISPOSAL, INC.)
- RAILROAD
- OU2 BOUNDARY (RI Site Study Area)
- HISTORICAL ACCESS ROAD
- WATER
- BURIED WASTE

0 400 800 Feet
GRAPHIC SCALE

Waste to be excavated – assumed to be approximately 44,000 cy
Soils to be excavated – approximately 13 acres at
an average depth of 3 ft, resulting in approximately 62,000 cy

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

UNNAMED ISLAND SOIL EXCAVATION AND WASTE REMOVAL LOCATIONS

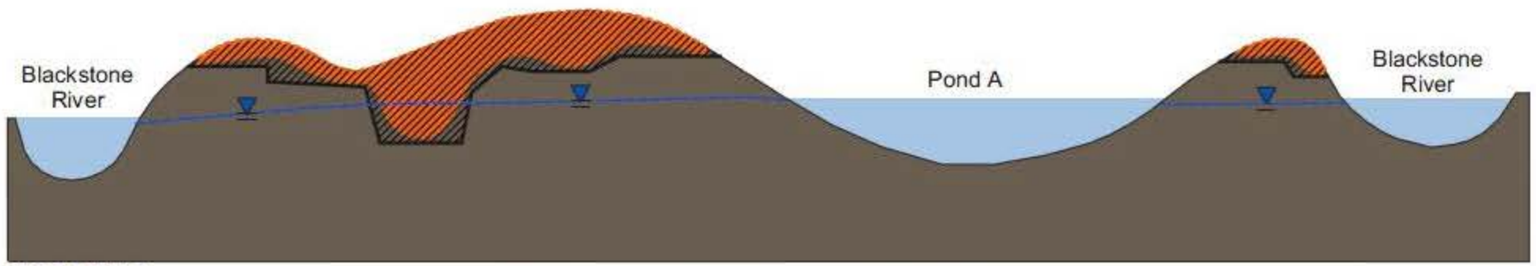
ARCADIS

FIGURE 7-10

QTY: (CLE) DWGROUP (ENWG#) DB: (LGREENE) LD: () PIC: () PM: () TM: (J.ROBERTS)
PROJECT: PETERSON PURITAN PATH: \\ad2fp1\Data\Peterson_Puritan\Cumberland_RI\Remedial Investigation Report\mxd\420130\1_Updates\Unnamedisland_WasteRemovalExcavation.mxd

UI-SO-3

02/27/2013 SYRACUSE, NY-ENV/CAD-DJHOWES
B0037902/0001/00500/CDR/37902G04.CDR



NOT-TO-SCALE

ALTERNATIVE UI-SO-3

NOTES:
1. Waste and/or soil exceeding remedial goals will be excavated and consolidated under the landfill cover at the J.M. Mills Landfill or Nunes Parcel.

LEGEND:

- Waste and/or Soil Exceeding Remedial Goals
- Surface Water
- Water Table
- Area of Excavation
- Ground Surface after Excavation

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

CONCEPTUAL CROSS-SECTION ALTERNATIVE UI-SO-3

ARCADIS

FIGURE
7-11

SE-2

WETLAND A

WETLAND B

WETLAND C

WETLAND D

POND N
(assumed to be removed during J.M. Mills remedial construction)

POND I
(assumed to be removed during Nunes Parcel remedial construction)

POND A

POND E

POND D

POND C

POND B

POND P

BLACKSTONE RIVER

BLACKSTONE CANAL

(BACKWATER)

PRATT DAM

POND F

LEGEND:

- HISTORICAL POND
- OU2 BOUNDARY (RI Site Study Area)
- RAILROAD
- HISTORICAL ACCESS ROAD
- DIRECTION OF SURFACE WATER FLOW
- WATER
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NFO NUNES DISPOSAL, INC.)
- APPROXIMATE EXTENT OF SEDIMENT EXCAVATION AREA

0 400 800 Feet
GRAPHIC SCALE

NOTES:
1) THE APPROXIMATE AREA TO BE EXCAVATED IS 5.4 ACRES.
2) EXCAVATED MATERIAL WILL BE CONSOLIDATED UNDER THE J.M. MILLS OR NUNES PARCEL COVER.

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

SEDIMENT EXCAVATION LOCATIONS

ARCADIS

FIGURE
7-12

CITY: (CLE) DIVGROUP:(ENVGIS) DB:(LGREENE) LD:() PC:() PM:() TM:(JROBERTS)
PROJECT: PETERSON PURITAN PATH: Y:\Peterson_Puritan\Cumberland_IR\Remedialinvestigation\Report\mxd\20130131_Updates\Sediment_Excavation.mxd

SE-3

WETLAND A
WETLAND B
WETLAND C
WETLAND D
POND N
(assumed to be removed during J.M. Mills remedial construction)
POND I
(assumed to be removed during Nunes Parcel remedial construction)
POND A
POND E
POND D
POND C
POND B
POND P
BLACKSTONE RIVER
BLACKSTONE CANAL
(BACKWATER)
POND F
PRATT DAM

LEGEND:

- HISTORICAL POND
- OU2 BOUNDARY (RI Site Study Area)
- RAILROAD
- HISTORICAL ACCESS ROAD
- DIRECTION OF SURFACE WATER FLOW
- WATER
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NFO NUNES DISPOSAL, INC.)
- APPROXIMATE EXTENT OF SEDIMENT EXCAVATION (0-1 FT) AND COVERING AS NEEDED

0 400 800 Feet
GRAPHIC SCALE

NOTES:
1) THE APPROXIMATE AREA TO BE EXCAVATED AND/OR COVERED IS 5.4 ACRES.
2) EXCAVATED MATERIAL WILL BE CONSOLIDATED UNDER THE J.M. MILLS OR NUNES PARCEL COVER.

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

SEDIMENT EXCAVATION AND/OR SUBAQUEOUS COVER LOCATIONS

ARCADIS

FIGURE 7-13

CITY (CLE) DIV/GROUP (ENV/GIS) DB (LGREENE) LD () RC () PM () TM (JROBERTS)
PROJECT PETERSON PURITAN PATH: V:\Peterson Puritan\Cumberland RI\Remedial Investigation\Report\Annex\2013\ Updated\Sediment Excavation Capping.mxd

SE-4

WETLAND A
WETLAND B
WETLAND C
WETLAND D
POND N
(assumed to be removed during J.M. Mills remedial construction)
POND I
(assumed to be removed during Nunes Parcel remedial construction)
POND A
POND E
POND D
POND C
POND B
POND P
BLACKSTONE RIVER
BLACKSTONE CANAL
(BACKWATER)
PRATT DAM
POND F

LEGEND:

- HISTORICAL POND
- OU2 BOUNDARY (RI Site Study Area)
- RAILROAD
- HISTORICAL ACCESS ROAD
- DIRECTION OF SURFACE WATER FLOW
- WATER
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NFO NUNES DISPOSAL, INC.)
- APPROXIMATE EXTENT OF SEDIMENT CAPPING AREA

0 400 800 Feet
GRAPHIC SCALE

NOTES:
1) THE APPROXIMATE AREA TO BE COVERED IS 5.4 ACRES.

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

SEDIMENT SUBAQUEOUS COVER LOCATIONS

ARCADIS

FIGURE 7-14

CITY:(CLE) DIV/GROUP:(ENV/GIS) DB:(LGREENE) LD:() PIC:() PM:() TM:(JROBERTS)

APPENDIX A

GROUNDWATER ALTERNATIVE COSTS

Appendix A

COMPARATIVE ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVE COSTS

		Remediation Capital Costs			O&M and Periodic Costs				Total
Remedial Alternative	**Description**	**Institutional Controls ($)**	**Well Installation ($)**	**Total Installation Capital Cost ($)**	**Annual Monitoring & Reporting Cost ($)**	**End of Project (decomissioning) Cost ($)**	**Time Frame for Monitoring ($)**	**Present Value Cost (O&M and periodic) ($)**	**Present Value Life Cycle Cost (capital costs plus all O&M) ($)**
GW-1	No Action	NA	NA	NA	NA	NA	NA	NA	NA
GW-2	• Monitoring (GW & SW) • Institutional Controls	$23,000	$143,000	$166,000	$41,000	$15,000 assumed for well abandonment	30 Years	$505,000	$671,000

Notes:

All costs are rounded to the nearest $1000

All costs are based on an accuracy of +50/-30% (USEPA, 2000)

Administrative costs associated with performance of 5-Year Reviews and maintenance of Institutional Controls are not included, but assumed to be within range of costs.

Acronyms:

GW - groundwater

NA - not applicable

O&M - operation and maintenance

GROUNDWATER CORRECTIVE MEASURES ALTERNATIVE COST ESTIMATE

INSTITUTIONAL CONTROLS

Design Assumptions:
Institutional Control will be implemented as part of the groundwater remedy.

	Quantity	Unit	Labor - D	Equipment	Materials	Cost Per Unit	Total	rounded to $1000	Reference
Institutional Control Implementation									
Institutional Control Implementation	1	LUMP SUM					$20,000	$20,000	Estimate
Capital Cost Subtotal:							$20,000	$20,000	
Total Indirect Cost:							$0	$0	
Capital and Indirect Cost Subtotal:							$20,000	$20,000	
Contingency (15%):							$3,000	$3,000	
Capital and Indirect Cost Total:							$23,000	$23,000	

GROUNDWATER CORRECTIVE MEASURES ALTERNATIVE COST ESTIMATE

LONG-TERM MONITORING

Design Assumptions

Monitoring Well Installation

Number of New Shallow Monitoring Wells	5	
Number of New Deep Monitoring Wells	5	
Depth of Shallow Monitoring Well	30	ft
Depth of Deep Monitoring Well	45	ft
Monitoring Well Screen Length	10	ft
Diameter of Monitoring Wells	2	inch
Monitoring Well Drilling Schedule	3	wells/day
Depth to water	5	ft bgs

Monitoring Program

Number of Shallow Sampling Well	12	
Number of Deep Sampling Well	14	Assumes inclusion of 2 Resid. Wells
Number of Monitoring Event per Year	2	
Sampling Schedule	3	wells per day
Groundwater Analysis Parameters:	VOCs, total and dissolved iron, dissolved manganese, sulfate, nitrate, TOC	
Surface Water Monitoring:	Assume labor covered by groundwater monitoring and analysis costs similar	

Soil and Water Disposal

Soil from Well Drilling		
Industrial Waste (assume 100% of excavated soil)	0.45	tons
Hazardous Waste (assume 0% of excavated soil)	0.00	tons
Volume of Development/Purge Water from Shallow Wells	12	gal (assumes 3 well volumes)
Volume of Development/Purge Water from Deep Wells	20	gal (assumes 3 well volumes)

	Quantity	**Unit**	**Labor / Equipment**	**Total**	**Rounded to $1000**	**Reference**
Capital Costs						
Site Preparation						
Mobilization/Demobilization	1	LUMP SUM	$5,000	$5,000	$5,000	
Monitoring Well Installation						
Drill Rig + Service Vehicle	1	LUMP SUM	$1,500	$1,500	$2,000	
Utility Clearance	1	LUMP SUM	$500	$500	$1,000	
Drilling	375	foot	$25	$9,375	$9,000	
Well Screen (2" PSSS)	100	foot	$75	$7,500	$8,000	
Well Riser (2" Black Steel)	275	foot	$25	$6,875	$7,000	
Surface Completions (Concrete Pad)	10	Each	$1,000	$10,000	$10,000	
Well Installation Oversight	27	Hour	$95	$2,533	$3,000	
Well Development	10	Each	$3,500	$35,000	$35,000	
Treatment and Disposal						
Soil Cutting Disposal (Industrial Waste)	0.45	ton	$40	$18	$0	
Soil Cutting Disposal (Hazardous Waste)	0.00	ton	$241	$0	$0	
Development Water Disposal	159	GAL	$1.00	$159	$0	
			Total Capital Cost:		$80,000	
Indirect Costs						
Engineering Design/MNA Modeling	30	% Capital Cost		$0	$24,000	
Engineering and Construction Oversight	10	% Capital Cost		$0	$8,000	
Project Management	10	% Capital Cost		$0	$8,000	
Implementation of H&S Measures	5	% Capital Cost		$0	$4,000	
			Total Indirect Cost:		$44,000	
			Direct Plus Indirect Cost:		$124,000	
			Contingency (15%):		$19,000	
			Total Installation Cost:		$143,000	
	Quantity	**Unit**	**Labor / Equipment**		**Total**	**Reference**
Annual Costs						
Monitoring Labor	104	Hour	$95	$9,880	$10,000	
Monitoring Analytical (GW + SW)	68	Each	$250	$17,000	$17,000	
Purge Water Disposal	842	GAL	$1.00	$842	$1,000	
Field Supplies for Monitoring	2	Each	$1,000	$2,000	$2,000	
System Reporting	1	LUMP SUM	$4,000	$4,000	$4,000	
Well Replacement/ Redevelopment	1	LUMP SUM	$2,000	$2,000	$2,000	
			Subtotal Annual Costs:		$36,000	
			Contingency (15%):		$5,000	
			Total Annual Costs:		$41,000	

NOTE:
All costs assume that site work can be performed in Level D
Costs subject to inflationary and energy fluctuations

Present Worth Analysis

Alternative GW-2 - Long-Term Monitoring and Institutional Controls

interest rate: 7%

LIFE CYCLE COST

Year	Amount	PW at Year 1	p/f factor
1	$ -	$ -	1.00
2	$ 41,000	$ 38,318	0.935
3	$ 41,000	$ 35,811	0.873
4	$ 41,000	$ 33,468	0.816
5	$ 41,000	$ 31,279	0.763
6	$ 41,000	$ 29,232	0.713
7	$ 41,000	$ 27,320	0.666
8	$ 41,000	$ 25,533	0.623
9	$ 41,000	$ 23,862	0.582
10	$ 41,000	$ 22,301	0.544
11	$ 41,000	$ 20,842	0.508
12	$ 41,000	$ 19,479	0.475
13	$ 41,000	$ 18,204	0.444
14	$ 41,000	$ 17,014	0.415
15	$ 41,000	$ 15,901	0.388
16	$ 41,000	$ 14,860	0.362
17	$ 41,000	$ 13,888	0.339
18	$ 41,000	$ 12,980	0.317
19	$ 41,000	$ 12,130	0.296
20	$ 41,000	$ 11,337	0.277
21	$ 41,000	$ 10,595	0.258
22	$ 41,000	$ 9,902	0.242
23	$ 41,000	$ 9,254	0.226
24	$ 41,000	$ 8,649	0.211
25	$ 41,000	$ 8,083	0.197
26	$ 41,000	$ 7,554	0.184
27	$ 41,000	$ 7,060	0.172
28	$ 41,000	$ 6,598	0.161
29	$ 41,000	$ 6,166	0.150
30	$ 56,000	$ 7,872	0.141
31		$ -	0.131
PRESENT WORTH:		**$505,493**	

Notes: Years 2 through 30 include Monitoring costs
Year 30 includes Decomissioning cost of $15,000

APPENDIX B

SOURCE AREA AND SEDIMENT ALTERNATIVE COSTS

Appendix B
Source Area Alternative Costs

Area	Alternative	Alternative Description	Capital Cost	Landfill Cost/Acre	Soil Cost/Acre	O&M/Periodic Costs (Present Value)	Total Cost (Present Value)
J.M. Mills Landfill	JM-SO-1	No Action	$0	NA	NA	$0	$0
	JM-SO-2	RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	$21,063,000	$983,000	$270,000	$496,000	$21,559,000
	JM-SO-3	Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls	$13,225,000	$563,000	$270,000	$496,000	$13,721,000
Nunes Parcel	NP-SO-1	No Action	$0	NA	NA	$0	$0
	NP-SO-2	RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls	$4,808,000	$713,000	298,000	$124,000	$4,932,000
	NP-SO-3	RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls	$5,956,000	$895,000	298,000	$124,000	$6,080,000
Unnamed Island	UI-SO-1	No Action	$0	NA	NA	$0	$0
	UI-SO-2	Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls	$4,312,000	NA	$335,000	$62,000	$4,374,000
	UI-SO-3	Remove/Consolidate All Waste/Soil Exceeding PRGs	$6,136,000	NA	$477,000	$0	$6,136,000

Notes

Administrative costs associated with establishing Institutional Controls and performance of 5-Year Reviews, as necessary, are not included, but assumed to be within range of costs.

Appendix B
Sediment Alternative Costs

Area	Alternative		Capital Cost	Sediment Cost/Acre	O&M/Periodic Costs (Present Value)	Total Cost (Present Value)
Unnamed Island Ponds	SE-1	No Action	$0	NA	$0	$0
	SE-2	Remove/Consolidate Sediment Exceeding PRGs	$8,120,000	$1,513,000	$0	$8,120,000
	SE-3	Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls	$5,103,000	$951,000	$701,000	$5,804,000
	SE-4	Subaqueous Cover (No Sediment Removal) with Institutional Controls	$2,883,000	$9,000	$701,000	$3,584,000

Notes

Administrative costs associated with establishing Institutional Controls and performance of 5-Year Reviews, as necessary, are not included, but assumed to be within range of costs.

Peterson Puritan Landfill

J.M. Mills Landfill

JM-SO-2 - RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Task #	Task	QTY	UNIT	RATE	COST	Assumptions
1.0	**Site Preparation**					
1.01	Mobilization/Demobilization (2% of Captial Costs Excluding O&M)	1	Lump Sum	$ 313,000.00	$ 313,000.00	
1.02	Furnish & Install Silt Fence (JM Mills Landfill)	6,000	Linear Feet	$ 3.00	$ 18,000.00	Assumes a 25% Increase to the perimeter and Maintenance
1.03	Clearing and Grubbing (JM Mills Landfill)	19	Acre	$ 6,000.00	$ 111,845.73	
1.04	Clearing and Grubbing (Riverbank and Floodplain)	10	Acre	$ 4,500.00	$ 45,454.55	
1.05	Construction Entrances	1	Each	$ 40,000.00	$ 40,000.00	
1.06	Equipment /Material Staging Areas/Temporary Construction Roads	1	Lump Sum	$ 75,000.00	$ 75,000.00	Costs for Construction Access, Site Logistics, Stockpile Management Areas, Etc.
1.07	Surveying Services	60	Day	$ 2,500.00	$ 150,000.00	
	SUBTOTAL				**$ 753,300.28**	
2.0	**Floodplain and Riverbank**					
2.01	Furnish & Install Sediment Controls	3,000	Linear Feet	$ 14.00	$ 42,000.00	
2.02	Excavation of Impacted Soils	32,593	Cubic Yards	$ 22.50	$ 733,333.33	Assumes 24-Inches of soil will be removed; See Figure 7-1 for extent
2.03	Transport, Place, and Grade Excavated Soils	32,593	Cubic Yards	$ 15.00	$ 488,888.89	Assumes excavated soils are placed at Nunes Parcel
2.04	Furnish Off-Site Fill Material	32,593	Cubic Yards	$ 28.00	$ 912,592.59	
2.05	Placement - Fill Material	32,593	Cubic Yards	$ 5.50	$ 179,259.26	
2.06	Bank Restoration/Erosion Controls	3,000	Linear Feet	$ 60.00	$ 180,000.00	
2.07	Debris Fields	1	Lump Sum	$ 150,000.00	$ 150,000.00	
	SUBTOTAL				**$ 2,686,074.07**	
3.0	**RCRA Subtitle C - Equivalent Cap Construction (JM Mills Landfill)**					
3.01	Slope Grading (soil/waste excavation for relocation)	82,000	Cubic Yards	$ 10.00	$ 820,000.00	Based on conceptual grading design - maintaining landfill toe outside 100-Yr floodplain
3.02	Waste placement/comapction - JM Mills Landfill	46,000	Cubic Yards	$ 8.00	$ 368,000.00	
3.03	Waste placement/comapction - Nunes Parcel Consolidation	36,000	Cubic Yards	$ 6.00	$ 216,000.00	Assumes on-site consolidation on the Nunes Parcel
3.04	Landfill Toe - Railroad Perimeter Establishment	3,000	Linear Feet	$ 55.00	$ 165,000.00	
3.05	Landfill Toe - Floodplain Perimeter Armoring	25,000	Square Feet	$ 9.00	$ 225,000.00	Based on conceptual grading design - maintaining landfill toe outside 100-Yr floodplain
3.06	Furnish Off-Site Material - Foundation Layer / Intermediate Cover - Base Grade	90,222	Cubic Yards	$ 28.00	$ 2,526,222.22	Costs of materials to establish gas venting layer (if needed) assumed to be included in base grade
3.07	Placement - Foundation Layer / Intermediate Cover - Base Grade	90,222	Cubic Yards	$ 7.50	$ 676,666.67	Costs of placement of gas venting layer (if needed) assumed to be included in base grade
3.08	Furnish & Install GCL Liner (assumed for costing - may not be appropriate for certain slopes)	1,015,000	Square Feet	$ 0.70	$ 710,500.00	Bentomat ST - Costs include material, delivery and installation
3.09	Construct Anchor Trench	6,000	Linear Feet	$ 7.50	$ 45,000.00	Assume 25% overage for overlapping and seams.
3.10	Furnish & Install 60-mil LLDPE Geomembrane (textured)	1,015,000	Square Feet	$ 0.85	$ 862,750.00	Assume 25% overage for overlapping and seams.
3.11	Furnish & Install Geocomposite-Geonet Drainage Layer	1,015,000	Square Feet	$ 0.75	$ 761,250.00	Assume 25% overage for overlapping and seams.
3.12	Furnish Off-Site Material - Protective Soil Cover (18")	56,389	Cubic Yards	$ 35.00	$ 1,973,615.00	Assume 25% overage to support positive drainage
3.13	Placement - Protective Soil Cover	56,389	Cubic Yards	$ 8.00	$ 451,112.00	
3.14	Furnish Off-Site Material - Topsoil (6")	18,800	Cubic Yards	$ 35.00	$ 658,000.00	Assume 25% overage to support positive drainage
3.15	Placement - Topsoil	18,800	Cubic Yards	$ 6.00	$ 112,800.00	
3.16	Gas Vents (Passive system assumed for costing)	1	Lump Sum	$ 60,000.00	$ 60,000.00	Assumed based on similar FS cost estimates
3.17	Clean Fill Samples- General	59	Each	$ 1,250.00	$ 73,305.61	Assume 1 per 2500 cubic yards
3.18	Dust Suppression (2 Treatments)	180,444	Square Yard	$ 2.00	$ 360,888.89	Treesap based sprayed dust suppressant
	SUBTOTAL				**$ 11,066,110.39**	
4.0	**CQA for CAP Construction**					
4.01	CQA Oversight	19	Acre	$ 40,000.00	$ 760,000.00	
4.02	CQA Soils Testing - Capping System	1	Each	$ 30,000.00	$ 30,000.00	
4.03	CQA Geosynthetics - GDC Conformance	1	Each	$ 8,000.00	$ 8,000.00	
4.04	CQA Geosynthetics - Geomembrane Conformance	1	Each	$ 15,000.00	$ 15,000.00	
4.05	CQA Geosynthetics - Geomembrane DT's	250	Each	$ 15.00	$ 3,750.00	
4.06	CQA Geosynthetics - Interface Friction Angle	4	Each	$ 3,500.00	$ 13,048.67	
	SUBTOTAL				**$ 829,798.67**	
5.0	**Stormwater Controls / Drainage Channels**					
5.01	Perimeter Ditches	30,000	Square Feet	$ 2.00	$ 60,000.00	
5.02	Stormwater Channels - Rip Rap Lined w/ Geotextile	15,000	Square Feet	$ 3.00	$ 45,000.00	
5.03	Diversion Berms	3,300	Linear Feet	$ 5.00	$ 16,500.00	
5.04	Downchute (grading, piping, erosion control)	2,500	Linear Feet	$ 15.00	$ 37,500.00	
5.05	Erosion Control Mat	30,000	Square Feet	$ 2.00	$ 60,000.00	
	SUBTOTAL				**$ 219,000.00**	
6.0	**Restoration of Construction Areas**					
6.01	Hydro-Seeding/stabilization	29	Acres	$ 6,000.00	$ 172,500.00	
6.02	8-Ft High Chain Link Fence - 9-Gauge, 2" Steel Mesh Fabric	6,000	Each	$ 32.00	$ 192,000.00	Assumes a 10% Increase to the perimeter
6.03	Pedestrian Gates	4	Each	$ 400.00	$ 1,600.00	Assumed (2) Pedestrian Gate for Each Perimeter Side
6.04	Vehicle Access Gates	4	Each	$ 800.00	$ 3,200.00	Assumed (4) Vehicle Access Gates
6.05	Identification Signage	20	Each	$ 100.00	$ 2,000.00	Assumed (1) Sign per 300 Liner Ft of Fencing
	SUBTOTAL				**$ 371,300.00**	
7.0	**Professional Services**					
7.01	Landfill Design, Permitting, Procurement (8% of Capital Costs)	1	Lump Sum	$ 1,275,000.00	$ 1,275,000.00	
7.02	Construction Management (7% of Capital Costs)	1	Lump Sum	$ 1,115,000.00	$ 1,115,000.00	
	SUBTOTAL				**$ 2,390,000.00**	

TOTAL	**$**	**18,315,583.41**
15% Contingency	**$**	**2,747,337.51**
Total Capital Costs =	**$**	**21,063,000.00**
Operation & Maintenance Costs =	$	40,000.00 per year (assumed based on experience)

Peterson Puritan Landfill

J.M. Mills Landfill

JM-SO-2 - RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Assumptions:				
Landfill Cell	812,000	Square Feet	90,222	Square Yards
	19	Acres		
Landfill Perimeter	4,800	Linear Feet		
Riverbank and Floodplain Soils	440000	Square Feet		6/10/13 - Added small area (30,000 ft2) due to revised PRGs
	10	Acres		
	32593	Cubic Yards (2' removal depth)		
	3000	Linear Feet of Riverbank		
Base Grade	30,074	Cubic Yards		
Foundation Layer / Intermediate Cover (36 - Inches)	90,222	Cubic Yards		Includes Gas Venting Layer (if needed)
Geosynthetic Clay Liner (GCL)	1,015,000	Square Feet		
Anchor Trench	6,000	Linear Feet		
60-Mil LLDPE Geomembrance	1,015,000	Square Feet		
Geocomposite Drainage Layer	1,015,000	Square Feet		
Surface Soils/Protective Layer (24-Inches)	75,185	Cubic Yards		
Stormwater Drainage Channels	28,800	Square Feet		
Rip Rap	1,600	Tons		

Peterson Puritan Landfill

J.M. Mills Landfill

JM-SO-3 - Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Task #	Task	QTY	UNIT	RATE	COST	Assumptions
1.0	**Site Preparation**					
1.01	Mobilization/Demobilization (2% of Captial Costs Excluding O&M)	1	Lump Sum	$ 205,000.00	$ 205,000.00	
1.02	Furnish & Install Silt Fence (JM Mills Landfill)	6,000	Linear Feet	$ 3.00	$ 18,000.00	Assumes a 25% Increase to the perimeter and Maintenance
1.03	Clearing and Grubbing (JM Mills Landfill)	19	Acre	$ 6,000.00	$ 111,845.73	
1.04	Clearing and Grubbing (Riverbank and Floodplain)	10	Acre	$ 4,500.00	$ 45,454.55	
1.05	Construction Entrances	1	Each	$ 40,000.00	$ 40,000.00	
1.06	Equipment /Material Staging Areas/Temporary Construction Roads	1	Lump Sum	$ 75,000.00	$ 75,000.00	Costs for Construction Access, Site Logistics, Stockpile Management Areas, Etc.
1.07	Surveying Services	60	Day	$ 2,500.00	$ 150,000.00	
	SUBTOTAL				**$ 645,300.28**	
2.0	**Floodplain and Riverbank**					
2.01	Furnish & Install Sediment Controls	3,000	Linear Feet	$ 14.00	$ 42,000.00	
2.02	Excavation of Impacted Soils	32,593	Cubic Yards	$ 22.50	$ 733,333.33	Assumes 24-Inches soil will be removed
2.03	Transport, Place, and Grade Excavated Soils	32,593	Cubic Yards	$ 15.00	$ 488,888.89	Assumes excavated soils are placed at Nunes Parcel
2.04	Furnish Off-Site Fill Material	32,593	Cubic Yards	$ 28.00	$ 912,592.59	
2.05	Bank Restoration/Erosion Controls	3,000	Linear Feet	$ 60.00	$ 180,000.00	
2.06	Placement - Fill Material	32,593	Cubic Yards	$ 5.50	$ 179,259.26	
2.07	Debris Fields	1	Lump Sum	$ 150,000.00	$ 150,000.00	
	SUBTOTAL				**$ 2,686,074.07**	
3.0	**Hybrid Cap* Construction (JM Mills Landfill)**					
3.01	Waste Consolidation from Grading Efforts - Slopes	46,000	Cubic Yards	$ 8.00	$ 368,000.00	
3.02	Furnish Off-Site Material - Foundation Layer / Intermediate Cover - Base Grade	9,924	Cubic Yards	$ 28.00	$ 277,884.44	Costs of materials to establish gas venting layer (if needed) assumed to be included in base grade
3.03	Placement - Foundation Layer / Intermediate Cover - Base Grade	9,924	Cubic Yards	$ 7.50	$ 74,433.33	Costs of placement of gas venting layer (if needed) assumed to be included in base grade
3.04	Furnish & Install GCL Liner (assumed for costing - may not be appropriate for certain slopes)	334,950	Square Feet	$ 0.70	$ 234,465.00	Bentomat ST - Costs include material, delivery and installation
3.05	Construct Anchor Trench	3,000	Linear Feet	$ 7.50	$ 22,500.00	Assume 25% overage for overlapping and seams.
3.06	Furnish & Install 60-mil LLDPE Geomembrane (textured)	334,950	Square Feet	$ 0.85	$ 284,707.50	Assume 25% overage for overlapping and seams.
3.07	Furnish & Install Geocomposite-Geonet Drainage Layer	334,950	Square Feet	$ 0.75	$ 251,212.50	Assume 25% overage for overlapping and seams.
3.08	Furnish Off-Site Material - Protective Soil Cover (18")	18,150	Cubic Yards	$ 28.00	$ 508,200.00	Assume 25% overage to support positive drainage
3.09	Placement - Protective Soil Cover	18,150	Cubic Yards	$ 8.00	$ 145,200.00	
3.10	Furnish Off-Site Material - Topsoil (6")	6,050	Cubic Yards	$ 35.00	$ 211,750.00	Assume 25% overage to support positive drainage
3.11	Gas Vents (Passive system assumed for costing)	1	Lump Sum	$ 60,000.00	$ 60,000.00	Assumed based on similar FS cost estimates
3.12	Placement - Topsoil	6,050	Cubic Yards	$ 6.00	$ 36,300.00	
3.13	Dust Suppression (2 Treatments)	180,444	Square Yard	$ 2.00	$ 360,888.89	Treesap based sprayed dust suppressant
	SUBTOTAL				**$ 2,835,541.67**	
4.0	**Hybrid Cap* Construction (JM Mills Landfill)**					
4.01	Slope Grading (soil/waste excavation for relocation)	65,000	Cubic Yards	$ 10.00	$ 650,000.00	Based on conceptual grading design - maintaining landfill toe outside 100-Yr floodplain
4.02	Waste placement/comapction - Nunes Parcel Consolidation	19,000	Cubic Yards	$ 6.00	$ 114,000.00	Assumes on-site consolidation on the Nunes Parcel
4.03	Landfill Toe - Railroad Perimeter Establishemnt	3,000	Linear Feet	$ 55.00	$ 165,000.00	Based on conceptual grading design - maintaining landfill toe outside 100-Yr floodplain
4.04	Landfill Toe - Floodplain Perimeter Armoring	25,000	Square Feet	$ 9.00	$ 225,000.00	
4.05	Furnish Off-Site Material - Base Grade (18 inches)	30,224	Cubic Yards	$ 28.00	$ 846,284.44	
4.06	Placement - Base Grade	30,224	Cubic Yards	$ 7.50	$ 226,683.33	
4.07	Furnish Off-Site Material - TopSoil Cover (6")	12,594	Cubic Yards	$ 35.00	$ 440,773.15	Assume 25% overage to support positive drainage
4.08	Placement - TopSoil Cover	12,594	Cubic Yards	$ 6.00	$ 75,561.11	
4.09	Dust Suppression (2 Treatments)	180,444	Square Yard	$ 2.00	$ 360,888.89	Treesap based sprayed dust suppressant
	SUBTOTAL				**$ 3,104,190.93**	
5.0	**CQA for Cap Construction**					Costs assumed lower than JM-SO-2 due to simplified cap on lower portion of landfill
5.01	CQA Oversight	19	Acre	$ 28,000.00	$ 532,000.00	
5.02	CQA Soils Testing - Capping System	1	Each	$ 25,000.00	$ 25,000.00	
5.03	CQA Geosynthetics - GDC Conformance	1	Each	$ 4,000.00	$ 4,000.00	
5.04	CQA Geosynthetics - Geomembrane Conformance	1	Each	$ 7,000.00	$ 7,000.00	
5.05	CQA Geosynthetics - Geomembrane DT's	100	Each	$ 15.00	$ 1,500.00	
5.06	CQA Geosynthetics - Interface Friction Angle	4	Each	$ 3,500.00	$ 14,000.00	
	SUBTOTAL				**$ 583,500.00**	
6.0	**Stormwater Controls / Drainage Channels**					
6.01	Perimeter Ditches	30,000	Square Feet	$ 2.00	$ 60,000.00	Assumes - 2 Soil Diversion Berms - 1-2,100 Linear Ft; 1-1,200 Linear Ft.;
6.02	Stormwater Channels - Rip Rap Lined w/ Geotextile	15,000	Square Feet	$ 3.00	$ 45,000.00	
6.03	Diversion Berms	3,300	Linear Feet	$ 5.00	$ 16,500.00	
6.04	Downschute (grading, piping, erosion control)	2,500	Linear Feet	$ 15.00	$ 37,500.00	
6.05	Erosion Control Mat	30,000	Square Feet	$ 2.00	$ 60,000.00	Assumes - 6 Channels - 300 Linear Ft Each
	SUBTOTAL				**$ 219,000.00**	
7.0	**Restoration of Construction Areas**					
7.01	Hydro-Seeding/stabilization	29	Acres	$ 6,000.00	$ 172,500.00	
7.02	8-Ft High Chain Link Fence - 9-Gauge, 2" Steel Mesh Fabric	6,000	Each	$ 32.00	$ 192,000.00	Assumes a 10% Increase to the perimeter
7.03	Pedestrian Gates	4	Each	$ 400.00	$ 1,600.00	Assumed (2) Pedestrian Gate for Each Perimeter Side
7.04	Vehicle Access Gates	4	Each	$ 800.00	$ 3,200.00	Assumed (4) Vehicle Access Gates
7.05	Identification Signage	20	Each	$ 100.00	$ 2,000.00	Assumed (1) Sign per 300 Liner Ft of Fencing
	SUBTOTAL				**$ 371,300.00**	
8.0	**Professional Services**					
8.01	Landfill Design, Permitting, Procurement (8% of Capital Costs)	1	Lump Sum	$ 563,000.00	$ 563,000.00	
8.02	Construction Management (7% of Capital Costs)	1	Lump Sum	$ 492,000.00	$ 492,000.00	
	SUBTOTAL				**$ 1,055,000.00**	

TOTAL	**$**	**11,499,906.94**
15% Contingency	**$**	**1,724,986.04**
Total Capital Costs =	**$**	**13,225,000.00**
Operation & Maintenance Costs =	$	40,000.00 per year (assumed based on experience)

* Hybrid Cap designed to meet following criteria 1) minimize maintenance, 2) promote drainage, 3) no settling or subsidence, 4) ensure cover has lower permeability than bottom layer below landfill.

Peterson Puritan Landfill

J.M. Mills Landfill

JM-SO-3 - Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Assumptions:					
Landfill Cell	812,000	Square Feet		90,222	Square Yards
	19	Acres			
Landfill Perimeter	4,800	Linear Feet			
Riverbank and Floodplain Soils	440000	Square Feet			6/10/13 - Added small area (30,000 ft2) due to revised PRGs
	10	Acres			
	32593	Cubic Yards (2' removal depth)			
	3000	Linear Feet of Riverbank			
Subtitle C Cover					
Base Grade (12 inches)	9,924	Cubic Yards	33% of cover		Includes Gas Venting Layer (if needed)
General Soil Fill 18 - Inches)	14,887	Cubic Yards	33% of cover		
Geosynthetic Clay Liner (GCL)	334,950	Square Feet	33% of cover		
Anchor Trench	3,000	Linear Feet	33% of cover		
60-Mil LLDPE Geomembrance	334,950	Square Feet	33% of cover		
Geocomposite Drainage Layer	334,950	Square Feet	33% of cover		
Surface Soils/Protective Layer 6-Inches)	6,203	Cubic Yards	33% of cover		
Subtitle					
Perimeter Soil Cover					
Foundation Layer / Intermediate Cover (18 - Inches)	30,224	Cubic Yards	67% of cover		
Surface Soils/Protective Layer (6-Inches)	12,594	Cubic Yards	67% of cover		
Gravel - Surface Cover	12,594	Cubic Yards	67% of cover		
Stormwater Drainage Channels	28,800	Square Feet			
Rip Rap	1,600	Tons			

Present Worth Analysis

JM-SO-2 - RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Interest rate: 7%

LIFE CYCLE COST

Year	Amount	Present Worth	p/f factor
1	$ 21,063,000	$ 21,063,000	1.00
2	$ 40,000	$ 37,383	0.935
3	$ 40,000	$ 34,938	0.873
4	$ 40,000	$ 32,652	0.816
5	$ 40,000	$ 30,516	0.763
6	$ 40,000	$ 28,519	0.713
7	$ 40,000	$ 26,654	0.666
8	$ 40,000	$ 24,910	0.623
9	$ 40,000	$ 23,280	0.582
10	$ 40,000	$ 21,757	0.544
11	$ 40,000	$ 20,334	0.508
12	$ 40,000	$ 19,004	0.475
13	$ 40,000	$ 17,760	0.444
14	$ 40,000	$ 16,599	0.415
15	$ 40,000	$ 15,513	0.388
16	$ 40,000	$ 14,498	0.362
17	$ 40,000	$ 13,549	0.339
18	$ 40,000	$ 12,663	0.317
19	$ 40,000	$ 11,835	0.296
20	$ 40,000	$ 11,060	0.277
21	$ 40,000	$ 10,337	0.258
22	$ 40,000	$ 9,661	0.242
23	$ 40,000	$ 9,029	0.226
24	$ 40,000	$ 8,438	0.211
25	$ 40,000	$ 7,886	0.197
26	$ 40,000	$ 7,370	0.184
27	$ 40,000	$ 6,888	0.172
28	$ 40,000	$ 6,437	0.161
29	$ 40,000	$ 6,016	0.150
30	$ 40,000	$ 5,623	0.141
31	$ 40,000	$ 5,255	0.131
PRESENT WORTH:		**$ 21,559,362**	

Notes: Capital Cost is Subtitle C Cap Installation + Floodplain Soil Removal

O&M is Cap and Inst. Control maintenance for 30 years (annual cost assumed based on experience)

Years 2 through 31 include O&M costs

Present Worth Analysis

JM-SO-3 - Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Interest rate: 7%

LIFE CYCLE COST

Year	Amount	Present Worth	p/f factor
1	$ 13,225,000	$ 13,225,000	1.00
2	$ 40,000	$ 37,383	0.935
3	$ 40,000	$ 34,938	0.873
4	$ 40,000	$ 32,652	0.816
5	$ 40,000	$ 30,516	0.763
6	$ 40,000	$ 28,519	0.713
7	$ 40,000	$ 26,654	0.666
8	$ 40,000	$ 24,910	0.623
9	$ 40,000	$ 23,280	0.582
10	$ 40,000	$ 21,757	0.544
11	$ 40,000	$ 20,334	0.508
12	$ 40,000	$ 19,004	0.475
13	$ 40,000	$ 17,760	0.444
14	$ 40,000	$ 16,599	0.415
15	$ 40,000	$ 15,513	0.388
16	$ 40,000	$ 14,498	0.362
17	$ 40,000	$ 13,549	0.339
18	$ 40,000	$ 12,663	0.317
19	$ 40,000	$ 11,835	0.296
20	$ 40,000	$ 11,060	0.277
21	$ 40,000	$ 10,337	0.258
22	$ 40,000	$ 9,661	0.242
23	$ 40,000	$ 9,029	0.226
24	$ 40,000	$ 8,438	0.211
25	$ 40,000	$ 7,886	0.197
26	$ 40,000	$ 7,370	0.184
27	$ 40,000	$ 6,888	0.172
28	$ 40,000	$ 6,437	0.161
29	$ 40,000	$ 6,016	0.150
30	$ 40,000	$ 5,623	0.141
31	$ 40,000	$ 5,255	0.131
PRESENT WORTH:		**$ 13,721,362**	

Notes: Capital Cost is Hybrid Cap Installation + Floodplain Soil Removal

O&M is Cap and Inst. Control maintenance for 30 years (annual cost assumed based on experience)

Years 2 through 31 include O&M costs

Peterson Puritan Landfill

Nunes Parcel

NP-SO-2 - RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls

Task #	Task	QTY	UNIT	RATE	COST	Assumptions
1.0	**Site Preparation**					
1.01	Mobilization/Demobilization (2% of Captial Costs Excluding O&M)	1	Lump Sum	$ 72,000.00	$ 72,000.00	
1.02	Furnish & Install Silt Fence	6,000	Linear Feet	$ 3.00	$ 18,000.00	Assumes a 25% Increase to the perimeter and Maintenance
1.03	Clearing and Grubbing	6	Acre	$ 3,000.00	$ 18,900.00	
1.04	Demolition/Debris Removal/Consolidation	1	Lump Sum	$ 300,000.00	$ 300,000.00	
1.05	Construction Entrances	1	Each	$ 7,500.00	$ 7,500.00	
1.06	Equipment /Material Staging Areas/Temporary Construction Roads	1	Lump Sum	$ 40,000.00	$ 40,000.00	Costs for Construction Access, Site Logistics, Stockpile Management Areas, Etc.
1.07	Surveying Services	60	Day	$ 2,500.00	$ 150,000.00	
	SUBTOTAL				**$ 606,400.00**	
2.0	**Riverbankand Additional Soils**					
2.01	Furnish & Install Sediment Controls	1,000	Linear Feet	$ 14.00	$ 14,000.00	
2.02	Excavation of Impacted Soils outside of waste extents (includes Pond I and peninsula)	3,448	Cubic Yards	$ 22.50	$ 77,583.33	Assumes 24-Inches of soil will be removed; See Figure 7-5 for extent
2.03	Transport, Place, and Grade Excavated Soils/Sediments	3,448	Cubic Yards	$ 15.00	$ 51,722.22	
2.04	Furnish Off-Site Fill Material	3,448	Cubic Yards	$ 28.00	$ 96,548.15	
2.05	Placement - Fill Material	3,448	Cubic Yards	$ 5.50	$ 18,964.81	
2.06	Bank Restoration/Erosion Controls	1,000	Linear Feet	$ 60.00	$ 60,000.00	
	SUBTOTAL				**$ 318,818.52**	
3.0	**RCRA Subtitle D/RIDEM Compliant Cap Construction Nunes Parcel***					
3.01	Regrading of Parcel	6	Acre	$ 35,000.00	$ 220,500.00	
3.02	Furnish Off-Site Material - Foundation Layer / Intermediate Cover - Base Grade	30,492	Cubic Yards	$ 28.00	$ 853,776.00	Costs of materials to establish gas venting layer (if needed) assumed to be included in base grade
3.03	Placement - Foundation Layer / Intermediate Cover - Base Grade	30,492	Cubic Yards	$ 6.00	$ 182,952.00	Costs of placement of gas venting layer (if needed) assumed to be included in base grade
3.04	Construct Anchor Trench	6,000	Linear Feet	$ 7.50	$ 45,000.00	Assume 25% overage for overlapping and seams.
3.05	Furnish & Install 60-mil LLDPE Geomembrane (textured)	343,035	Square Feet	$ 0.85	$ 291,579.75	Assume 25% overage for overlapping and seams.
3.06	Furnish & Install Geocomposite-Geonet Drainage Layer	343,035	Square Feet	$ 0.75	$ 257,276.25	Assume 25% overage for overlapping and seams.
3.07	Furnish Off-Site Material - Vegetative Soil Cover (12")	10,164	Cubic Yards	$ 35.00	$ 355,740.00	Assume 25% overage to support positive drainage
3.08	Placement - Vegetative Soil Cover	10,164	Cubic Yards	$ 7.00	$ 71,148.00	
3.09	Gas Vents (Passive system assumed for costing)	1	Lump Sum	$ 15,000.00	$ 15,000.00	Assumed based on similar FS cost estimates
3.10	Dust Suppression (2 Treatments)	60,984	Square Yard	$ 2.00	$ 121,968.00	Treesap based sprayed dust suppressant
	SUBTOTAL				**$ 2,414,940.00**	
4.0	**CQA for CAP Construction**					
4.01	CQA Oversight	4	Acre	$ 24,000.00	$ 96,000.00	
4.02	CQA Soils Testing - Capping System	1	Each	$ 30,000.00	$ 30,000.00	
4.03	CQA Geosynthetics - GDC Conformance	1	Each	$ 8,000.00	$ 8,000.00	
4.04	CQA Geosynthetics - Geomembrane Conformance	1	Each	$ 15,000.00	$ 15,000.00	
4.05	CQA Geosynthetics - Geomembrane DT's	250	Each	$ 15.00	$ 3,750.00	
4.06	CQA Geosynthetics - Interface Friction Angle	1	Each	$ 3,500.00	$ 4,410.00	
	SUBTOTAL				**$ 157,160.00**	
5.0	**Stormwater Controls / Drainage Channels**					
5.01	Diversion Berms	1,000	Linear Feet	$ 5.00	$ 5,000.00	Assumes - 2 Soil Diversion Berms - 2-500 Linear Ft
5.02	Stormwater Channels - Rip Rap Lined w/ Geotextile	9,600	Square Feet	$ 2.50	$ 24,000.00	Assumes - 3 Channels - 200 Linear Ft Each
	SUBTOTAL				**$ 29,000.00**	
6.0	**Restoration of Construction Areas**					
6.01	Hydro-Seeding/stabilization	7	Acres	$ 6,000.00	$ 44,200.00	
6.02	8-Ft High Chain Link Fence - 9-Gauge, 2" Steel Mesh Fabric	1,900	Each	$ 32.00	$ 60,800.00	Assumes a 10% Increase to the perimeter
6.03	Pedestrian Gates	3	Each	$ 400.00	$ 1,200.00	Assumed (2) Pedestrian Gate for Each Perimeter Side
6.04	Vehicle Access Gates	2	Each	$ 800.00	$ 1,600.00	Assumed (4) Vehicle Access Gates
6.05	Identification Signage	7	Each	$ 100.00	$ 700.00	Assumed (1) Sign per 300 Liner Ft of Fencing
	SUBTOTAL				**$ 108,500.00**	
7.0	**Professional Services**					
7.01	Landfill Design, Permitting, Procurement (8% of Capital Costs)	1	Lump Sum	$ 291,000.00	$ 291,000.00	
7.02	Construction Management (7% of Capital Costs)	1	Lump Sum	$ 255,000.00	$ 255,000.00	
	SUBTOTAL				**$ 546,000.00**	

* Costs for floodplain armoring assumed to be within range of FS cost estimate

TOTAL	**$**	**4,180,818.52**
15% Contingency	**$**	**627,122.78**
Total Capital Costs =	**$**	**4,808,000.00**
Operation & Maintenance Costs =	$	10,000.00 per year (assumed based on experience)

Peterson Puritan Landfill

Nunes Parcel

NP-SO-2 - RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls

Assumptions:				
Landfill Cell	274,428	Square Feet	30,492	Square Yards
	6.3	Acres		9/10/13 - Increased landfill area based on existing waste extent
Landfill Perimeter	4,800	Linear Feet		Source unclear; appears to be conservative
Riverbank and Floodplain Soils	46550	Square Feet		6/10/13 - Added area outside waste, Pond I peninsula and Pond I sediments
	1	Acres		
	3448	Cubic Yards (2' removal depth)		
	1000	Linear Feet of Riverbank		
Base Grade	10,164	Cubic Yards		
Foundation Layer / Intermediate Cover (36 - Inches)	30,492	Cubic Yards		
Anchor Trench	6,000	Linear Feet		
Geomembrance	343,035	Square Feet		
Geocomposite Drainage Layer	343,035	Square Feet		
Vegetative Soil Layer (12-Inches)	10,164	Cubic Yards		
Stormwater Drainage Channels	9,600	Square Feet		
Rip Rap	533	Tons		

Peterson Puritan Landfill

Nunes Parcel

NP-SO-3 - RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Task #	Task	QTY	UNIT	RATE	COST	Assumptions
1.0	**Site Preparation**					
1.01	Mobilization/Demobilization (2% of Captial Costs Excluding O&M)	1	Lump Sum	$ 89,000.00	$ 89,000.00	
1.02	Furnish & Install Silt Fence	6,000	Linear Feet	$ 3.00	$ 18,000.00	Assumes a 25% Increase to the perimeter and Maintenance
1.03	Clearing and Grubbing	6.3	Acre	$ 3,000.00	$ 18,900.00	
1.04	Demolition/Debris Removal/Consolidation	1	Lump Sum	$ 300,000.00	$ 300,000.00	
1.05	Construction Entrances	1	Each	$ 7,500.00	$ 7,500.00	
1.06	Equipment /Material Staging Areas/Temporary Construction Roads	1	Lump Sum	$ 40,000.00	$ 40,000.00	Costs for Construction Access, Site Logistics, Stockpile Management Areas, Etc.
1.07	Surveying Services	60	Day	$ 2,500.00	$ 150,000.00	
	SUBTOTAL				**$ 623,400.00**	
2.0	**Riverbankand Additional Soils**					
2.01	Furnish & Install Sediment Controls	1,000	Linear Feet	$ 14.00	$ 14,000.00	
2.02	Excavation of Impacted Soils outside of waste extents (includes Pond I and peninsula)	3,448	Cubic Yards	$ 22.50	$ 77,583.33	Assumes 24-Inches of soil will be removed; See Figure 7-5 for extent
2.03	Transport, Place, and Grade Excavated Soils/Sediments	3,448	Cubic Yards	$ 15.00	$ 51,722.22	
2.04	Furnish Off-Site Fill Material	3,448	Cubic Yards	$ 28.00	$ 96,548.15	
2.05	Placement - Fill Material	3,448	Cubic Yards	$ 5.50	$ 18,964.81	
2.06	Bank Restoration/Erosion Controls	1,000	Linear Feet	$ 60.00	$ 60,000.00	
	SUBTOTAL				**$ 318,818.52**	
3.0	**RCRA Subtitle C - Equivalent Cap Construction Nunes Parcel***					
3.01	Regrading of Parcel	6.3	Acre	$ 35,000.00	$ 220,500.00	
3.02	Furnish Off-Site Material - Foundation Layer / Intermediate Cover - Base Grade	30,492	Cubic Yards	$ 28.00	$ 853,776.00	Costs of materials to establish gas venting layer (if needed) assumed to be included in base grade
3.03	Placement - Foundation Layer / Intermediate Cover - Base Grade	30,492	Cubic Yards	$ 6.00	$ 182,952.00	Costs of placement of gas venting layer (if needed) assumed to be included in base grade
3.04	Furnish & Install GCL Liner	343,035	Square Feet	$ 0.70	$ 240,124.50	Bentomat ST - Costs include material, delivery and installation
3.05	Construct Anchor Trench	6,000	Linear Feet	$ 7.50	$ 45,000.00	Assume 25% overage for overlapping and seams.
3.06	Furnish & Install 40-mil LLDPE Geomembrane (textured)	343,035	Square Feet	$ 0.60	$ 205,821.00	Assume 25% overage for overlapping and seams.
3.07	Furnish & Install Geocomposite-Geonet Drainage Layer	343,035	Square Feet	$ 0.75	$ 257,276.25	Assume 25% overage for overlapping and seams.
3.08	Furnish Off-Site Material - Protective Soil Cover (18")	25,410	Cubic Yards	$ 35.00	$ 889,350.00	Assume 25% overage to support positive drainage
3.09	Placement - Protective Soil Cover	25,410	Cubic Yards	$ 7.00	$ 177,870.00	
3.10	Gas Vents (Passive system assumed for costing)	1	Lump Sum	$ 15,000.00	$ 15,000.00	Assumed based on similar FS cost estimates
3.11	Dust Suppression (2 Treatments)	60,984	Square Yard	$ 2.00	$ 121,968.00	Treesap based sprayed dust suppressant
	SUBTOTAL				**$ 3,209,637.75**	
4.0	**CQA for CAP Construction**					
4.01	CQA Oversight	6.3	Acre	$ 24,000.00	$ 151,200.00	
4.02	CQA Soils Testing - Capping System	1	Each	$ 30,000.00	$ 30,000.00	
4.03	CQA Geosynthetics - GDC Conformance	1	Each	$ 8,000.00	$ 8,000.00	
4.04	CQA Geosynthetics - Geomembrane Conformance	1	Each	$ 15,000.00	$ 15,000.00	
4.05	CQA Geosynthetics - Geomembrane DT's	250	Each	$ 15.00	$ 3,750.00	
4.06	CQA Geosynthetics - Interface Friction Angle	1	Each	$ 3,500.00	$ 4,410.00	
	SUBTOTAL				**$ 212,360.00**	
5.0	**Stormwater Controls / Drainage Channels**					
5.01	Diversion Berms	1,000	Linear Feet	$ 5.00	$ 5,000.00	Assumes - 2 Soil Diversion Berms - 2-500 Linear Ft
5.02	Stormwater Channels - Rip Rap Lined w/ Geotextile	9,600	Square Feet	$ 2.50	$ 24,000.00	Assumes - 3 Channels - 200 Linear Ft Each
	SUBTOTAL				**$ 29,000.00**	
6.0	**Restoration of Construction Areas**					
6.01	Hydro-Seeding/stabilization	7.4	Acres	$ 6,000.00	$ 44,200.00	
6.02	8-Ft High Chain Link Fence - 9-Gauge, 2" Steel Mesh Fabric	1,900	Each	$ 32.00	$ 60,800.00	Assumes a 10% Increase to the perimeter
6.03	Pedestrian Gates	3	Each	$ 400.00	$ 1,200.00	Assumed (2) Pedestrian Gate for Each Perimeter Side
6.04	Vehicle Access Gates	2	Each	$ 800.00	$ 1,600.00	Assumed (4) Vehicle Access Gates
6.05	Identification Signage	7	Each	$ 100.00	$ 700.00	Assumed (1) Sign per 300 Liner Ft of Fencing
	SUBTOTAL				**$ 108,500.00**	
7.0	**Professional Services**					
7.01	Landfill Design, Permitting, Procurement (8% of Capital Costs)	1	Lump Sum	$ 361,000.00	$ 361,000.00	
7.02	Construction Management (7% of Capital Costs)	1	Lump Sum	$ 316,000.00	$ 316,000.00	
	SUBTOTAL				**$ 677,000.00**	

* Costs for floodplain armoring assumed to be within range of FS cost estimate

TOTAL	**$**	**5,178,716.27**
15% Contingency	**$**	**776,807.44**
Total Capital Costs =	**$**	**5,956,000.00**
Operation & Maintenance Costs =	$	10,000.00 per year (assumed based on experience)

Peterson Puritan Landfill

Nunes Parcel

NP-SO-3 - RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Assumptions:				
Landfill Cell	274,428	Square Feet	30,492	Square Yards
	6.3	Acres		9/10/13 - Increased landfill area based on existing waste extent
Landfill Perimeter	4,800	Linear Feet		Source unclear; appears to be conservative
Riverbank and Floodplain Soils	46550	Square Feet		6/10/13 - Added area outside waste, Pond I peninsula and Pond I sediments
	1	Acres		
	3448	Cubic Yards (2' removal depth)		
	1000	Linear Feet of Riverbank		
Base Grade	10,164	Cubic Yards		
Foundation Layer / Intermediate Cover (36 - Inches)	30,492	Cubic Yards		
Geosynthetic Clay Liner (GCL)	343,035	Square Feet		
Anchor Trench	6,000	Linear Feet		
40-Mil PVC Geomembrance	343,035	Square Feet		
Geocomposite Drainage Layer	343,035	Square Feet		
Surface Soils/Protective Layer (24-Inches)	25,410	Cubic Yards		
Gravel - Surface Cover	6,353	Cubic Yards		
Stormwater Drainage Channels	9,600	Square Feet		
Rip Rap	533	Tons		

Present Worth Analysis

NP-SO-2 -RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls

Interest rate: 7%

LIFE CYCLE COST

Year	Amount	Present Worth	p/f factor
1	$ 4,808,000	$ 4,808,000	1.00
2	$ 10,000	$ 9,346	0.935
3	$ 10,000	$ 8,734	0.873
4	$ 10,000	$ 8,163	0.816
5	$ 10,000	$ 7,629	0.763
6	$ 10,000	$ 7,130	0.713
7	$ 10,000	$ 6,663	0.666
8	$ 10,000	$ 6,227	0.623
9	$ 10,000	$ 5,820	0.582
10	$ 10,000	$ 5,439	0.544
11	$ 10,000	$ 5,083	0.508
12	$ 10,000	$ 4,751	0.475
13	$ 10,000	$ 4,440	0.444
14	$ 10,000	$ 4,150	0.415
15	$ 10,000	$ 3,878	0.388
16	$ 10,000	$ 3,624	0.362
17	$ 10,000	$ 3,387	0.339
18	$ 10,000	$ 3,166	0.317
19	$ 10,000	$ 2,959	0.296
20	$ 10,000	$ 2,765	0.277
21	$ 10,000	$ 2,584	0.258
22	$ 10,000	$ 2,415	0.242
23	$ 10,000	$ 2,257	0.226
24	$ 10,000	$ 2,109	0.211
25	$ 10,000	$ 1,971	0.197
26	$ 10,000	$ 1,842	0.184
27	$ 10,000	$ 1,722	0.172
28	$ 10,000	$ 1,609	0.161
29	$ 10,000	$ 1,504	0.150
30	$ 10,000	$ 1,406	0.141
31	$ 10,000	$ 1,314	0.131
PRESENT WORTH:		**$ 4,932,090**	

Notes: Capital Cost is Subtitle D Cap Installation + Soil/Sediment Removal

O&M is Cap and Inst. Control maintenance for 30 years (annual cost assumed based on experience)

Years 2 through 31 include O&M costs

Present Worth Analysis

NP-SO-3 - RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Interest rate: 7%

LIFE CYCLE COST

Year	Amount	Present Worth	p/f factor
1	$ 5,956,000	$ 5,956,000	1.00
2	$ 10,000	$ 9,346	0.935
3	$ 10,000	$ 8,734	0.873
4	$ 10,000	$ 8,163	0.816
5	$ 10,000	$ 7,629	0.763
6	$ 10,000	$ 7,130	0.713
7	$ 10,000	$ 6,663	0.666
8	$ 10,000	$ 6,227	0.623
9	$ 10,000	$ 5,820	0.582
10	$ 10,000	$ 5,439	0.544
11	$ 10,000	$ 5,083	0.508
12	$ 10,000	$ 4,751	0.475
13	$ 10,000	$ 4,440	0.444
14	$ 10,000	$ 4,150	0.415
15	$ 10,000	$ 3,878	0.388
16	$ 10,000	$ 3,624	0.362
17	$ 10,000	$ 3,387	0.339
18	$ 10,000	$ 3,166	0.317
19	$ 10,000	$ 2,959	0.296
20	$ 10,000	$ 2,765	0.277
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22	$ 10,000	$ 2,415	0.242
23	$ 10,000	$ 2,257	0.226
24	$ 10,000	$ 2,109	0.211
25	$ 10,000	$ 1,971	0.197
26	$ 10,000	$ 1,842	0.184
27	$ 10,000	$ 1,722	0.172
28	$ 10,000	$ 1,609	0.161
29	$ 10,000	$ 1,504	0.150
30	$ 10,000	$ 1,406	0.141
31	$ 10,000	$ 1,314	0.131
PRESENT WORTH:		**$ 6,080,090**	

Notes: Capital Cost is Subtitle C Cap Installation + Soil/Sediment Removal

O&M is Cap and Inst. Control maintenance for 30 years (annual cost assumed based on experience)

Years 2 through 31 include O&M costs

Peterson Puritan Landfill

Unnamed Island

UI-SO-2 - Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Task #	Task	QTY	UNIT	RATE	COST	Assumptions
1.0	**Site Preparation**					
1.01	Mobilization/Demobilization (2% of Captial Costs Excluding O&M)	1	Lump Sum	$ 64,000.00	$ 64,000.00	
1.02	Furnish & Install Silt Fence	5,000	Linear Feet	$ 3.00	$ 15,000.00	Assumes a 25% Increase to the perimeter and Maintenance
1.03	Clearing and Grubbing	13	Acre	$ 5,000.00	$ 64,279.16	Includes removal of surficial waste to Nunes Parcel
1.04	Bridge Installation	1	Each	$ 15,000.00	$ 15,000.00	
1.05	Bridge Rental	2	Months	$ 42,500.00	$ 85,000.00	
1.06	Equipment /Material Staging Areas/Temporary Construction Roads	1	Lump Sum	$ 40,000.00	$ 40,000.00	Costs for Construction Access, Site Logistics, Stockpile Management Areas, Etc.
1.07	Surveying Services	10	Day	$ 2,500.00	$ 25,000.00	
	SUBTOTAL				**$ 308,279.16**	
2.0	**Surface Soil Removal Action**					
2.01	Furnish & Install Sediment Controls	6,800	Linear Feet	$ 14.00	$ 95,200.00	Controls needed on all sides due to surrounding water bodies
2.02	Excavation of Impacted Soils	41,481	Cubic Yards	$ 22.50	$ 933,333.33	
2.03	Transport, Place, and Grade Excavated Soils	41,481	Cubic Yards	$ 15.00	$ 622,222.22	Assumes excavated soils are placed at Nunes Parcel
2.04	Furnish & Install Geotextile	168,000	Square Feet	$ 0.70	$ 117,600.00	Assumes PRGs remain that require capping under 30% of excavated areas
2.05	Rip Rap (furnished and placed/24-inch)	12,444	Cubic Yards	$ 95.00	$ 1,182,222.22	Assumes PRGs remain that require capping under 30% of excavated areas
	SUBTOTAL				**$ 2,950,577.78**	
3.0	**Restoration of Construction Areas**					
3.01	Identification Signage	6	Each	$ 100.00	$ 600.00	Assumed placed near covered areas
	SUBTOTAL				**$ 600.00**	
4.0	**Professional Services**					
4.01	Landfill Design, Permitting, Procurement (8% of Capital Costs)	1	Lump Sum	$ 261,000.00	$ 261,000.00	
4.02	Construction Management (7% of Capital Costs)	1	Lump Sum	$ 229,000.00	$ 229,000.00	
	SUBTOTAL				**$ 490,000.00**	

TOTAL	**$**	**3,749,456.93**
15% Contingency	**$**	**562,418.54**
Total Capital Costs =	**$**	**4,311,875.47**
Operation & Maintenance Costs =	$	5,000.00 per year (assumed based on experience)

Assumptions:

Surface Soil Area	560000	Square Feet	6/10/13 - Added area based on recreational user PRG exceedances
	13	Acres	
	41481	Cubic Yards (2' removal depth)	
	3400	Linear Feet of Riverbank	6/10/13 - Added estimated length based on recreational user PRG exceedances
Surface Soil Perimeter	6,800	Linear Feet	6/10/13 - Added estimated length based on recreational user PRG exceedances
Geotextile Cover	168,000	Square Feet - Assume 30% of Excavated Area	

Peterson Puritan Landfill

Unnamed Island

UI-SO-3 - Remove/Consolidate All Waste/Soil Exceeding PRGs

Task #	Task	QTY	UNIT	RATE	COST	Assumptions
1.0	**Site Preparation**					
1.01	Mobilization/Demobilization (2% of Captial Costs Excluding O&M)	1	Lump Sum	$ 91,000.00	$ 91,000.00	
1.02	Furnish & Install Silt Fence	5,000	Linear Feet	$ 3.00	$ 15,000.00	Assumes a 25% Increase to the perimeter and Maintenance
1.03	Clearing and Grubbing	13	Acre	$ 5,000.00	$ 64,279.16	
1.04	Bridge Installation	1	Each	$ 15,000.00	$ 15,000.00	
1.05	Bridge Rental	2	Months	$ 42,500.00	$ 85,000.00	
1.06	Equipment /Material Staging Areas/Temporary Construction Roads	1	Lump Sum	$ 40,000.00	$ 40,000.00	Costs for Construction Access, Site Logistics, Stockpile Management Areas, Etc.
1.07	Surveying Services	10	Day	$ 2,500.00	$ 25,000.00	
	SUBTOTAL				**$ 335,279.16**	
2.0	**Surface Soil and Waste Removal Action**					
2.01	Furnish & Install Sediment Controls	6,800	Linear Feet	$ 14.00	$ 95,200.00	Controls needed on all sides due to surrounding water bodies
2.02	Excavation of Impacted Soils	62,222	Cubic Yards	$ 22.50	$ 1,400,000.00	Assumes average depth of 3 ft required to meet PRGs over entire area
2.03	Excavation of Waste	40,000	Cubic Yards	$ 30.00	$ 1,200,000.00	Volume estimate from RI - bulk of waste present below water table
2.04	Temporary Water Treatment Setup and Operation	1	Months	$ 75,000	$ 75,000.00	Intial setup and procurement prorated over the length of operation.
2.05	Transport, Place, and Grade Excavated Soils	62,222	Cubic Yards	$ 15.00	$ 933,333.33	Assumes excavated soils are placed at Nunes Parcel
2.06	Transport, Place, and Grade Excavated Waste	40,000	Cubic Yards	$ 15.00	$ 600,000.00	Assumes excavated waste is placed at Nunes Parcel
	SUBTOTAL				**$ 4,303,533.33**	
3.0	**Professional Services**					
3.01	Landfill Design, Permitting, Procurement (8% of Capital Costs)	1	Lump Sum	$ 372,000.00	$ 372,000.00	
3.02	Construction Management (7% of Capital Costs)	1	Lump Sum	$ 325,000.00	$ 325,000.00	
	SUBTOTAL				**$ 697,000.00**	

TOTAL	**$**	**5,335,812.49**
15% Contingency	**$**	**800,371.87**
Total Capital Costs =	**$**	**6,136,184.36**
Operation & Maintenance Costs =	$	- per year (all waste/soil above PRGs removed)

Assumptions:

Surface Soil Area	560000	Square Feet	6/10/13 - Added area based on recreational user PRG exceedances
	13	Acres	
	62222	Cubic Yards (3' removal depth)	
	3400	Linear Feet of Riverbank	6/10/13 - Added estimated length based on recreational user PRG exceedances
Surface Soil Perimeter	6,800	Linear Feet	6/10/13 - Added estimated length based on recreational user PRG exceedances

Present Worth Analysis

UI-SO-2 - Remove/Consolidate Surface Waste/Soil (0 to 2 feet) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Interest rate: 7%

LIFE CYCLE COST

Year	Amount	Present Worth	p/f factor
1	$ 4,311,875	$ 4,311,875	1.00
2	$ 5,000	$ 4,673	0.935
3	$ 5,000	$ 4,367	0.873
4	$ 5,000	$ 4,081	0.816
5	$ 5,000	$ 3,814	0.763
6	$ 5,000	$ 3,565	0.713
7	$ 5,000	$ 3,332	0.666
8	$ 5,000	$ 3,114	0.623
9	$ 5,000	$ 2,910	0.582
10	$ 5,000	$ 2,720	0.544
11	$ 5,000	$ 2,542	0.508
12	$ 5,000	$ 2,375	0.475
13	$ 5,000	$ 2,220	0.444
14	$ 5,000	$ 2,075	0.415
15	$ 5,000	$ 1,939	0.388
16	$ 5,000	$ 1,812	0.362
17	$ 5,000	$ 1,694	0.339
18	$ 5,000	$ 1,583	0.317
19	$ 5,000	$ 1,479	0.296
20	$ 5,000	$ 1,383	0.277
21	$ 5,000	$ 1,292	0.258
22	$ 5,000	$ 1,208	0.242
23	$ 5,000	$ 1,129	0.226
24	$ 5,000	$ 1,055	0.211
25	$ 5,000	$ 986	0.197
26	$ 5,000	$ 921	0.184
27	$ 5,000	$ 861	0.172
28	$ 5,000	$ 805	0.161
29	$ 5,000	$ 752	0.150
30	$ 5,000	$ 703	0.141
31	$ 5,000	$ 657	0.131
PRESENT WORTH:		**$ 4,373,921**	

Notes: Capital Cost is Removal Action and Geotextile Cover

O&M is Cover and Inst. Control maintenance for 30 years (annual cost assumed based on experience)

Years 2 through 31 include O&M costs

Present Worth Analysis

UI-SO-3 - Remove/Consolidate All Waste/Soil Exceeding PRGs

Interest rate: 7%

LIFE CYCLE COST

Year	Amount	Present Worth	p/f factor
1	$ 6,136,184	$ 6,136,184	1.00
2	$ -	$ -	0.935
3	$ -	$ -	0.873
4	$ -	$ -	0.816
5	$ -	$ -	0.763
6	$ -	$ -	0.713
7	$ -	$ -	0.666
8	$ -	$ -	0.623
9	$ -	$ -	0.582
10	$ -	$ -	0.544
11	$ -	$ -	0.508
12	$ -	$ -	0.475
13	$ -	$ -	0.444
14	$ -	$ -	0.415
15	$ -	$ -	0.388
16	$ -	$ -	0.362
17	$ -	$ -	0.339
18	$ -	$ -	0.317
19	$ -	$ -	0.296
20	$ -	$ -	0.277
21	$ -	$ -	0.258
22	$ -	$ -	0.242
23	$ -	$ -	0.226
24	$ -	$ -	0.211
25	$ -	$ -	0.197
26	$ -	$ -	0.184
27	$ -	$ -	0.172
28	$ -	$ -	0.161
29	$ -	$ -	0.150
30	$ -	$ -	0.141
31	$ -	$ -	0.131
PRESENT WORTH:		**$ 6,136,184**	

Notes: Capital Cost is Removal Action

No O&M will be needed

Peterson Puritan Landfill

Sediment Removal

SE-2 - Remove/Consolidate Sediment Exceeding PRGs

Task #	Task	QTY	UNIT	RATE	COST	Assumptions
1.0	**Site Preparation**					
1.01	Mobilization/Demobilization (2% of Captial Costs Excluding O&M)	1	Lump Sum	$ 121,000.00	$ 121,000.00	
1.03	Temporary Dock Structure	1	Each	$ 50,000.00	$ 50,000.00	
1.05	Bridge Installation	0	Each	$ 15,000.00	$ -	Bridge setup cost included in Unnamed Island Soil Remedy
1.05	Bridge Rental	1	Months	$ 42,500.00	$ 42,500.00	
1.06	Equipment /Material Staging Areas/Temporary Construction Roads	40,000	Square Feet	$ 4.00	$ 160,000.00	Costs for Construction Access, Site Logistics, Stockpile Management Areas, Etc.
	SUBTOTAL				**$ 373,500.00**	
2.0	**Pond Dredging**					
2.01	Sediment Dredging	17,315	Cubic Yards	$ 290.00	$ 5,021,296.30	Assume average 2-ft removal
2.02	Sediment Management	17,315	Cubic Yards	$ 5.00	$ 86,574.07	Assumes 24-Inches cover w/ additional material to support positive drainage
2.03	Temporary Water Treatment Setup and Operation	3	Months	$ 75,000	$ 225,000.00	Intial setup and procurement prorated over the length of operation.
2.04	Transport, Place, and Grade Dredged Sediments	17,315	Cubic Yards	$ 25.00	$ 432,870.37	Assumes dredged sediments will be placed and stabilized at Nunes Parcel
	SUBTOTAL				**$ 5,765,740.74**	
3.0	**Professional Services**					
3.01	Dredging Design, Permitting, Procurement (8% of Capital Costs)*	1	Lump Sum	$ 492,000.00	$ 492,000.00	
3.02	Construction Management (7% of Capital Costs)	1	Lump Sum	$ 430,000.00	$ 430,000.00	
	SUBTOTAL				**$ 922,000.00**	

* Includes pre-design extent sampling

TOTAL	**$**	**7,061,240.74**
15% Contingency	**$**	**1,059,186.11**
Total Capital Costs =	**$**	**8,120,426.85**
Operation & Maintenance Costs =	$ -	per year (all sediment above PRGs removed)

Assumptions:

Pond A	205000	Square Feet
Pond D	18750	
Pond E	10000	
Ponds I & N managed during Source Area remedies		
Total	233750	
	5.37	Acres
	17315	Cubic Yards (Average removal depth of 2 ft)

Peterson Puritan Landfill

Sediment Removal

SE-3 - Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Task #	Task	QTY	UNIT	RATE	COST	Assumptions
1.0	**Site Preparation**					
1.01	Mobilization/Demobilization (2% of Captial Costs Excluding O&M)	1	Lump Sum	$ 76,000.00	$ 76,000.00	
1.02	Temporary Dock Structure	1	Each	$ 50,000.00	$ 50,000.00	
1.03	Bridge Installation	0	Each	$ 15,000.00	$ -	Bridge setup cost included in Unnamed Island Soil Remedy
1.04	Bridge Rental	1	Months	$ 42,500.00	$ 42,500.00	
1.05	Equipment /Material Staging Areas/Temporary Construction Roads	40,000	Square Feet	$ 4.00	$ 160,000.00	Costs for Construction Access, Site Logistics, Stockpile Management Areas, Etc.
	SUBTOTAL				**$ 328,500.00**	
2.0	**Pond Dredging and Subaqueous Cover**					
2.01	Sediment Dredging	8,657	Cubic Yards	$ 290.00	$ 2,510,648.15	
2.02	Sediment Management	17,315	Cubic Yards	$ 5.00	$ 86,574.07	Assumes 24-Inches cover w/ additional material to support positive drainage
2.03	Temporary Water Treatment Setup and Operation	2	Months	$ 75,000	$ 150,000.00	Intial setup and procurement prorated over the length of operation.
2.04	Transport, Place, and Grade Dredged Sediments	8,657	Cubic Yards	$ 25.00	$ 216,435.19	Assumes dredged sediments will be placed and stabilized at Nunes Parcel
2.05	Geotextile Installation	70,125	Square Feet	$ 2.50	$ 175,312.50	
2.06	Supply and Place Sand Cover	2,597	Cubic Yards	$ 150.00	$ 389,583.33	
	SUBTOTAL				**$ 3,528,553.24**	
3.0	**Restoration of Construction Areas**					
3.01	Identification Signage	6	Each	$ 100.00	$ 600.00	Assumed placed around ponds
	SUBTOTAL				**$ 600.00**	
4.0	**Professional Services**					
4.01	Dredging Design, Permitting, Procurement (8% of Capital Costs)*	1	Lump Sum	$ 309,000.00	$ 309,000.00	
4.02	Construction Management (7% of Capital Costs)	1	Lump Sum	$ 271,000.00	$ 271,000.00	
	SUBTOTAL				**$ 580,000.00**	

* Includes pre-design extent sampling

TOTAL	**$ 4,437,653.24**	
15% Contingency	**$ 665,647.99**	
Total Capital Costs =	**$ 5,103,301.23**	
Operation & Maintenance Costs =	$ 50,000.00	per year (assumed based on experience)

Assumptions:

Pond A	205000	Square Feet
Pond D	18750	
Pond E	10000	
Ponds I & N managed during Source Area remedies		
Total	233750	
	5.37	Acres
	8657	Cubic Yards (1' removal depth)
	70125	Square feet of Sediment Cover (assumes 30% coverage)
	2,597	Cubic Yards of sediment Cover (assumes 30% coverage)

Operations and Maintenance

Cover Monitoring Event (during first 5-yr review)	$ 105,000	Assumed
Periodic Replenishment	$50,000/yr	Annual maintenance unlikely to be required, but episodic repleneshment may be needed following heavy storms. Current observations of pond do not indicate scouring is occurring within ponds.

Peterson Puritan Landfill

Sediment Removal

SE-4 - Subaqueous Cover (No Sediment Removal) with Institutional Controls

Task #	Task	QTY	UNIT	RATE	COST	Assumptions
1.0	**Site Preparation**					
1.01	Mobilization/Demobilization (2% of Captial Costs Excluding O&M)	1	Lump Sum	$ 43,000.00	$ 43,000.00	
1.02	Temporary Dock Structure	1	Each	$ 50,000.00	$ 50,000.00	
1.03	Bridge Installation	0	Each	$ 15,000.00	$ -	Bridge setup cost included in Unnamed Island Soil Remedy
1.04	Bridge Rental	1	Months	$ 42,500.00	$ 42,500.00	
1.05	Equipment /Material Staging Areas/Temporary Construction Roads	40,000	Square Feet	$ 4.00	$ 160,000.00	Costs for Construction Access, Site Logistics, Stockpile Management Areas, Etc.
	SUBTOTAL				**$ 295,500.00**	
2.0	**Subaqueous Cover**					
2.01	Geotextile Installation	233,750	Square Feet	$ 2.50	$ 584,375.00	
2.02	Supply and Place Sand Cover	8,657	Cubic Yards	$ 150.00	$ 1,298,611.11	
	SUBTOTAL				**$ 1,882,986.11**	
3.0	**Restoration of Construction Areas**					
3.01	Identification Signage	6	Each	$ 100.00	$ 600.00	Assumed placed around ponds
	SUBTOTAL				**$ 600.00**	
4.0	**Professional Services**					
4.01	Dredging Design, Permitting, Procurement (8% of Capital Costs)	1	Lump Sum	$ 175,000.00	$ 175,000.00	
4.02	Construction Management (7% of Capital Costs)	1	Lump Sum	$ 153,000.00	$ 153,000.00	
	SUBTOTAL				**$ 328,000.00**	

TOTAL	**$ 2,507,086.11**	
15% Contingency	**$ 376,062.92**	
Total Capital Costs =	**$ 2,883,149.03**	
Operation & Maintenance Costs =	$ 50,000.00	per year (assumed based on experience)

Assumptions:

Pond A	205000	Square Feet
Pond D	18750	
Pond E	10000	
Ponds I & N managed during Source Area remedies		
Total	233750	
	5.37	Acres
	8657	Cubic Yards (for 1' cover material)

Operations and Maintenance

Cover Monitoring Event (5 yr review)	$ 105,000	
Periodic Replenishment	$50,000/yr	Annual maintenance unlikely to be required, but episodic repleneshment may be needed following heavy storms. Current observations of pond do not indicate scouring is occurring within ponds.

Present Worth Analysis

SE-2 - Remove/Consolidate Sediment Exceeding PRGs

Interest rate: 7%

LIFE CYCLE COST

Year	Amount	Present Worth	p/f factor
1	$ 8,120,427	$ 8,120,427	1.00
2	$ -	$ -	0.935
3	$ -	$ -	0.873
4	$ -	$ -	0.816
5	$ -	$ -	0.763
6	$ -	$ -	0.713
7	$ -	$ -	0.666
8	$ -	$ -	0.623
9	$ -	$ -	0.582
10	$ -	$ -	0.544
11	$ -	$ -	0.508
12	$ -	$ -	0.475
13	$ -	$ -	0.444
14	$ -	$ -	0.415
15	$ -	$ -	0.388
16	$ -	$ -	0.362
17	$ -	$ -	0.339
18	$ -	$ -	0.317
19	$ -	$ -	0.296
20	$ -	$ -	0.277
21	$ -	$ -	0.258
22	$ -	$ -	0.242
23	$ -	$ -	0.226
24	$ -	$ -	0.211
25	$ -	$ -	0.197
26	$ -	$ -	0.184
27	$ -	$ -	0.172
28	$ -	$ -	0.161
29	$ -	$ -	0.150
30	$ -	$ -	0.141
31	$ -	$ -	0.131
PRESENT WORTH:		**$ 8,120,427**	

Notes: Capital Cost is Removal Action

No O&M will be needed

Present Worth Analysis

SE-3 - Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Interest rate: 7%

LIFE CYCLE COST

Year	Amount	Present Worth	p/f factor
1	$ 5,103,301	$ 5,103,301	1.00
2	$ 50,000	$ 46,729	0.935
3	$ 50,000	$ 43,672	0.873
4	$ 50,000	$ 40,815	0.816
5	$ 155,000	$ 118,249	0.763
6	$ 50,000	$ 35,649	0.713
7	$ 50,000	$ 33,317	0.666
8	$ 50,000	$ 31,137	0.623
9	$ 50,000	$ 29,100	0.582
10	$ 50,000	$ 27,197	0.544
11	$ 50,000	$ 25,417	0.508
12	$ 50,000	$ 23,755	0.475
13	$ 50,000	$ 22,201	0.444
14	$ 50,000	$ 20,748	0.415
15	$ 50,000	$ 19,391	0.388
16	$ 50,000	$ 18,122	0.362
17	$ 50,000	$ 16,937	0.339
18	$ 50,000	$ 15,829	0.317
19	$ 50,000	$ 14,793	0.296
20	$ 50,000	$ 13,825	0.277
21	$ 50,000	$ 12,921	0.258
22	$ 50,000	$ 12,076	0.242
23	$ 50,000	$ 11,286	0.226
24	$ 50,000	$ 10,547	0.211
25	$ 50,000	$ 9,857	0.197
26	$ 50,000	$ 9,212	0.184
27	$ 50,000	$ 8,610	0.172
28	$ 50,000	$ 8,047	0.161
29	$ 50,000	$ 7,520	0.150
30	$ 50,000	$ 7,028	0.141
31	$ 50,000	$ 6,568	0.131
PRESENT WORTH:		**$ 5,803,857**	

Notes: Capital Cost is Removal Action and Subaqueous Cover

O&M is Cover and Inst. Control maintenance for 30 years

Years 2 through 31 include O&M costs

Year 5 includes an additional cover evaluation study

Present Worth Analysis

SE-4 - Subaqueous Cover (No Sediment Removal) with Institutional Controls

Interest rate: 7%

LIFE CYCLE COST

Year	Amount	Present Worth	p/f factor
1	$ 2,883,149	$ 2,883,149	1.00
2	$ 50,000	$ 46,729	0.935
3	$ 50,000	$ 43,672	0.873
4	$ 50,000	$ 40,815	0.816
5	$ 155,000	$ 118,249	0.763
6	$ 50,000	$ 35,649	0.713
7	$ 50,000	$ 33,317	0.666
8	$ 50,000	$ 31,137	0.623
9	$ 50,000	$ 29,100	0.582
10	$ 50,000	$ 27,197	0.544
11	$ 50,000	$ 25,417	0.508
12	$ 50,000	$ 23,755	0.475
13	$ 50,000	$ 22,201	0.444
14	$ 50,000	$ 20,748	0.415
15	$ 50,000	$ 19,391	0.388
16	$ 50,000	$ 18,122	0.362
17	$ 50,000	$ 16,937	0.339
18	$ 50,000	$ 15,829	0.317
19	$ 50,000	$ 14,793	0.296
20	$ 50,000	$ 13,825	0.277
21	$ 50,000	$ 12,921	0.258
22	$ 50,000	$ 12,076	0.242
23	$ 50,000	$ 11,286	0.226
24	$ 50,000	$ 10,547	0.211
25	$ 50,000	$ 9,857	0.197
26	$ 50,000	$ 9,212	0.184
27	$ 50,000	$ 8,610	0.172
28	$ 50,000	$ 8,047	0.161
29	$ 50,000	$ 7,520	0.150
30	$ 50,000	$ 7,028	0.141
31	$ 50,000	$ 6,568	0.131
PRESENT WORTH:		**$ 3,583,705**	

Notes: Capital Cost is Subaqueous Cover Installation and Inst. Control

O&M is Cover and Inst. Control maintenance for 30 years

Years 2 through 31 include O&M costs

Year 5 includes an additional cover evaluation study

APPENDIX C

HUMAN HEALTH RISK REFINEMENT AND PRG DEVELOPMENT

APPENDIX C.1

HUMAN HEALTH RISK REFINEMENT: LEAD MODELING FOR OU2

1.0 Introduction

As requested by the United States Environmental Protection Agency (USEPA), this technical memorandum presents an evaluation of potential risks associated with exposure of human receptors to lead in site-related media at the Peterson Puritan Operable Unit 2 (OU2) Superfund Site located in Cumberland and Lincoln, Rhode Island. This technical memorandum is included as Appendix C to the *Draft Feasibility Study*.

Lead was identified as a constituent of potential concern (COPC) in the HHRA (ARCADIS, 2009) for the following subareas and media:

- Site-wide surface soil (excluding Nunes Parcel and wetlands)
- Nunes Parcel surface soil
- Nunes Parcel subsurface soil
- Site-wide sediments
- Wetland sediments
- Site-wide groundwater
- Leachate
- Fish (fillet) tissue

As requested by the USEPA, the lead evaluation consists of a separate evaluation for each subarea of the site and each exposure scenario previously evaluated in the HHRA (ARCADIS, 2009). Although lead was identified as a COPC in leachate, this exposure pathway is not quantitatively evaluated because uncertainty in assigning a dermal absorption fraction for lead precludes quantification of potential risks associated with the dermal exposure route (USEPA, 2003a; 2004; 2007).

2.0 Methodology

Risks associated with exposure to lead in various site-related media were evaluated using USEPA's lead models – the Adult Lead Model (ALM) and the IEUBK Model for Lead in Children (USEPA, 1994a; 2003a). Specifically, the ALM was used to evaluate potential lead risks for non-residential scenarios, and the IEUBK Model was used to evaluate potential lead risks for residential scenarios (i.e., children ages 0 to 84 months of age). Parameter values used in the ALM and IEUBK are largely based on the USEPA's recommended default values and were previously approved by the USEPA on May 13, 2008. The dose equations and modeling approaches are consistent with USEPA guidance (1994a; 2003a; 2007).

Incidental ingestion of lead in soil is generally the primary exposure pathway of concern for risk assessments. However, the models can also quantify cumulative doses and risk attributed to other sources of exposure, such as drinking water, diet, lead-based paint, and air emissions. Because lead is ubiquitous in the environment, predicted blood lead levels (PbB) associated with exposure to site-related sources of lead are added to an assumed age-specific baseline PbB that reflects exposure to non-site-related sources of lead. Forty-one different exposure scenarios (current and future) were evaluated using the ALM, including exposure of recreational users (adults and older children, age 6 to 12 years), commercial workers, construction workers, adolescent trespassers (age 9 to 18 years), and adult anglers. Four exposure scenarios were evaluated using the IEUBK Model: exposure of residential young children to site-wide groundwater, exposure of young children to fish tissue, exposure of residential young children to soil and groundwater at Nunes

Parcel, and exposure of residential young children to soil and groundwater at the Rhode Island Department of Environmental Management (RIDEM) Soil Removal Area.

In both the ALM and IEUBK Model, potential health risks associated with lead exposure are evaluated by comparing the estimated PbB to the target PbB of 10 micrograms per deciliter (µg/dL) (Centers for Disease Control [CDC], 1991). The target PbB is based on potentially adverse neurological effects in children (CDC, 1991). Therefore, lead risk is evaluated based on the probability that PbB among a receptor population will exceed 10 ug/dL. This is sometimes referred to as the "P10 statistic." Consistent with USEPA guidance (USEPA, 1994a; 2003b), this lead evaluation focuses on determining if P10 equals or exceeds 5 percent, which is equivalent to calculating the 95th percentile of the probability distribution of PbB among a receptor population.

The USEPA employs a simplifying assumption in both models to estimate the probability distribution of PbBs. Each model first generates a point estimate of the central tendency of the PbB distribution, and it is assumed that the value represents the geometric mean PbB among a receptor population that is exposed to the same levels of lead in the environment. Epidemiological data on PbBs among various populations suggests that the distribution is roughly lognormal in shape (USEPA, 1994b). The USEPA applies the assumption of lognormality to both models using the following equation:

$$PbB_{0.95} \quad PbB_{GM} \times GSD^{1.645}$$

$PbB_{0.95}$ = 95th percentile of the distribution of PbBs (ug/dL)
PbB_{GM} = geometric mean (or 50th percentile) of the lognormal distribution of PbBs (ug/dL)
GSD = geometric standard deviation of the lognormal distribution of PbBs (unitless)

3.0 Adult Lead Model for Non-Residential Receptor Populations

The USEPA's ALM is used to evaluate risks to non-residential receptor populations (USEPA, 2007). The following equation is used in the ALM to estimate quasi-steady state PbBs:

$$PbB_{GM} \quad PbB_0 + \frac{PbS \times BKSF \times IR \times AF \times EF}{AT}$$

PbB_{GM} = geometric mean (or 50th percentile) of the lognormal distribution of PbBs in adult workers (ug/dL)
PbB_0 = baseline PbB due to exposure to non-site-related sources of lead (ug/dL)
PbS = soil lead concentration (milligrams per kilogram [mg/kg])
BKSF = biokinetic slope factor (ug/dL per micrograms per day)
IR = soil ingestion rate (grams per day [g/day])
AF = gastrointestinal absorption fraction for lead in soil (unitless)
EF = exposure frequency (days per year)
AT = averaging time (years)

The receptor of concern in the ALM is the fetus of an adult worker. The USEPA assumes a linear relationship between PbB in the adult woman and the fetus. Therefore, the geometric mean PbB in the fetus is equal to PbB_{GM} multiplied by a constant, R. USEPA guidance (2003b) indicates that because the IEUBK Model is limited to 0 to 84 months, the ALM may also be used to assess older children and adolescents with appropriate adjustments. Per the USEPA's request, a time-

weighted approach was used to evaluate potential risks for recreational users and trespassers consistent with USEPA guidance (2003b).

3.1 Adult Lead Model Parameter Values

Table 1a presents the central tendency parameter values used to evaluate lead risks for the following receptors:

- Current and future commercial worker (risks presented in Table 1b)
- Future construction worker (risks presented in Table 1c)
- Current and future adult recreational user (risks presented in Table 1d)
- Current and future older child recreational user (risks presented in Table 1e)
- Current adolescent trespasser (risks presented in Table 1f)
- Current and future adult angler (risks presented in Table 1g)

Baseline Blood Lead Concentration (PbB_0)

The baseline PbB is intended to represent the best estimate of a reasonable central value of PbB in women of child-bearing age who are not exposed to lead-contaminated non-residential soil or dust at the site. The USEPA (2003b) recommends a range of baseline concentrations (1.7 to 2.2 µg/dL) based on national survey data for women from different demographic groups defined by geographic region, ethnicity, and race. Per the USEPA's request, a baseline value of 1.9 µg/dL was used in the ALM, which represents non-Hispanic white populations from the Northeast Region (USEPA, 2002a).

Geometric Standard Deviation

The USEPA recommends a range of geometric standard deviations (GSDs) that may be used in the ALM Model, depending on site-specific demographics and the characteristics of the receptor population (USEPA, 2003b). Higher GSD values imply greater variability in PbBs and will result in a higher probability of exceeding the target PbB of 10 µg/dL. Per the USEPA's request, a GSD of 2.01 was used in this lead evaluation to reflect a non-Hispanic white population from the Northeast (USEPA, 2002a).

Biokinetic Slope Factor

The Biokinetic Slope Factor (BKSF) represents the increase in typical adult PbB due to average daily lead uptake. The USEPA (2003b) recommends a default value of 0.4 µg lead/dL blood per µg lead absorbed per day for the BKSF. This value is based on empirical data on the relationship between tap-water lead concentrations and PbBs for a sample group of adult males. This default value was used for all exposure pathways in this evaluation.

Soil Ingestion Rate (IR_s)

Consistent with USEPA guidance (2003a; 2007), a soil ingestion rate of 50 mg/day was used to evaluate potential risks for the commercial worker, adult recreational user, older child recreational user, and adolescent trespasser. This value represents the central tendency ingestion rate for soil non-contact-intensive activities (including soil-derived indoor dust) (USEPA, 2007). A soil ingestion rate of 100 mg/day was used for the construction worker, which represents the central tendency ingestion rate for soil contact-intensive activities. This is a refinement from the ingestion rate used in the BHHRA (330 mg/kg) based on frequent questions on the ALM (USEPA, 2007).

Exposure Frequency and Averaging Time

Exposure frequencies used in this lead evaluation were consistent with values used in the HHRA (ARCADIS, 2009). Consistent with USEPA guidance (2003b), a time-weighted average approach was used to evaluate potential risks for recreational users and trespassers.

Lead Absorption Fraction

This evaluation used a lead absorption fraction of 0.12, which is the default value recommended by the USEPA (2003b). This value is based on experimental studies of the bioavailability of ingested lead in adults with considerations for the following three major sources of variability: 1) effect of food on lead bioavailability, 2) nonlinearity in PbB, and 3) effect of lead form and particle size on bioavailability. The value assumes the a relative bioavailability of 0.6 for lead in site-related media as compared to soluble lead, and also assumes an absorption fraction (AF) of 0.2 for soluble lead. Thus, the final AF is 0.12 (i.e., AF = 0.6 x 0.2 = 0.12).

Fetal/Maternal Blood Lead Concentration ($R_{fetal/maternal}$)

This evaluation used a fetal/maternal blood lead ratio of 0.9 for adult receptors, which is the default value recommended by the USEPA (2003b) based on studies that have explored the relationship between umbilical cord and maternal PbBs. Because the older child recreational user and adolescent trespasser are not of child-bearing age, the fetal/maternal PbB ratio for these receptors was set equal to 1.

Fish Ingestion Rate

For the adult angler scenario, it was assumed that site-related lead exposure is restricted to fish consumption. The lead evaluation used the same Central Tendency Exposure fish ingestion rate (8.9 g/day) as was used in the HHRA (ARCADIS, 2009). This value represents the 50th percentile for fish-consuming anglers in Maine from Ebert et al. (1993). The lead evaluation conservatively assumes that 100 percent of fish consumed by the adult angler are from on-site sources.

3.2 Exposure Point Concentrations

The exposure point concentrations (EPCs) used in the lead evaluation are arithmetic means based on site-related data. As requested by the USEPA, media within each subarea were evaluated separately (i.e., medium-specific arithmetic means were used as the EPCs). Per the USEPA's request, one-half the laboratory detection limit was used as a surrogate for non-detects in calculating arithmetic mean lead concentrations.

3.3 Adult Lead Model Results

Table 1b presents the modeling results for the commercial worker. The ALM predicts that exposure of commercial workers to site-related media at Nunes Parcel and Quinnville Wellfield

will result in a P10 less than 5 percent (i.e., less than 5 percent of fetal PbBs will be greater than the target of 10 µg/dL). However, exposure of commercial workers to soils within the RIDEM Soil Removal Area results in a P10 of 10 percent for surface soils and a P10 of 12 percent for surface and subsurface soils combined.

Table 1c presents the modeling results for the construction worker. Exposure of construction workers to site-wide shallow groundwater (incidental ingestion during intrusive activities) and soils at Quinnville Wellfield, Southern Bank, and Nunes Parcel result in a P10 of less than the threshold of 5 percent. However, exposure of construction workers to soils at the RIDEM Soil Removal Area results in a P10 of 39 percent, which is well above the 5 percent threshold.

Table 1d presents the modeling results for the adult recreational user. Exposure of adult recreational users to site-related media associated with Southern Bank, Nunes Parcel, Quinnville Wellfield, Debris Fields, Wetlands, RIDEM Soil Removal Area, and Landfill results in P10s less than 5 percent.

Table 1e presents the modeling results for the older child recreational user. Because this receptor is not of child-bearing age, the ALM was only used to estimate the geometric mean of PbB for the exposed individual. Exposure of older child recreational users to site-related media associated with Southern Bank, Nunes Parcel, Quinnville Wellfield, Debris Fields, Wetlands, RIDEM Soil Removal Area, and Landfill results in PbBs less than 10 µg/dL.

Table 1f presents the modeling results for the adolescent trespasser. Similar to the older child recreational user, the ALM was only used to estimate the geometric mean of PbB for the exposed individual. Exposure of the adolescent trespasser to site-related media associated with Southern Bank, Nunes Parcel, Quinnville Wellfield, Debris Fields, Wetlands, RIDEM Soil Removal Area, and Landfill results in PbBs less than 10 µg/dL.

Table 1g presents the modeling results for the adult angler. Exposure of adult anglers via consumption of fish tissue from the site (OU2) results in a P10 of less 1 percent, which is well below the threshold of 5 percent. Likewise, evaluation of potential lead risks associated with consumption of fish from upstream reaches of the Blackstone River (BR1 and BR2) result in P10s less than 1 percent.

3.4 Uncertainties Associated with the Adult Lead Model

Notable uncertainties associated with the ALM in this evaluation are associated with the limited analytical data for the RIDEM Soil Removal Area. At the request of the USEPA, the RIDEM Soil Removal Area was evaluated as a separate subarea within the Nunes Parcel using only three sampling points (SO-033-NP, SO-107-NP, and SO-108- NP). However, this conservatively assumes that the receptor would preferentially spend all of their time in a relatively small area of the site. Lead concentrations in these samples ranged from10 mg/kg (SO-107-NP) to 5,460 mg/kg (SO-033-NP, 1 to 5 feet).

4.0 IEUBK Model for Residential Receptor Populations

The IEUBK Model consists of four modules (exposure, uptake, biokinetics, and variability) that mathematically and statistically link environmental lead exposure to blood lead concentrations for a population of children, ages 0 to 84 months (USEPA, 2002b). USEPA's IEUBK Model (Windows version 1, Build 264) was used to assess risks for the following scenarios for children ages 0 to 84 months:

- Hypothetical future exposure of young child residents to site-wide groundwater
- Current and hypothetical future exposure of young child anglers to fish from the site (OU2) and upstream reaches of the Blackstone River (BR1 and BR2)
- Hypothetical future exposure of young child residents to soils at Nunes Parcel and site-wide groundwater
- Hypothetical future exposure of young child residents to soils at the RIDEM Soil Removal Area and site-wide groundwater.

The application of the IEUBK Model assumed one child, one location, and homogeneous media concentrations. Similar to the ALM, the EPC(s) used in the IEUBK Model represent arithmetic means of the available data. Per the USEPA's request, one-half the laboratory detection limit was used for non-detects in the calculation of arithmetic means.

4.1 IEUBK Model Parameters Values

Tables 2a, 3a, and 5a present the parameter values used in the IEUBK Model. The majority of the parameter values used in the IEUBK Model were defaults, with the exception of using more recent estimates of dietary lead intake, evaluating an alternate diet intake scenario (i.e., fish ingestion), using site-specific lead concentration in drinking water, and using a site-specific background lead concentration for soils. The use of site-specific background soils data was previously approved by the USEPA following the February 20, 2007 meeting in Boston. Specifically, as noted in Table 1: "Technical items discussed during the 2/20/07 meeting in Boston, MA regarding the Peterson Puritan Superfund Site HHRA," on the issue of "identification of background soil samples," Metcalf & Eddy state "offsite soil samples from Mackland Farms will be used as site-specific background samples." Attachment B presents the sample groupings used to calculate site-specific EPCs for each exposure scenario evaluated using the IEUBK Model.

Dietary Data

The default dietary lead intakes in the IEUBK Model are based on data collected by the U.S. Food and Drug Administration (USFDA) in the late 1980s. More recent USFDA (2001) data are available, and therefore, were incorporated into the model. In addition, for the fish consumption scenario, alternate diet intakes consisted of site-specific data for fish tissue collected from OU2, BR1, and BR2. The lead intake from fish was calculated using the following equation:

Fish Intake (µg lead/day) = (Total meat intake rate, g/day) x (% Total Meat Intake from Fish) x (% Fish from Source) x (Fish Concentration, µg lead/day)

Where:

% of Total Meat Intake from Fish = 10%
% Fish Consumption from Source = 100%

The fish concentrations represent the arithmetic means of the fish fillet data for each subarea (OU2 = 0.012 mg/kg; BR1 = 0.013 mg/kg; and BR2 = 0.0056 mg/kg). The resulting lead intakes attributable to consumption of fish for OU2, BR1, and BR2 are presented in Table 4.

Lead Concentration in Drinking Water

To evaluate hypothetical future exposure of residential young children to lead in drinking water, the arithmetic mean of the site-wide groundwater data (2.17 micrograms per liter) was used in the IEUBK Model. This evaluation assumes that site-related groundwater may be used as a potable source in the future, and that current measured concentrations are representative of future concentrations.

Lead Concentration in Soil/Dust

For the site-wide groundwater and fish scenarios, the soil/dust concentration represents a site-specific background concentration (i.e., the arithmetic mean of the Mackland Farms soils data [samples SO-072-MF, SO-073-MF, and SO-074-MF]). For the evaluation of hypothetical future residential young children exposed to soils and groundwater at Nunes Parcel, the soil/dust lead concentration (270 mg/kg) represents the arithmetic mean of surface and subsurface soils from Nunes Parcel. For the evaluation of hypothetical future residential young children exposed to soils and groundwater at the RIDEM Soils Removal Area, the soil/dust lead concentration (2,050 mg/kg) represents the arithmetic mean of surface and subsurface soils (i.e., the three sampling sampling points identified by the USEPA [SO-033-NP, SO-107-NP, and SO-108-NP]).

4.2 IEUBK Model Results

Table 2b presents the input parameters and results for evaluation of hypothetical future exposure of young child residents to site-wide groundwater. There is less than a 1 percent probability that children exposed to lead in groundwater will have a PbB that exceeds the target PbB of concern (10 µg/dL) (i.e., well below the P10 = 5 percent threshold).

Table 3b presents the input parameters and results for evaluation of exposure of young child anglers to fish tissue from OU2. There is less than a 1 percent probability that children exposed to lead in fish will have a PbB greater than 10 µg/dL.

To place OU2 lead risks into perspective, consumption of fish from upstream reaches of the Blackstone River (BR1 and BR2) was also evaluated. Table 3c presents the input parameters and results for evaluation of exposure of young child anglers to fish tissue from BR1. Results indicate there is less than a 1 percent probability that children exposed to lead in fish from BR1 will have a PbB greater than 10 µg/dL. Table 3d presents the input parameters and results for evaluation of exposure of young child anglers to fish tissue from BR2. Results indicate there is less than a 1 percent probability that children exposed to lead in fish from BR2 will have a PbB greater than 10 µg/dL.

Table 5b presents the input parameters and results for evaluation of exposure of hypothetical young child residents to soil and groundwater from Nunes Parcel. Results indicate there is a 2

percent probability (less than the 5 percent threshold) that children exposed to soil a nd groundwater will have a PbB greater than 10 µg/dL.

Table 5c presents the input parameters and results for evaluation of exposu re of hypothetical young child residents to soil and groundwater from the RIDEM Soil Removal Area. Results indicate there is an 87 percent probability (above the 5 percent threshold) that children exposed to soil and groundwater will have a PbB greater than 10 µg/dL.

4.3 Uncertainties Associated with the IEUBK Model

The notable uncertainty associated with the use of the IEUBK Model is that many of the default parameters may not accurately reflect site conditions (e.g., air emissions, dietary lead intake, bioavailability). Specifically, the bioavailability factors used in the model are based on the absolute bioavailability of soluble lead acetate (50 percent) (used for lead in food and water) and the relative bioavailability of lead in soil (60 percent), which yields an absolute bioavailability for soil lead of 30 percent (i.e., 60 percent x 50 percent = 30 percent). The USEPA (1999) notes that the default estimates of bioavailability have significant variability and uncertainty due to many factors related to the site-specific conditions (e.g., lead speciation, mineralogy, soil particle size) and receptor population (complex biological process of gastrointestinal absorption).

5.0 Summary and Conclusions

In summary, the lead evaluation identified the following scenarios as having estimated (potential) lead risks above the USEPA target:

- Exposure of commercial workers to soils within the RIDEM Soil Removal Area
- Exposure of construction workers to soils within the RIDEM Soil Removal Area
- Exposure of hypothetical young child residents to soil and groundwater from the RIDEM Soil Removal Area

However, the quantification of potential risks for the commercial worker, construction worker, and hypothetical young child resident exposed to soils within the RIDEM Soil Removal Area is based on a very limited (n = 5) sample size, which may present an artificially high average due to lead concentrations in sample SO-033-NP (2,380 mg/kg in the 0 to 1 foot interval and 5,460 mg/kg in the 1 to 5-foot interval). Although the potential exposure of construction workers to site soils produces risks above the USEPA target, these risks would likely be mitigated with the use of proper health and safety protocols, properly trained personnel, and personal protective equipment.

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Table 1a. Summary of Parameter Values Used in the Adult Lead Model (ALM) for Evaluation of Non-Residential Lead Risks Associated with Site-Related Soil, Sediment, Groundwater, and Fish
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Exposure Variable	Description	Units	Receptor Scenarios					
			Commercial Worker [1]	Construction Worker [1]	Adult Recreational User [2]	Older Child Recreational User [2,3]	Adolescent Trespasser [2,4]	Adult Angler [1]
			Table 1b	Table 1c	Table 1d	Table 1e	Table 1f	Table 1g
PbS	Lead concentration in medium of interest	ppm	Site-specific	Site-specific	Site-specific	Site-specific	Site-specific	Site-specific
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9 [a]	0.9 [a]	0.9 [a]	1.0 [b]	1.0 [b]	0.9 [a]
$BKSF_S$	Biokinetic Slope Factor (soil, sediment, and food)	µg/dL per µg/day	0.4 [a]	0.4 [a]	0.4 [a]	0.4 [a]	0.4 [a]	0.4 [a]
$BKSF_W$	Biokinetic Slope Factor (groundwater)	µg/dL per µg/day	NA	0.4 [a]	NA	NA	NA	NA
GSD_i	Geometric standard deviation PbB	--	2.01 [c]	2.01 [c]	2.01 [c]	2.01 [c]	2.01 [c]	2.01 [c]
PbB_0	Baseline PbB	µg/dL	1.9 [c]	1.9 [c]	1.9 [c]	1.9 [c]	1.9 [c]	1.9 [c]
IR_S	Soil/sediment ingestion rate (including soil-derived indoor dust)	g/day	0.05 [d]	0.10 [o]	0.05 [d]	0.05 [d]	0.05 [d]	NA
IR_f	Food ingestion rate (fish)	g/day	NA	NA	NA	NA	NA	8.9 [e]
IR_w	Shallow groundwater ingestion rate	L/day	NA	0.05 [m]	NA	NA	NA	NA
$AF_{S, D, W}$	Absorption fraction, Pb in soil, dust, sediment, and groundwater	--	0.12 [a]	0.12 [a]	0.12 [a]	0.12 [a]	0.12 [a]	NA
AF_f	Absorption fraction, Pb in food	--	NA	NA	NA	NA	NA	0.12 [f]
$EF_{S, D, W}$	Exposure frequency, Pb pathway	days/yr	219 [i]	62 [h]	2 [g]	2 [g]	2 [g]	365 [j]
$AT_{S, D, W}$	Averaging time, Pb pathway	days/yr	365 [k]	84 [l]	7 [n]	7 [n]	7 [n]	365 [k]

Notes:

[1] Lead exposures for these receptors were evaluated individually for each applicable subarea. Consistent with the ALM guidance (USEPA, 2003a; 2007), the arithmetic mean of lead concentrations was used in the ALM.

[2] A time-weighted approach was used to evaluate potential lead risks for these receptors in the ALM, consistent with Example 6 in Appendix A in USEPA (2003b).

[3] Older child = 6 - 12 years of age

[4] Adolescent = 9 - 18 years of age

[5] Consistent with USEPA (2003a; 2004; 2007) guidance, dermal exposures to lead in aqueous and non-aqueous media were not quantitatively evaluated with the ALM due to the uncertainty in assigning a dermal absorption fraction that would apply to the numerous inorganic forms of lead that are typically found in environmental settings.

[a] Default value (USEPA, 2003a).

[b] Fetal/maternal PbB ratio does not apply because receptor is assumed to be an older child (6-12 years) or adolescent (9-18 years); risks to fetus of pregnant women are evaluated in adult receptor scenarios.

[c] Default value for non-Hispanic white populations from the Northeast region (USEPA, 2002).

[d] Default CTE value for soil ingestion (USEPA, 2003a; 2007). Value for commercial worker assumes non-contact-intensive activities.

[e] CTE fish ingestion rate based on the 50th percentile for Maine anglers (Ebert et al., 1993. Estimating Consumption of Freshwater Fish among Maine Anglers. *North American Journal of Fisheries Management* 13:737-745.). Assumes 100% of fish consumed are from on-site sources.

Table 1a. Summary of Parameter Values Used in the Adult Lead Model (ALM) for Evaluation of Non-Residential Lead Risks Associated with Site-Related Soil, Sediment, Groundwater, and Fish
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Notes (continued):

[f] Value considered protective for bioavailable fraction of lead in fish (USEPA, 2007).
[g] Reflects the same CTE value used in baseline human health risk assessment (2 days per week for approximately 6 months). Applying the time-weighted approach consistent with note [2] above, the resulting exposure frequency is set equal to 2 days/week.
[h] Same CTE value used in baseline human health risk assessment (5 days per week for approximately 12 weeks).
[i] Default central tendency estimate of exposure frequency for commercial/industrial workers from USEPA (2007).
[j] Fish ingestion rate reflects a longterm average daily intake assuming 100% of fish are obtained from the site; therefore, EF is 365 days/year.
[k] Averaging time appropriate for chronic exposure scenario (USEPA, 2003a; 2007).
[l] Averaging time is based on EF to avoid diluting exposures over the entire year (7 days per week x 12 weeks/year = 84 days/year).
[m] Default surface water contact rate for recreational swimmers (USEPA, 1989). Assumed to provide a conservative estimate of incidental ingestion by construction workers exposed to shallow groundwater.
[n] Applying the time-weighted approach consistent with note [2] above, the resulting averaging time is set equal to 7 days/week.
[o] Default CTE for construction worker soil ingestion (USEPA, 2007) - Value is revised from BHHRA based on EPA comments to the draft Feasability Study, February 6 (USEPA, 2013).
µg/dL = micrograms per deciliter
g/day = grams per day
L/day = liters per day
NA = not applicable

References:

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USEPA. 2003a. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. EPA-540-R-03-001. January 2003.
USEPA. 2003b. Assessing Intermittent or Variable Exposures at Lead Sites. OSWER Directive #9285.7-76. EPA-540-R-03-008. November 2003.
USEPA. 2002. Blood Lead Concentrations of U.S. Adult Females: Summary Statistics From Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). OSWER #9285.7-52. March 2002.
USEPA. 1989. Risk Assessment Guidance for Superfund, Part A, Interim Final. EPA/540/1-89/002. December 1989.

Table 1b. Adult Lead Model (ALM) for Evaluation of Lead Risks for Commercial Workers Exposed to Site-Related Soil
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Commercial Workers				
			Nunes Parcel Surface Soil [1]	Quinnville Well Field Surface Soil [1,2]	RIDEM Soil Removal Area, Surface Soil [1,3]	RIDEM Soil Removal Area, All Soil [2,4]	Nunes Parcel Surface and Subsurface Soil [2]
PbS	Soil lead concentration (arithmetic mean) [a]	mg/kg or ppm	239	142	1790	2050	270
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	2.01	2.01	2.01	2.01	2.01
PbB_0	Baseline PbB	µg/dL	1.9	1.9	1.9	1.9	1.9
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	0.050	0.050	0.050
AF	Absorption fraction (Pb in soil and dust)	--	0.12	0.12	0.12	0.12	0.12
EF	Exposure frequency, Pb pathway	days/yr	219	219	219	219	219
AT	Averaging time, Pb pathway	days/yr	365	365	365	365	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**µg/dL**	**2.2**	**2.1**	**4.5**	**4.9**	**2.3**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	6.4	6.0	12.7	13.8	6.5
PbB_t	Target PbB level of concern	µg/dL	10.0	10.0	10.0	10.0	10.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**1.1%**	**0.9%**	**9.6%**	**11.8%**	**1.2%**

Notes:
ALM Version date 5/19/05
[1] Current scenario, as indicated in Table 1 of the baseline HHRA.
[2] Future scenario, as indicated in Table 1 of the baseline HHRA.
[3] Per USEPA's request, the RIDEM soil removal area was evaluated using only three soil samples, only one of which (SO-033-NP) was surficial (0 - 1 foot below ground surface). Therefore, the surface soil PbS for the soil removal area represents one sampling point rather than an arithmetic mean of several sampling points.
[4] Per USEPA's request, the RIDEM soil removal area was evaluated using only three soil samples.
[a] Per USEPA's request, arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1c. Adult Lead Model (ALM) for Evaluation of Lead Risks for Construction Workers Exposed to Site-Related Soil and Shallow Groundwater
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Construction Workers				
			Site-Wide Shallow Groundwater [1]	Quinnville Well Field Surface Soil [1]	Southern Bank Surface Soil [1]	RIDEM Soil Removal Area, All Soil [1,2]	Nunes Parcel Surface and Subsurface Soil [1]
PbS	Lead concentration in medium of interest (arithmetic mean) [a]	ppm	0.0030	142	168	2050	270
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	2.01	2.01	2.01	2.01	2.01
PbB_0	Baseline PbB	µg/dL	1.9	1.9	1.9	1.9	1.9
$IR_{S,W}$	Ingestion rate (soil, groundwater)	g/day	0.050	0.100	0.100	0.100	0.100
AF	Absorption fraction (Pb in soil, dust, and groundwater)	--	0.12	0.12	0.12	0.12	0.12
EF	Exposure frequency, Pb pathway	days/yr	62	62	62	62	62
AT	Averaging time, Pb pathway	days/yr	84	84	84	84	84
PbB_{adult}	**PbB of adult worker, geometric mean**	**µg/dL**	**1.9**	**2.4**	**2.5**	**9.2**	**2.9**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	5.4	6.8	7.1	26.0	8.1
PbB_t	Target PbB level of concern	µg/dL	10.0	10.0	10.0	10.0	10.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.6%**	**1.4%**	**1.6%**	**39.1%**	**2.6%**

Notes:
ALM Version date 5/19/05
[1] Future scenario, as indicated in Table 1 of the baseline HHRA.
[a] Per USEPA's request, arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1d. Adult Lead Model (ALM) for Evaluation of Lead Risks for Adult Recreational Users Exposed to Site-Related Soil and Sediment
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Adult Recreational Users												
			Southern Bank Surface Soil [1,2]	Southern Bank Sediment [1,2]	Nunes Parcel Surface and Subsurface Soil [2]	Downstream of Landfill Sediment [2,3]	Unnamed Island Surface Soil [2]	Unnamed Island Sediment [2]	Quinnville Well Field Surface Soil [2]	Upstream of Landfill Sediment [2,4]	Debris Fields Surface Soil [2]	Wetlands Sediment [2]	RIDEM Soil Removal Area, All Soil [1,5]	Landfill Surface Soil [2]	Adjacent to Landfill Sediment [2,6]
PbS	Lead concentration in media of interest (arithmetic mean)[a]	mg/kg or ppm	168	41	270	105	295	260	142	76	154	71	2050	201	71
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
PbB_0	Baseline PbB	µg/dL	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
IR_S	Soil/sediment ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
AF	Absorption fraction (Pb in soil, dust, and sediment)	--	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
EF	Exposure frequency, Pb pathway	days/yr	2	2	2	2	2	2	2	2	2	2	2	2	2
AT	Averaging time, Pb pathway	days/yr	7	7	7	7	7	7	7	7	7	7	7	7	7
PbB_{adult}	**PbB of adult recreational user, geometric mean**	**µg/dL**	**2.0**	**1.9**	**2.1**	**2.0**	**2.1**	**2.1**	**2.0**	**2.0**	**2.0**	**1.9**	**3.3**	**2.0**	**1.9**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adults	µg/dL	5.7	5.5	5.9	5.6	6.0	5.9	5.7	5.5	5.7	5.5	9.4	5.8	5.5
PbB_T	Target PbB level of concern	µg/dL	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
$P(PbB_{fetal} > PbB_T)$	**Probability that fetal PbB > PbB_T assuming lognormal distribution**	**%**	**0.7%**	**0.6%**	**0.8%**	**0.7%**	**0.9%**	**0.8%**	**0.7%**	**0.6%**	**0.7%**	**0.6%**	**4.1%**	**0.8%**	**0.6%**

Notes:
ALM Version date 5/19/05
[1] Current scenario, as indicated in Table 1 of the baseline HHRA.
[2] Future scenario, as indicated in Table 1 of the baseline HHRA.
[3] Sediment data represent those collected from the Blackstone River, downstream of the landfill.
[4] Sediment data represent those collected from the Blackstone River, upstream of the landfill.
[5] Per USEPA's request, the RIDEM soil removal area was evaluated using only three soil samples.
[6] Sediment data represent those collected from the Blackstone River, adjacent to the landfill.
[a] Per USEPA's request, arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1e. Adult Lead Model (ALM) for Evaluation of Lead Risks for Older Child Recreational Users Exposed to Site-Related Soil and Sediment
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Older Child Recreational Users												
			Southern Bank Surface Soil [1,2]	Southern Bank Sediment [1,2]	Nunes Parcel Surface and Subsurface Soil [2]	Downstream of Landfill Sediment [2,3]	Unnamed Island Surface Soil [2]	Unnamed Island Sediment [2]	Quinnville Well Field Surface Soil [2]	Upstream of Landfill Sediment [2,4]	Debris Fields Surface Soil [2]	Wetlands Sediment [2]	RIDEM Soil Removal Area, All Soil [1,5]	Landfill Surface Soil [2]	Adjacent to Landfill Sediment [2,6]
PbS	Lead concentration in media of interest (arithmetic mean)[a]	mg/kg or ppm	168	41	270	105	295	260	142	76	154	71	2050	201	71
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
PbB_0	Baseline PbB	µg/dL	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
IR_S	Soil/sediment ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
AF	Absorption fraction (Pb in soil, dust, and sediment)	--	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
EF	Exposure frequency, Pb pathway	days/yr	2	2	2	2	2	2	2	2	2	2	2	2	2
AT	Averaging time, Pb pathway	days/yr	7	7	7	7	7	7	7	7	7	7	7	7	7
PbB_{adult}	**PbB of older child recreational user, geometric mean**	**µg/dL**	**2.0**	**1.9**	**2.1**	**2.0**	**2.1**	**2.1**	**2.0**	**2.0**	**2.0**	**1.9**	**3.3**	**2.0**	**1.9**
$PbB_{fetal,\ 0.95}$	95th percentile PbB among fetuses of adults	µg/dL	--	--	--	--	--	--	--	--	--	--	--	--	--
PbB_T	Target PbB level of concern	µg/dL	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
$P(PbB_{fetal} > PbB_T)$	**Probability that fetal PbB > PbB_T assuming lognormal distribution**	**%**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**

Notes:
ALM Version date 5/19/05
[1] Current scenario, as indicated in Table 1 of the baseline HHRA.
[2] Future scenario, as indicated in Table 1 of the baseline HHRA.
[3] Sediment data represent those collected from the Blackstone River, downstream of the landfill.
[4] Sediment data represent those collected from the Blackstone River, upstream of the landfill.
[5] Per USEPA's request, the RIDEM soil removal area was evaluated using only three soil samples.
[6] Sediment data represent those collected from the Blackstone River, adjacent to the landfill.
[a] Per USEPA's request, arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1f. Adult Lead Model (ALM) for Evaluation of Lead Risks for Adolescent Trespassers Exposed to Site-Related Soil and Sediment
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Adolescent Trespassers											
			Nunes Parcel Surface Soil [1]	Downstream of Landfill Sediment [1,2]	Quinnville Well Field Surface Soil [1]	Debris Fields Surface Soil [1]	Upstream of Landfill Sediment [1,3]	Unnamed Island Surface Soils [1]	Unnamed Island Sediment [1]	Southern Bank Sediment [1,4]	Wetlands Sediment [1]	RIDEM Soil Removal Area, Surface Soil [1,5]	Landfill Surface Soil [1]	Adjacent to Landfill Sediment [1,6]
PbS	Lead concentration in media of interest (arithmetic mean)[a]	mg/kg or ppm	239	105	142	154	76	295	260	41	71	1790	201	71
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
PbB_0	Baseline PbB	µg/dL	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
IR_S	Soil/sediment ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
AF	Absorption fraction (Pb in soil, dust, and sediment)	--	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
EF	Exposure frequency, Pb pathway	days/yr	2	2	2	2	2	2	2	2	2	2	2	2
AT	Averaging time, Pb pathway	days/yr	7	7	7	7	7	7	7	7	7	7	7	7
PbB_{adult}	**PbB of adolescent trespasser, geometric mean**	**µg/dL**	**2.1**	**2.0**	**2.0**	**2.0**	**2.0**	**2.1**	**2.1**	**1.9**	**1.9**	**3.1**	**2.0**	**1.9**
$PbB_{fetal,\ 0.95}$	95th percentile PbB among fetuses of adults	µg/dL	--	--	--	--	--	--	--	--	--	--	--	--
PbB_t	Target PbB level of concern	µg/dL	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t assuming lognormal distribution**	**%**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**

Notes:
ALM Version date 5/19/05
[1] Current scenario, as indicated in Table 1 of the baseline HHRA.
[2] Sediment data represent those collected from the Blackstone River, downstream of the landfill.
[3] Sediment data represent those collected from the Blackstone River, upstream of the landfill.
[4] Sediment data represent those collected from the backwater area of Blackstone River and Pond F.
[5] Per USEPA's request, the RIDEM soil removal area was evaluated using only three soil samples, only one of which (SO-033-NP) was surficial (0 - 1 foot below ground surface). Therefore, the surface soil PbS for the soil removal area represents one sampling point rather than an arithmetic mean of several sampling points.
[6] Sediment data represent those collected from the Blackstone River, adjacent to the landfill.
[a] Per USEPA's request, arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1g. Adult Lead Model (ALM) for Evaluation of Lead Risks for Adult Angler Exposed to Edible Fish Tissue
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Adult Angler		
			OU2 Fish Fillets [1,2]	BR-1 Fish Fillets [1,2]	BR-2 Fish Fillets [1,2]
PbS	Fish (fillet) tissue lead concentration (arithmetic mean) [a]	mg/kg or ppm	0.01	0.01	0.006
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	2.01	2.01	2.01
PbB_0	Baseline PbB	µg/dL	1.9	1.9	1.9
IR_S	Fish ingestion rate	g/day	8.9	8.9	8.9
AF	Absorption fraction (food)	--	0.12	0.12	0.12
EF	Exposure frequency, Pb pathway	days/yr	365	365	365
AT	Averaging time, Pb pathway	days/yr	365	365	365
PbB_{adult}	**PbB of adult angler, geometric mean**	**µg/dL**	**1.9**	**1.9**	**1.9**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult anglers	µg/dL	5.4	5.4	5.4
PbB_t	Target PbB level of concern	µg/dL	10.0	10.0	10.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.6%**	**0.6%**	**0.6%**

Notes:
ALM Version date 5/19/05
[1] Current scenario, as indicated in Table 1 of the baseline HHRA.
[2] Future scenario, as indicated in Table 1 of the baseline HHRA.
[a] Per USEPA's request, arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 2a. Summary of Parameter Values Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Evaluation of Residential Lead Risks Associated with Site-Related Groundwater
Baseline Human Health Risk Assessment
Peterson Puritan Site (OU2), Cumberland and Lincoln, Rhode Island

Receptor Scenario: Young Child [1,2] (Resident)

Parameter		Value	Units
Indoor air lead concentration (% of outdoor)		30 [a]	%
AIR (by year)			
Air Concentration			
Age (years) =	0 - 1	0.10 [a]	µg/m^3
	1 - 2	0.10 [a]	µg/m^3
	2 - 3	0.10 [a]	µg/m^3
	3 - 4	0.10 [a]	µg/m^3
	4 - 5	0.10 [a]	µg/m^3
	5 - 6	0.10 [a]	µg/m^3
	6 - 7	0.10 [a]	µg/m^3
Time Outdoors			
Age (years) =	0 - 1	1 [a]	hours/day
	1 - 2	2 [a]	hours/day
	2 - 3	3 [a]	hours/day
	3 - 7	4 [a]	hours/day
Ventilation Rate			
Age (years) =	0 - 1	2 [a]	m^3/day
	1 - 2	3 [a]	m^3/day
	2 - 5	5 [a]	m^3/day
	5 - 7	7 [a]	m^3/day
Lung Absorption		32 [a]	%
DIET (by year)			
Dietary Lead Intake			
Age (years) =	0 - 1	3.16 [b]	µg Pb/day
	1 - 2	2.60 [b]	µg Pb/day
	2 - 3	2.87 [b]	µg Pb/day
	3 - 4	2.74 [b]	µg Pb/day
	4 - 5	2.61 [b]	µg Pb/day
	5 - 6	2.74 [b]	µg Pb/day
	6 - 7	2.99 [b]	µg Pb/day
ALTERNATE DIET SOURCES (by food class)			
Concentration:			
	home-grown fruits	0 [a]	µg Pb/g
	home-grown vegetables	0 [a]	µg Pb/g
	fish from fishing	0 [a]	µg Pb/g
	game animals from hunting	0 [a]	µg Pb/g

Table 2a. Summary of Parameter Values Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Evaluation of Residential Lead Risks Associated with Site-Related Groundwater
Baseline Human Health Risk Assessment
Peterson Puritan Site (OU2), Cumberland and Lincoln, Rhode Island

Receptor Scenario: Young Child [1,2] (Resident)

Parameter	Value	Units
ALTERNATE DIET SOURCES (by food class) (continued)		
Percent of food class:		
home-grown fruits	0 [a]	%
home-grown vegetables	0 [a]	%
fish from fishing	0 [a]	%
game animals from hunting	0 [a]	%
DRINKING WATER		
Lead Concentration in drinking water	2.17 [c]	µg/L
Ingestion rate:		
Age (years) = 0 - 1	0.20 [a]	L/day
1 - 2	0.50 [a]	L/day
2 - 3	0.52 [a]	L/day
3 - 4	0.53 [a]	L/day
4 - 5	0.55 [a]	L/day
5 - 6	0.58 [a]	L/day
6 - 7	0.59 [a]	L/day
SOIL/DUST INGESTION		
Concentration:		
soil	101.2 [d]	µg/g
dust	101.2 [d]	µg/g
Soil/dust ingestion weighting factor (% soil)	45 [a]	%
Soil/dust ingestion:		
Age (years) = 0 - 1	0.085 [a]	g/day
1 - 4	0.135 [a]	g/day
4 - 5	0.100 [a]	g/day
5 - 6	0.090 [a]	g/day
6 - 7	0.085 [a]	g/day
SOIL/DUST MULTIPLE SOURCE ANALYSIS		
Fraction of indoor dust lead attributable to soil	0.70 [a]	unitless
Ratio of dust lead concentration to outdoor air lead concentration	100 [a]	µg Pb/g dust per µg Pb/m^3 air
BIOAVAILABILITY FOR GUT ABSORPTION PATHWAYS		
Total lead absorption (at low intake):		
diet	50 [a]	%
drinking water	50 [a]	%
soil	30 [a]	%
dust	30 [a]	%
alternate source	0 [a]	%
Fraction of total net absorption at low intake rate that is attributable to non-saturable (passive) processes	0.2 [a]	unitless

Table 2a. Summary of Parameter Values Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Evaluation of Residential Lead Risks Associated with Site-Related Groundwater
Baseline Human Health Risk Assessment
Peterson Puritan Site (OU2), Cumberland and Lincoln, Rhode Island

Receptor Scenario: Young Child [1,2] (Resident)

Parameter	Value	Units
ALTERNATE SOURCES OF LEAD		
Total lead intake:		
Age (years) = 0 - 1	0 [a]	µg/day
1 - 2	0 [a]	µg/day
2 - 3	0 [a]	µg/day
3 - 4	0 [a]	µg/day
4 - 5	0 [a]	µg/day
5 - 6	0 [a]	µg/day
6 - 7	0 [a]	µg/day
MATERNAL-TO-NEWBORN LEAD EXPOSURE		
Mothers blood lead concentration at childbirth	2.5 [a]	µg/dL
PLOTTING AND RISK ESTIMATION		
Geometric standard deviation (GSD) for blood lead	1.6 [a]	unitless
Blood lead level of concern	10 [a]	µg/dL
COMPUTATION OPTIONS		
Iteration time step for numerical integration	4 [a]	hours

Notes:

[1] Young child = 0 - 7 years of age (0 - 84 months)

[2] Assumes exposure to site-specific groundwater concentrations of lead via ingestion from a potable source

[3] The IEUBK model (USEPA, 2002) does not allow for a quantitative evaluation of dermal exposures to lead in groundwater presumably due to the uncertainty in assigning a dermal absorption fraction that would apply to the numerous inorganic forms of lead that are typically found in environmental settings.

[a] Default value (USEPA, 2002).

[b] Defaults in IEUBK model represent U.S. Food and Drug Administration (FDA) data collected in the late 1980s. More recent FDA (2001) data are presented. Source: FDA (2001) Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages. June 2001. Available online at The U.S. Food and Drug Administration Center for Food Safety and Applied Nutrition Web site. (http://www.cfsan.fda.gov/~comm/tdstoc. html).

[c] Groundwater concentration represents arithmetic mean of site data.

[d] Background soil concentrations of lead represent arithmetic mean of Mackland Farms soils data (samples

References:

USEPA. 2002. User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK). Office of Solid Waste and Emergency Response. EPA-540-K-01-005. OSWER #9285.7-42. May 2002.

Table 2b: IEUBK Model for Exposure of Young Child Residents to Site-Wide Groundwater

LEAD MODEL FOR WINDOWS Version 1.0

==========

Model Version: 1.0 Build 264
User Name: Serese Marotta
Date: 06/12/2008
Site Name: Peterson Puritan
Operable Unit: OU2
Run Mode: Site Risk Assessment

Diet Data
FDA (2001) data
Water Data
Arithmetic mean of site data.
Soil/Dust Data
Soil and dust concentration represent arithmetic mean of Mackland Farms soils data.
GSD, Cutoff and Age Type
GSD, Cutoff and Age Type

==========

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 2.170 ug Pb/L

****** Soil & Dust ******

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	101.000	101.000
1-2	101.000	101.000
2-3	101.000	101.000
3-4	101.000	101.000
4-5	101.000	101.000
5-6	101.000	101.000
6-7	101.000	101.000

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.507	0.000	0.207
1-2	0.034	1.237	0.000	0.516
2-3	0.062	1.374	0.000	0.540
3-4	0.067	1.320	0.000	0.554
4-5	0.067	1.271	0.000	0.581
5-6	0.093	1.340	0.000	0.615
6-7	0.093	1.465	0.000	0.627

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	2.456	4.191	2.3
1-2	3.894	5.682	2.4
2-3	3.917	5.894	2.2
3-4	3.943	5.884	2.1
4-5	2.952	4.871	1.7
5-6	2.667	4.715	1.5
6-7	2.523	4.709	1.4

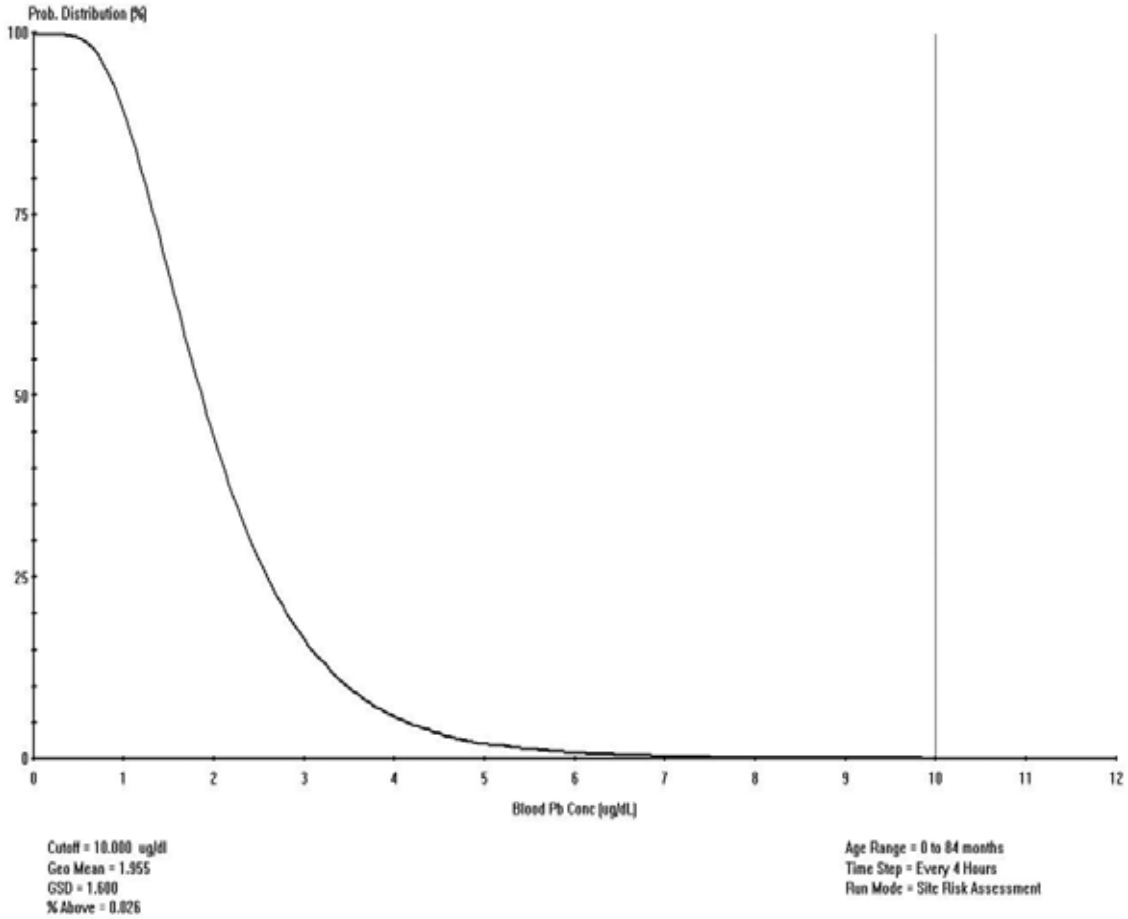


Table 3a. Summary of Parameter Values Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Evaluation of Lead Risks Associated with Consumption of Fish Tissue
Baseline Human Health Risk Assessment
Peterson Puritan Site (OU2), Cumberland and Lincoln, Rhode Island

Receptor Scenario: Young Child [1,2] (Angler)

Parameter		Value	Units
Indoor air lead concentration (% of outdoor)		30 [a]	%
AIR (by year)			
Air Concentration			
Age (years) =	0 - 1	0.10 [a]	µg/m^3
	1 - 2	0.10 [a]	µg/m^3
	2 - 3	0.10 [a]	µg/m^3
	3 - 4	0.10 [a]	µg/m^3
	4 - 5	0.10 [a]	µg/m^3
	5 - 6	0.10 [a]	µg/m^3
	6 - 7	0.10 [a]	µg/m^3
Time Outdoors			
Age (years) =	0 - 1	1 [a]	hours/day
	1 - 2	2 [a]	hours/day
	2 - 3	3 [a]	hours/day
	3 - 7	4 [a]	hours/day
Ventilation Rate			
Age (years) =	0 - 1	2 [a]	m^3/day
	1 - 2	3 [a]	m^3/day
	2 - 5	5 [a]	m^3/day
	5 - 7	7 [a]	m^3/day
Lung Absorption		32 [a]	%
DIET (by year)			
Dietary Lead Intake			
Age (years) =	0 - 1	3.16 [b]	µg Pb/day
	1 - 2	2.60 [b]	µg Pb/day
	2 - 3	2.87 [b]	µg Pb/day
	3 - 4	2.74 [b]	µg Pb/day
	4 - 5	2.61 [b]	µg Pb/day
	5 - 6	2.74 [b]	µg Pb/day
	6 - 7	2.99 [b]	µg Pb/day
ALTERNATE DIET SOURCES (by food class)			
Concentration:			
	home-grown fruits	0 [a]	µg Pb/g
	home-grown vegetables	0 [a]	µg Pb/g
	fish from fishing	0 [a]	µg Pb/g
	game animals from hunting	0 [a]	µg Pb/g
Percent of food class:			
	home-grown fruits	0 [a]	%
	home-grown vegetables	0 [a]	%
	fish from fishing	0 [a]	%
	game animals from hunting	0 [a]	%
ALTERNATE INTAKE (Fish Ingestion)			

Table 3a. Summary of Parameter Values Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Evaluation of Lead Risks Associated with Consumption of Fish Tissue
Baseline Human Health Risk Assessment
Peterson Puritan Site (OU2), Cumberland and Lincoln, Rhode Island

Receptor Scenario: Young Child [1,2] (Angler)

Parameter	Value	Units
Ingestion rate:		
Age (years) = 0 - 1	see Table 4	µg Pb/day
1 - 2	see Table 4	µg Pb/day
2 - 3	see Table 4	µg Pb/day
3 - 4	see Table 4	µg Pb/day
4 - 5	see Table 4	µg Pb/day
5 - 6	see Table 4	µg Pb/day
6 - 7	see Table 4	µg Pb/day
DRINKING WATER		
Lead Concentration in drinking water	4 [a]	µg/L
Ingestion rate:		
Age (years) = 0 - 1	0.20 [a]	L/day
1 - 2	0.50 [a]	L/day
2 - 3	0.52 [a]	L/day
3 - 4	0.53 [a]	L/day
4 - 5	0.55 [a]	L/day
5 - 6	0.58 [a]	L/day
6 - 7	0.59 [a]	L/day
SOIL/DUST INGESTION		
Concentration:		
soil	101.2 [c]	µg/g
dust	101.2 [c]	µg/g
Soil/dust ingestion weighting factor (% soil)	45 [a]	%
Soil/dust ingestion:		
Age (years) = 0 - 1	0.085 [a]	g/day
1 - 4	0.135 [a]	g/day
4 - 5	0.100 [a]	g/day
5 - 6	0.090 [a]	g/day
6 - 7	0.085 [a]	g/day
SOIL/DUST MULTIPLE SOURCE ANALYSIS		
Fraction of indoor dust lead attributable to soil	0.70 [a]	unitless
Ratio of dust lead concentration to outdoor air lead concentration	100 [a]	µg Pb/g dust per µg Pb/m^3 air
BIOAVAILABILITY FOR GUT ABSORPTION PATHWAYS		
Total lead absorption (at low intake):		
diet	50 [a]	%
drinking water	50 [a]	%
soil	30 [a]	%
dust	30 [a]	%
alternate source	50 [d]	%

Table 3a. Summary of Parameter Values Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Evaluation of Lead Risks Associated with Consumption of Fish Tissue
Baseline Human Health Risk Assessment
Peterson Puritan Site (OU2), Cumberland and Lincoln, Rhode Island

Receptor Scenario: Young Child [1,2] (Angler)

Parameter	Value	Units
BIOAVAILABILITY FOR GUT ABSORPTION PATHWAYS (continued)		
Fraction of total net absorption at low intake rate that is attributable to non-saturable (passive) processes	0.2 [a]	unitless
ALTERNATE SOURCES OF LEAD		
Total lead intake:		
Age (years) = 0 - 1	0 [a]	µg/day
1 - 2	0 [a]	µg/day
2 - 3	0 [a]	µg/day
3 - 4	0 [a]	µg/day
4 - 5	0 [a]	µg/day
5 - 6	0 [a]	µg/day
6 - 7	0 [a]	µg/day
MATERNAL-TO-NEWBORN LEAD EXPOSURE		
Mothers blood lead concentration at childbirth	2.5 [a]	µg/dL
PLOTTING AND RISK ESTIMATION		
Geometric standard deviation (GSD) for blood lead	1.6 [a]	unitless
Blood lead level of concern	10 [a]	µg/dL
COMPUTATION OPTIONS		
Iteration time step for numerical integration	4 [a]	hours

Notes:

[1] Young child = 0 - 7 years of age (0 - 84 months)

[2] Assumes exposure to lead via consumption of edible fish tissue.

[a] Default value (USEPA, 2002).

[b] Defaults in IEUBK model represent U.S. Food and Drug Administration (FDA) data collected in the late 1980s. More recent FDA (2001) data are presented. Source: FDA (2001) Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages. June 2001. Available online at The U.S. Food and Drug Administration Center for Food

[c] Background soil concentrations of lead represent arithmetic mean of Mackland Farms soils data (samples

[d] Bioavailability for fish ingestion would be the same as that for diet.

References:

USEPA. 2007. Frequent Questions from Risk Assessors on the IEUBK Model. Accessed on-line 4/24/08 at http://www.epa.gov/superfund/health/contaminants/lead/ieubkfaq.htm. Updated August 24, 2007.

USEPA. 2002. User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK). Office of Solid Waste and Emergency Response. EPA-540-K-01-005. OSWER #9285.7-42. May 2002.

Table 3b: IEUBK Model for Consumption of OU2 Fish by Young Child Angler

LEAD MODEL FOR WINDOWS Version 1.0

==========

Model Version: 1.0 Build 264
User Name: Serese Marotta
Date: 06/12/2008
Site Name: Peterson Puritan
Operable Unit: OU2
Run Mode: Site Risk Assessment

Diet Data
FDA (2001) data
Alternate Source Data
OU2 fish intake
Soil/Dust Data
Arithmetic mean of Mackland Farms soils data.
GI Values + Bioavailability Data
Bioavailability for fish ingestion.

==========

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	101.200	101.200
1-2	101.200	101.200
2-3	101.200	101.200
3-4	101.200	101.200
4-5	101.200	101.200
5-6	101.200	101.200
6-7	101.200	101.200

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.036
1-2	0.100
2-3	0.110
3-4	0.120
4-5	0.130
5-6	0.130
6-7	0.150

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.504	0.017	0.381
1-2	0.034	1.232	0.047	0.948
2-3	0.062	1.369	0.052	0.992
3-4	0.067	1.316	0.058	1.018
4-5	0.067	1.267	0.063	1.068
5-6	0.093	1.336	0.063	1.131
6-7	0.093	1.461	0.073	1.153

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	2.456	4.379	2.4
1-2	3.885	6.147	2.6
2-3	3.911	6.387	2.4
3-4	3.938	6.396	2.3
4-5	2.949	5.414	1.9
5-6	2.665	5.289	1.7
6-7	2.522	5.302	1.5

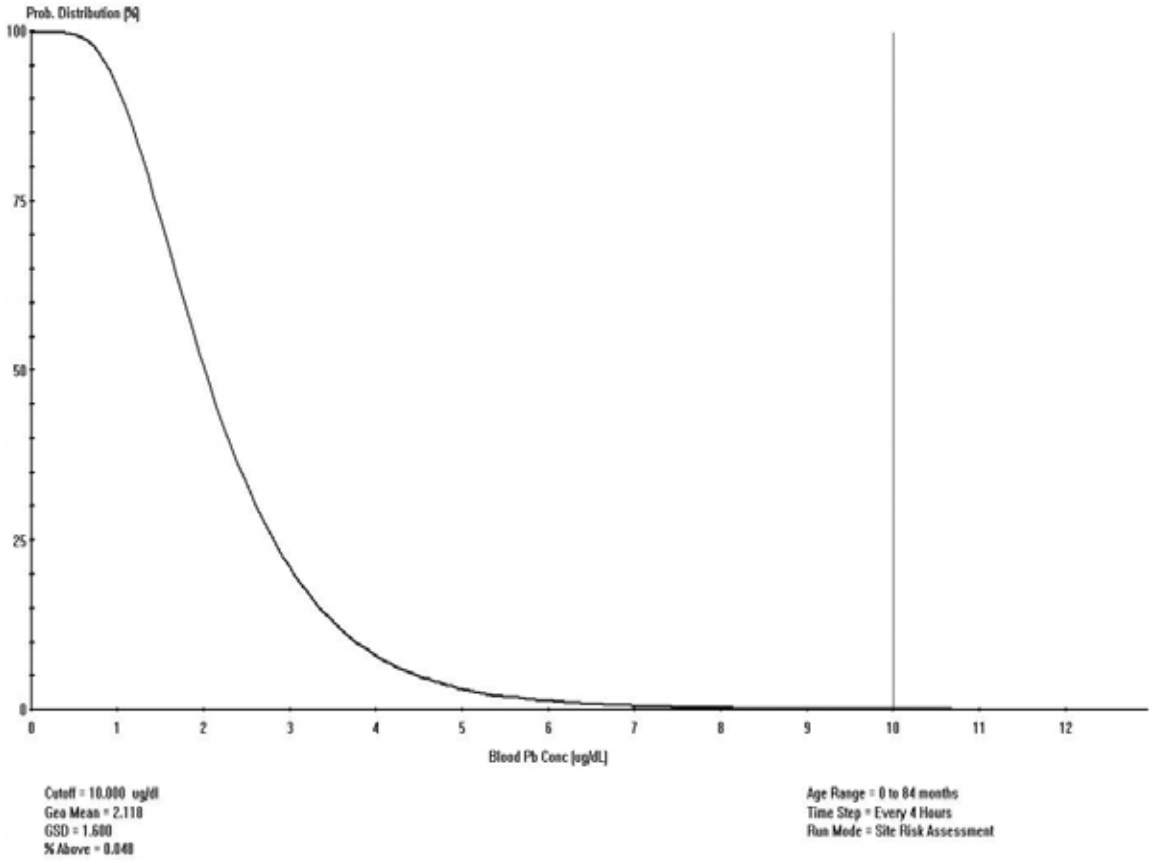


Table 3c: IEUBK Model for Consumption of BR1 Fish by Young Child Anglers

LEAD MODEL FOR WINDOWS Version 1.0

==========

Model Version: 1.0 Build 264
User Name: Serese Marotta
Date: 06/12/2008
Site Name: Peterson Puritan
Operable Unit: OU2
Run Mode: Site Risk Assessment

Diet Data
FDA (2001) data
GI Values + Bioavailability Data
Bioavailability for fish ingestion
Alternate Source Data
BR1 fish intake
Soil/Dust Data
Arithmetic mean of Mackland Farms soils data.
GI Values + Bioavailability Data

==========

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	101.200	101.200
1-2	101.200	101.200
2-3	101.200	101.200
3-4	101.200	101.200
4-5	101.200	101.200
5-6	101.200	101.200
6-7	101.200	101.200

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.038
1-2	0.110
2-3	0.120
3-4	0.130
4-5	0.140
5-6	0.140
6-7	0.160

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.504	0.018	0.381
1-2	0.034	1.232	0.052	0.948
2-3	0.062	1.369	0.057	0.992
3-4	0.067	1.316	0.062	1.018
4-5	0.067	1.267	0.068	1.068
5-6	0.093	1.336	0.068	1.131
6-7	0.093	1.461	0.078	1.153

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	2.456	4.379	2.4
1-2	3.885	6.152	2.6
2-3	3.910	6.391	2.4
3-4	3.937	6.401	2.3
4-5	2.949	5.419	1.9
5-6	2.665	5.293	1.7
6-7	2.522	5.307	1.5

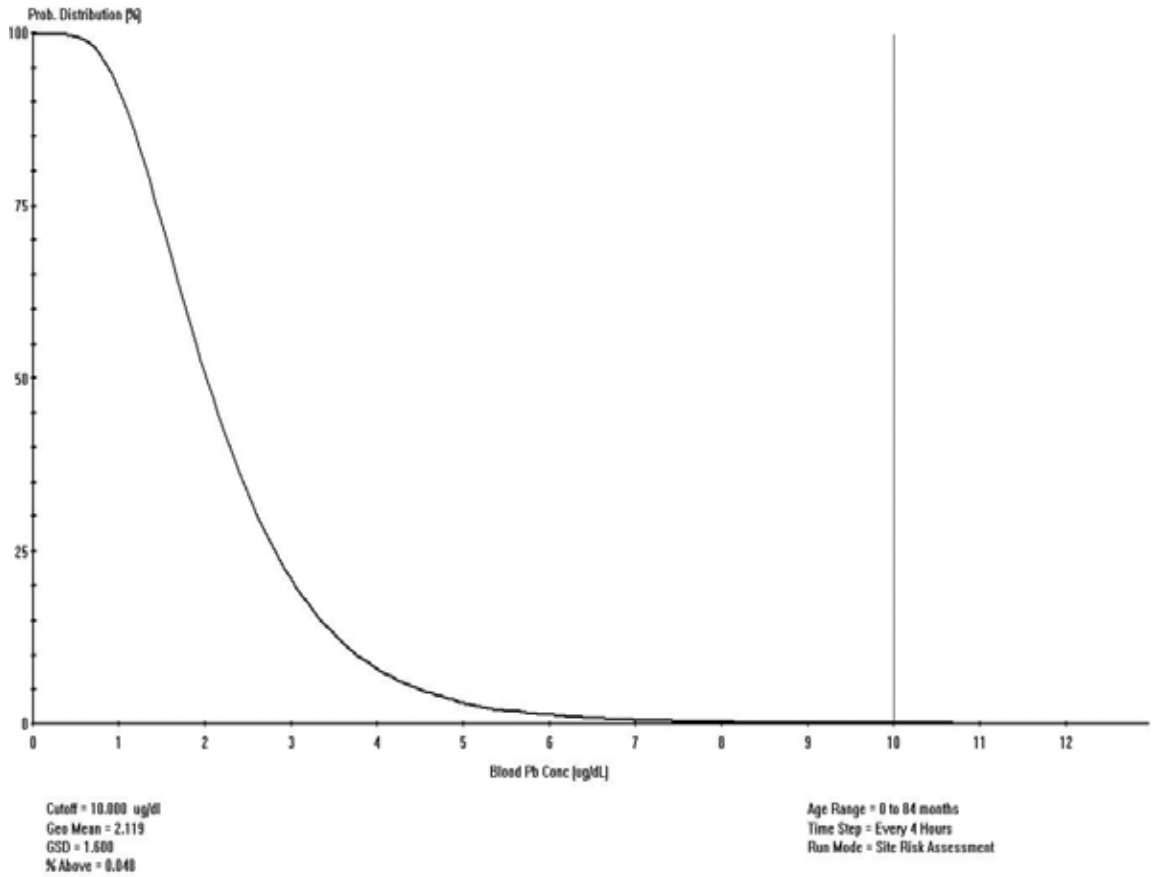


Table 3d: IEUBK Model for Consumption of BR2 Fish by Young Child Anglers

LEAD MODEL FOR WINDOWS Version 1.0

==========

Model Version: 1.0 Build 264
User Name: Serese Marotta
Date: 06/12/2008
Site Name: Peterson Puritan
Operable Unit: OU2
Run Mode: Site Risk Assessment

Diet Data
FDA (2001) data
GI Values + Bioavailability Data
Bioavailability for fish ingestion
Alternate Source Data
BR2 fish intake
Soil/Dust Data
Arithmetic mean of Mackland Farms soils data.

==========

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	101.200	101.200
1-2	101.200	101.200
2-3	101.200	101.200
3-4	101.200	101.200
4-5	101.200	101.200
5-6	101.200	101.200
6-7	101.200	101.200

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.017
1-2	0.049
2-3	0.054
3-4	0.057
4-5	0.060
5-6	0.062
6-7	0.068

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.504	0.008	0.381
1-2	0.034	1.233	0.023	0.948
2-3	0.062	1.369	0.026	0.992
3-4	0.067	1.316	0.027	1.019
4-5	0.067	1.268	0.029	1.069
5-6	0.093	1.336	0.030	1.131
6-7	0.093	1.461	0.033	1.153

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	2.456	4.370	2.4
1-2	3.886	6.124	2.6
2-3	3.911	6.361	2.4
3-4	3.938	6.367	2.2
4-5	2.949	5.381	1.9
5-6	2.665	5.256	1.7
6-7	2.522	5.263	1.5

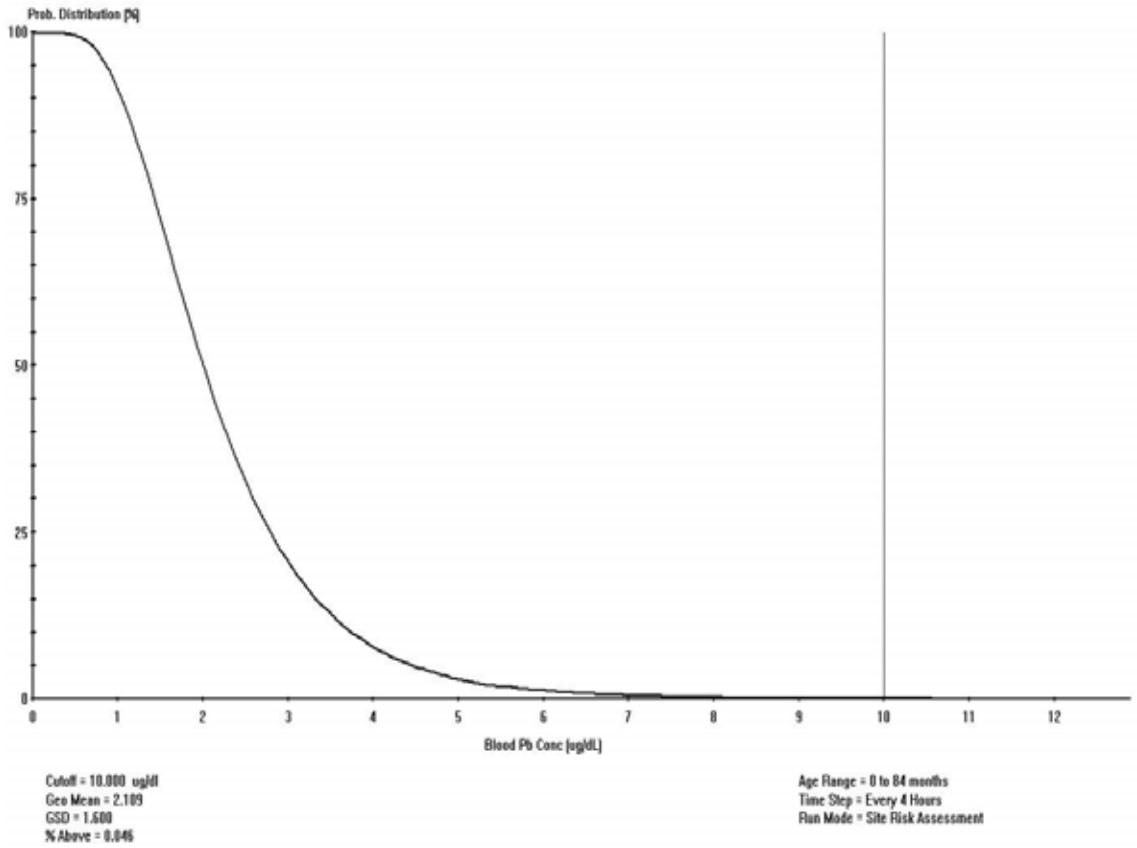


Table 4. Summary of Parameter Values Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model to Calculate Average Daily Lead Intake from Fish
Baseline Human Health Risk Assessment
Peterson Puritan Site (OU2), Cumberland and Lincoln, Rhode Island

Receptor Scenario: Young Child [1,2] (Angler)

Parameter	Value	Units
TOTAL MEAT INTAKE (g/day)		
Ingestion rate:		
Age (years) = 0 - 1	29.6 [a]	g/day
1 - 2	87.4 [a]	g/day
2 - 3	95.7 [a]	g/day
3 - 4	101.6 [a]	g/day
4 - 5	107.4 [a]	g/day
5 - 6	111.9 [a]	g/day
6 - 7	121.0 [a]	g/day
% of Total Meat Intake from Fish	10 [b]	%
% Fish Consumption from Source	100 [c]	%
Lead Concentration in Fish	site-specific [d]	µg Pb/g fish
DIETARY INTAKE FROM FISH (µg Pb/day)		
Dietary Lead Intake		
Age (years) = 0 - 1	calculation [e]	µg Pb/day
1 - 2	calculation [e]	µg Pb/day
2 - 3	calculation [e]	µg Pb/day
3 - 4	calculation [e]	µg Pb/day
4 - 5	calculation [e]	µg Pb/day
5 - 6	calculation [e]	µg Pb/day
6 - 7	calculation [e]	µg Pb/day
DIETARY INTAKE FROM FISH (µg Pb/day) - OU2		
Dietary Lead Intake		
Age (years) = 0 - 1	0.036 [f]	µg Pb/day
1 - 2	0.10 [f]	µg Pb/day
2 - 3	0.11 [f]	µg Pb/day
3 - 4	0.12 [f]	µg Pb/day
4 - 5	0.13 [f]	µg Pb/day
5 - 6	0.13 [f]	µg Pb/day
6 - 7	0.15 [f]	µg Pb/day
DIETARY INTAKE FROM FISH (µg Pb/day) - BR1		
Dietary Lead Intake		
Age (years) = 0 - 1	0.038 [g]	µg Pb/day
1 - 2	0.11 [g]	µg Pb/day
2 - 3	0.12 [g]	µg Pb/day
3 - 4	0.13 [g]	µg Pb/day
4 - 5	0.14 [g]	µg Pb/day
5 - 6	0.14 [g]	µg Pb/day
6 - 7	0.16 [g]	µg Pb/day

Table 4. Summary of Parameter Values Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model to Calculate Average Daily Lead Intake from Fish
Baseline Human Health Risk Assessment
Peterson Puritan Site (OU2), Cumberland and Lincoln, Rhode Island

Receptor Scenario: Young Child [1,2] (Angler)

Parameter		Value	Units
DIETARY INTAKE FROM FISH (µg Pb/day) - BR2			
Dietary Lead Intake			
Age (years) =	0 - 1	0.017 [h]	µg Pb/day
	1 - 2	0.049 [h]	µg Pb/day
	2 - 3	0.054 [h]	µg Pb/day
	3 - 4	0.057 [h]	µg Pb/day
	4 - 5	0.060 [h]	µg Pb/day
	5 - 6	0.062 [h]	µg Pb/day
	6 - 7	0.068 [h]	µg Pb/day

Notes:

[1] Young child = 0 - 7 years of age (0 - 84 months)

[2] Assumes exposure to lead concentrations via consumption of edible fish tissue.

[a] USEPA. Frequently Asked Questions - Can IEUBK be Used to Develop a Site-specific Fish Advisory?
http://www.epa.gov/superfund/lead/ieubkfaq.htm#fish

[b] Estimate for recreational anglers. USEPA. Frequently Asked Question - Can IEUBK be Used to Develop a
Site-specific Fish Advisory? http://www.epa.gov/superfund/lead/ieubkfaq.htm#fish

[c] Assumes 100% of fish come from Blackstone River or on-site ponds. This may overestimate lead intake
from fish because a portion of the default dietary Pb intake includes fish from other sources.

[d] Fish tissue concentration represents arithmetic mean of site-related data.
OU2 fish = 0.012 mg/kg; BR1 fish = 0.013 mg/kg; BR2 fish = 0.0056 mg/kg

[e] Intake from Fish (µg Pb/day) = (Total Meat Intake Rate g/day) x (% Total Meat Intake from Fish) x (% Fish
from Source) x (Concentration in Fish µg Pb/g)

[f] Arithmetic mean of OU2 fish fillets is 0.012 mg/kg.

[g] Arithmetic mean of BR1 fish fillets is 0.013 mg/kg.

[h] Arithmetic mean of BR2 fish fillets is 0.0056 mg/kg.

Reference:

USEPA. 2002. User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK). Office of Solid Waste and Emergency Response. EPA-540-K-01-005. OSWER #9285.7-42. May 2002.

Table 5a. Summary of Parameter Values Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Evaluation of Residential Lead Risks Associated with Groundwater and Soils from Nunes Parcel
Baseline Human Health Risk Assessment
Peterson Puritan Site (OU2), Cumberland and Lincoln, Rhode Island

Receptor Scenario: Young Child [1,2] (Resident)

Parameter		Value	Units
Indoor air lead concentration (% of outdoor)		30 [a]	%
AIR (by year)			
Air Concentration			
Age (years) =	0 - 1	0.10 [a]	µg/m^3
	1 - 2	0.10 [a]	µg/m^3
	2 - 3	0.10 [a]	µg/m^3
	3 - 4	0.10 [a]	µg/m^3
	4 - 5	0.10 [a]	µg/m^3
	5 - 6	0.10 [a]	µg/m^3
	6 - 7	0.10 [a]	µg/m^3
Time Outdoors			
Age (years) =	0 - 1	1 [a]	hours/day
	1 - 2	2 [a]	hours/day
	2 - 3	3 [a]	hours/day
	3 - 7	4 [a]	hours/day
Ventilation Rate			
Age (years) =	0 - 1	2 [a]	m^3/day
	1 - 2	3 [a]	m^3/day
	2 - 5	5 [a]	m^3/day
	5 - 7	7 [a]	m^3/day
Lung Absorption		32 [a]	%
DIET (by year)			
Dietary Lead Intake			
Age (years) =	0 - 1	3.16 [b]	µg Pb/day
	1 - 2	2.60 [b]	µg Pb/day
	2 - 3	2.87 [b]	µg Pb/day
	3 - 4	2.74 [b]	µg Pb/day
	4 - 5	2.61 [b]	µg Pb/day
	5 - 6	2.74 [b]	µg Pb/day
	6 - 7	2.99 [b]	µg Pb/day
ALTERNATE DIET SOURCES (by food class)			
Concentration:			
	home-grown fruits	0 [a]	µg Pb/g
	home-grown vegetables	0 [a]	µg Pb/g
	fish from fishing	0 [a]	µg Pb/g
	game animals from hunting	0 [a]	µg Pb/g

Table 5a. Summary of Parameter Values Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Evaluation of Residential Lead Risks Associated with Groundwater and Soils from Nunes Parcel
Baseline Human Health Risk Assessment
Peterson Puritan Site (OU2), Cumberland and Lincoln, Rhode Island

Receptor Scenario: Young Child [1,2] (Resident)

Parameter	Value	Units
ALTERNATE DIET SOURCES (by food class) (continued)		
Percent of food class:		
home-grown fruits	0 [a]	%
home-grown vegetables	0 [a]	%
fish from fishing	0 [a]	%
game animals from hunting	0 [a]	%
DRINKING WATER		
Lead Concentration in drinking water	2.17 [c]	µg/L
Ingestion rate:		
Age (years) = 0 - 1	0.20 [a]	L/day
1 - 2	0.50 [a]	L/day
2 - 3	0.52 [a]	L/day
3 - 4	0.53 [a]	L/day
4 - 5	0.55 [a]	L/day
5 - 6	0.58 [a]	L/day
6 - 7	0.59 [a]	L/day
SOIL/DUST INGESTION		
Concentration:		
soil	532 [d]	µg/g
dust	532 [d]	µg/g
Soil/dust ingestion weighting factor (% soil)	45 [a]	%
Soil/dust ingestion:		
Age (years) = 0 - 1	0.085 [a]	g/day
1 - 4	0.135 [a]	g/day
4 - 5	0.100 [a]	g/day
5 - 6	0.090 [a]	g/day
6 - 7	0.085 [a]	g/day
SOIL/DUST MULTIPLE SOURCE ANALYSIS		
Fraction of indoor dust lead attributable to soil	0.70 [a]	unitless
Ratio of dust lead concentration to outdoor air lead concentration	100 [a]	µg Pb/g dust per µg Pb/m^3 air
BIOAVAILABILITY FOR GUT ABSORPTION PATHWAYS		
Total lead absorption (at low intake):		
diet	50 [a]	%
drinking water	50 [a]	%
soil	30 [a]	%
dust	30 [a]	%
alternate source	0 [a]	%
Fraction of total net absorption at low intake rate that is attributable to non-saturable (passive) processes	0.2 [a]	unitless

Table 5a. Summary of Parameter Values Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Evaluation of Residential Lead Risks Associated with Groundwater and Soils from Nunes Parcel
Baseline Human Health Risk Assessment
Peterson Puritan Site (OU2), Cumberland and Lincoln, Rhode Island

Receptor Scenario: Young Child [1,2] (Resident)

Parameter	Value	Units
ALTERNATE SOURCES OF LEAD		
Total lead intake:		
Age (years) = 0 - 1	0 [a]	µg/day
1 - 2	0 [a]	µg/day
2 - 3	0 [a]	µg/day
3 - 4	0 [a]	µg/day
4 - 5	0 [a]	µg/day
5 - 6	0 [a]	µg/day
6 - 7	0 [a]	µg/day
MATERNAL-TO-NEWBORN LEAD EXPOSURE		
Mothers blood lead concentration at childbirth	2.5 [a]	µg/dL
PLOTTING AND RISK ESTIMATION		
Geometric standard deviation (GSD) for blood lead	1.6 [a]	unitless
Blood lead level of concern	10 [a]	µg/dL
COMPUTATION OPTIONS		
Iteration time step for numerical integration	4 [a]	hours

Notes:

[1] Young child = 0 - 7 years of age (0 - 84 months)

[2] Assumes exposure to lead in onsite surface and subsurface soils within Nunes Parcel and ingestion of site-related groundwater.

[3] The IEUBK model (USEPA, 2002) does not allow for a quantitative evaluation of dermal exposures to lead in soils presumably due to the uncertainty in assigning a dermal absorption fraction that would apply to the numerous inorganic forms of lead that are typically found in environmental settings.

[a] Default value (USEPA, 2002a).

[b] Defaults in IEUBK model represent U.S. Food and Drug Administration (FDA) data collected in the late 1980s. More recent FDA (2001) data are presented. Source: FDA (2001) Total Diet Study. U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition Office of Plant and Dairy Foods and Beverages. June 2001. Available online at The U.S. Food and Drug Administration Center for Food Safety and Applied Nutrition Web site. (http://www.cfsan.fda.gov/~comm/tdstoc. html).

[c] Groundwater concentration represents arithmetic mean of site data.

[d] Soil concentration represents arithmetic mean of site data.

References:

USEPA. 2002. User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK). Office of Solid Waste and Emergency Response. EPA-540-K-01-005. OSWER #9285.7-42. May 2002.

Table 5b: IEUBK Model for Exposure of Young Child Residents to Nunes Parcel Soil and Groundwater

LEAD MODEL FOR WINDOWS Version 1.0

==========

Model Version: 1.0 Build 264
User Name: Serese Marotta
Date: 08/20/2008
Site Name: Peterson Puritan
Operable Unit: OU2
Run Mode: Site Risk Assessment

Diet Data
FDA (2001) data
Water Data
Arithmetic mean of site data
Soil/Dust Data
Arithmetic mean of Nunes Parcel soils data (surface and subsurface)

==========

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 2.170 ug Pb/L

****** Soil & Dust ******

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	270.000	270.000
1-2	270.000	270.000
2-3	270.000	270.000
3-4	270.000	270.000
4-5	270.000	270.000
5-6	270.000	270.000
6-7	270.000	270.000

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.443	0.000	0.198
1-2	0.034	1.174	0.000	0.490
2-3	0.062	1.313	0.000	0.516
3-4	0.067	1.269	0.000	0.533
4-5	0.067	1.239	0.000	0.566
5-6	0.093	1.312	0.000	0.603
6-7	0.093	1.438	0.000	0.616

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	6.287	7.949	4.3
1-2	9.875	11.573	4.8
2-3	10.007	11.899	4.4
3-4	10.133	12.001	4.2
4-5	7.689	9.561	3.4
5-6	6.982	8.990	2.9
6-7	6.624	8.772	2.5

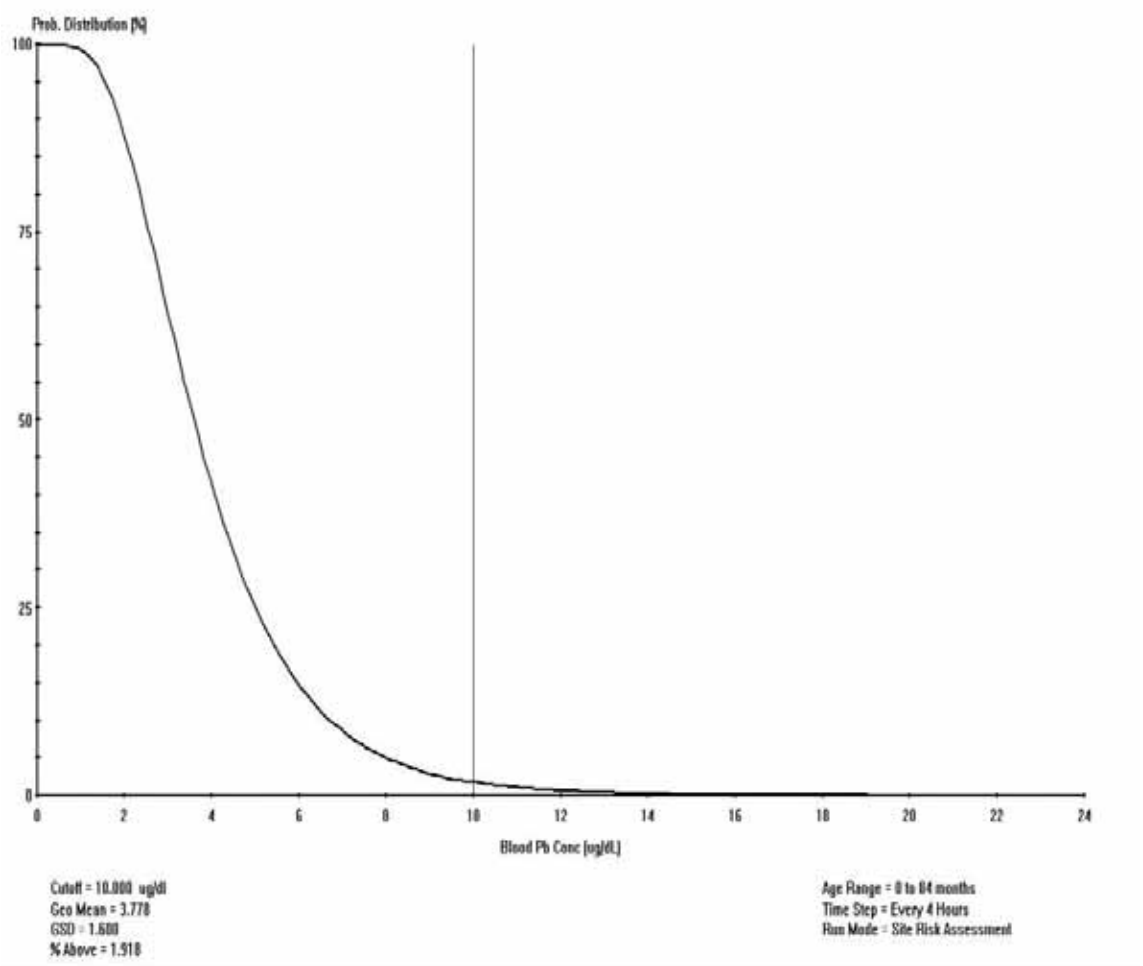


Table 5c: IEUBK Model for Exposure of Young Child Residents to Soils within RIDEM Soil Removal Area and Groundwater

LEAD MODEL FOR WINDOWS Version 1.0

==========

Model Version: 1.0 Build 264
User Name: Serese Marotta
Date: 08/20/2008
Site Name: Peterson Puritan
Operable Unit: OU2
Run Mode: Site Risk Assessment

Diet Data
FDA (2001) data
Water Data
Arithmetic mean of site data
Soil/Dust Data
Arithmetic mean of Nunes Parcel soils data (surface and subsurface)
GSD, Cutoff and Age Type

Soil/Dust Data
Arithmetic mean of samples from RIDEM Soil Removal Area (surface and subsurface)

==========

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 2.170 ug Pb/L

****** Soil & Dust ******

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	2050.000	2050.000
1-2	2050.000	2050.000
2-3	2050.000	2050.000
3-4	2050.000	2050.000
4-5	2050.000	2050.000
5-6	2050.000	2050.000
6-7	2050.000	2050.000

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

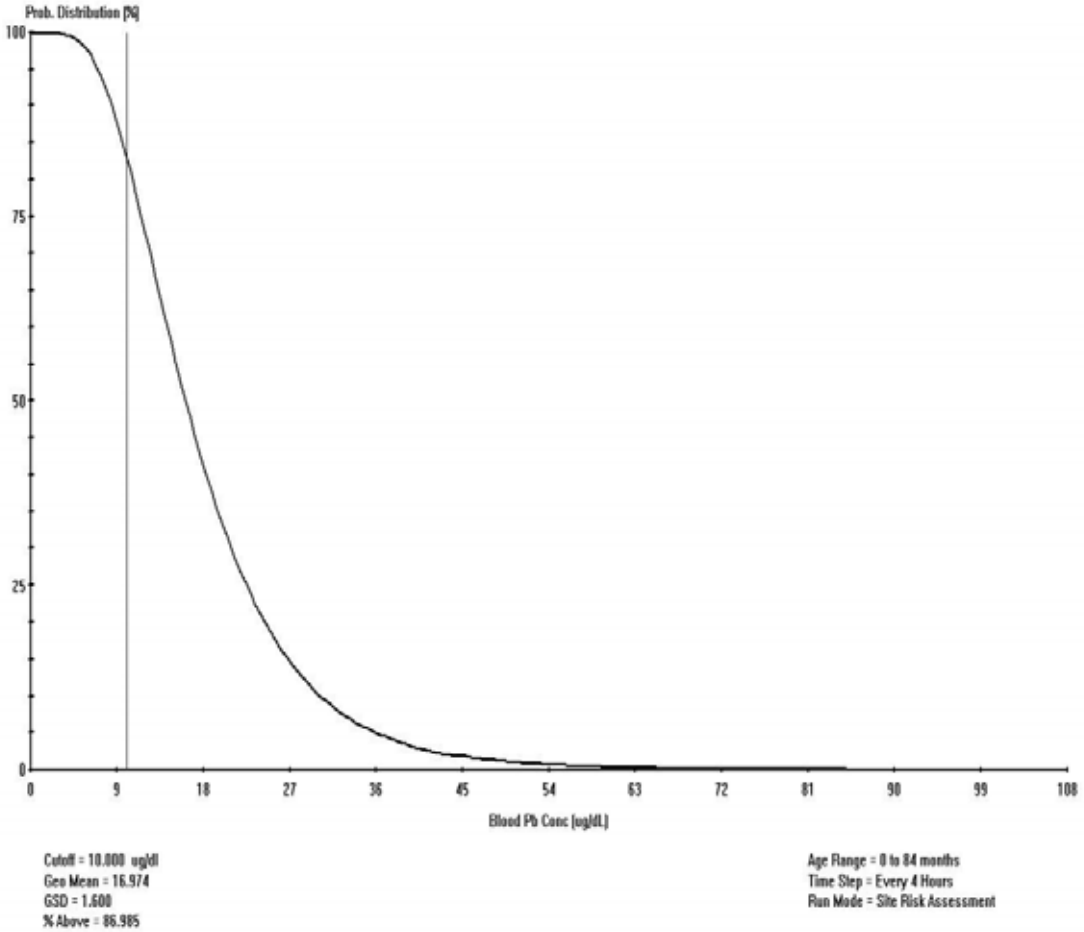
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.036	0.000	0.142
1-2	0.034	0.803	0.000	0.335
2-3	0.062	0.932	0.000	0.366
3-4	0.067	0.932	0.000	0.391
4-5	0.067	0.991	0.000	0.453
5-6	0.093	1.089	0.000	0.500
6-7	0.093	1.219	0.000	0.522

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	34.277	35.476	18.1
1-2	51.291	52.464	20.8
2-3	53.929	55.289	19.8
3-4	56.476	57.866	19.4
4-5	46.726	48.237	16.5
5-6	44.002	45.684	14.2
6-7	42.623	44.457	12.6



APPENDIX C.2

HUMAN HEALTH RISK REFINEMENT: LEAD MODELING FOR UNNAMED ISLAND

1.0 Introduction

This technical memorandum presents an evaluation of potential risks associated with exposure of human receptors to lead in surface soil, subsurface soil, sediment, and groundwater at the Unnamed Island portion of the Peterson Puritan Operable Unit 2 (OU2) Superfund Site located in Cumberland and Lincoln, Rhode Island. This technical memorandum is included as Appendix D to the Draft Feasibility Study.

The lead evaluation consists of a separate evaluation for each medium and each exposure scenario applicable to the Unnamed Island. Although lead was identified as a contaminant of potential concern (COPC) in leachate and surface water, these exposure pathways are not quantitatively evaluated because uncertainty in assigning a dermal absorption fraction for lead precludes quantification of potential risks associated with the dermal exposure route (USEPA, 2003a; 2004; 2007).

2.0 Methodology

Risks associated with exposure to lead in various site-related media were evaluated using USEPA's Adult Lead Model (ALM). Specifically, the ALM was used to evaluate potential lead risks for non-residential scenarios (i.e., recreational users and construction workers). Parameter values used in the ALM are largely based on the USEPA's recommended default values. The dose equations and modeling approaches are consistent with USEPA guidance (2003a; 2007; 2009).

Incidental ingestion of lead in soil is generally the primary exposure pathway of concern for risk assessments. However, the models can also quantify cumulative doses and risk attributed to other sources of exposure, such as the ingestion of shallow groundwater during excavation activities. Because lead is ubiquitous in the environment, predicted blood lead levels (PbB) associated with exposure to site-related sources of lead are added to an assumed age-specific baseline PbB that reflects exposure to non-site-related sources of lead. Four different exposure scenarios (current and future) were evaluated using the ALM, including exposure of recreational users (adults and older children, age 6 to 12 years), construction workers, and adolescent trespassers (age 9 to 18 years).

In the ALM, potential health risks associated with lead exposure are evaluated by comparing the estimated PbB to the target PbB of 10 micrograms per deciliter (µg/dL) (Centers for Disease Control [CDC], 1991). The target PbB is based on potentially adverse neurological effects in children (CDC, 1991). Therefore, lead risk is evaluated based on the probability that PbB among a receptor population will exceed 10 ug/dL. This is sometimes referred to as the "P10 statistic." Consistent with USEPA guidance (USEPA, 2003b), this lead evaluation focuses on determining if P10 equals or exceeds 5 percent, which is equivalent to calculating the 95th percentile of the probability distribution of PbB among a receptor population.

Due to recent scientific evidence that has demonstrated adverse health effects at blood lead concentrations below 10 ug/dL down to 5 ug/dL and possibly below, an additional assessment has been performed using a target PbB of 5 ug/dL (EPA, 2009) and determining whether the "P5 statistic" equals or exceeds 5 percent. The Office of Superfund Remediation and Technology Innovation (OSRTI) is developing a new soil lead policy to address this new information. Until that soil lead policy is finalized, EPA Region 1 is assessing lead exposures using both 10 ug/dL and 5 ug/dL as target PbB values.

The USEPA employs a simplifying assumption to estimate the probability distribution of PbBs. The model first generates a point estimate of the central tendency of the PbB distribution, and it is assumed that the value represents the geometric mean PbB among a receptor population that is exposed to the same levels of lead in the environment. Epidemiological data on PbBs among various populations suggests that the distribution is roughly lognormal in shape (USEPA, 2003a). USEPA applies the assumption of lognormality using the following equation:

$$PbB_{0.95} \quad PbB_{GM} \times GSD^{1.645}$$

$PbB_{0.95}$ = 95th percentile of the distribution of PbBs (ug/dL)
PbB_{GM} = geometric mean (or 50th percentile) of the lognormal distribution of PbBs (ug/dL)
GSD = geometric standard deviation of the lognormal distribution of PbBs (unitless)

3.0 Adult Lead Model for Non-Residential Receptor Populations

The USEPA's ALM is used to evaluate risks to non-residential receptor populations (USEPA, 2007). The following equation is used in the ALM to estimate quasi-steady state PbBs:

$$PbB_{GM} \quad PbB_0 + \frac{PbS \times BKSF \times IR \times AF \times EF}{AT}$$

PbB_{GM} = geometric mean (or 50th percentile) of the lognormal distribution of PbBs in adult workers (ug/dL)
PbB_0 = baseline PbB due to exposure to non-site-related sources of lead (ug/dL)
PbS = soil lead concentration (milligrams per kilogram [mg/kg])
BKSF = biokinetic slope factor (ug/dL per micrograms per day)
IR = soil ingestion rate (grams per day [g/day])
AF = gastrointestinal absorption fraction for lead in soil (unitless)
EF = exposure frequency (days per year or days per week)
AT = averaging time (years)

The receptor of concern in the ALM is the fetus of an adult worker. The USEPA assumes a linear relationship between PbB in the adult woman and the fetus. Therefore, the geometric mean PbB in the fetus is equal to PbB_{GM} multiplied by a constant, R. USEPA guidance (2003b) indicates that the ALM may also be used to assess older children and adolescents with appropriate adjustments. A time-weighted approach was used to evaluate potential risks for recreational users and trespassers consistent with USEPA guidance (2003b).

3.1 Adult Lead Model Parameter Values

Table 1a presents the central tendency parameter values used to evaluate lead risks for the following receptors based on a target PbB of 10 ug/dL:

- Future construction worker (risks presented in Table 1b)
- Future adult recreational user (risks presented in Table 1c)
- Future older child recreational user (risks presented in Table 1d)
- Current adolescent trespasser (risks presented in Table 1e)

Tables 1f through 1i present the receptor-specific evaluations using a PbB of 5 ug/dL for the construction worker, adult recreational user, older child recreational user and current adolescent trespasser, respectively.

Baseline Blood Lead Concentration (PbB_0)

The baseline PbB is intended to represent the best estimate of a reasonable central value of PbB in women of child-bearing age who are not exposed to lead-contaminated non-residential soil or dust at the site. The USEPA (2009) recommends a default baseline concentration of 1.0 µg/dL based on national survey data gathered between 1999 and 2004 for women 17 to 45 years of age.

Geometric Standard Deviation

The USEPA recommends a default geometric standard deviation (GSD) of 1.8 that has been used in the ALM Model (USEPA, 2009).

Biokinetic Slope Factor

The Biokinetic Slope Factor (BKSF) represents the increase in typical adult PbB due to average daily lead uptake. The USEPA (2003b) recommends a default value of 0.4 µg lead/dL blood per µg lead absorbed per day for the BKSF. This value is based on empirical data on the relationship between tap-water lead concentrations and PbBs for a sample group of adult males. This default value was used for all exposure pathways in this evaluation.

Soil Ingestion Rate (IR_S)

Consistent with USEPA guidance (2003a; 2007), a soil ingestion rate of 50 mg/day was used to evaluate potential risks for the adult recreational user, older child recreational user, and adolescent trespasser. This value represents the central tendency ingestion rate for soil non-contact-intensive activities (including soil-derived indoor dust) (USEPA, 2007). A soil ingestion rate of 100 mg/day was used to evaluate potential lead exposures for the construction worker. This is a refinement from the ingestion rate used in the supplemental HHRA (330 mg/kg) based on frequent questions on the ALM (USEPA, 2007).

Exposure Frequency and Averaging Time

Exposure frequencies used in this lead evaluation were consistent with values used in the supplemental HHRA. Consistent with USEPA guidance (2003b), a time-weighted average approach was used to evaluate potential risks for recreational users and trespassers.

Lead Absorption Fraction

This evaluation used a lead absorption fraction of 0.12, which is the default value recommended by the USEPA (2003b). This value is based on experimental studies of the bioavailability of ingested lead in adults with considerations for the following three major sources of variability: 1) effect of food on lead bioavailability, 2) nonlinearity in PbB, and 3) effect of lead form and particle size on bioavailability. The value assumes a relative bioavailability of 0.6 for lead in site-related media as compared to soluble lead, and also assumes an absorption fraction (AF) of 0.2 for soluble lead. Thus, the final AF is 0.12 (i.e., AF = 0.6 x 0.2 = 0.12).

Fetal/Maternal Blood Lead Concentration ($R_{fetal/maternal}$)

This evaluation used a fetal/maternal blood lead ratio of 0.9 for adult receptors, which is the default value recommended by the USEPA (2003b) based on studies that have explored the relationship between umbilical cord and maternal PbBs. Because the older child recreational user and adolescent trespasser are not of child-bearing age, the fetal/maternal PbB ratio for these receptors was set equal to 1.

3.2 Exposure Point Concentrations

The exposure point concentrations (EPCs) used in the lead evaluation are arithmetic means based on site-related data. Media were evaluated separately (i.e., medium-specific arithmetic means were used as the EPCs). One-half the laboratory detection limit was used as a surrogate for non-detects in calculating arithmetic mean lead concentrations.

3.3 Adult Lead Model Results

Tables 1b and 1f present the modeling results for the construction worker. Exposure of construction workers to shallow groundwater (incidental ingestion during intrusive activities) results in a P10 and a P5 of less than 1 percent, which are well below the threshold of 5 percent. Exposure of construction workers to soils results in a P10 of 1.1 percent, which is below the 5 percent threshold, and a P5 of 13.6 percent, which is above the 5 percent threshold.

Tables 1c and 1g present the modeling results for the adult recreational user. Exposure of adult recreational users to soils and sediment results in P10s and P5s of less than 5 percent.

Table 1d and 1h present the modeling results for the older child recreational user. Because this receptor is not of child-bearing age, the ALM was only used to estimate the geometric mean of PbB for the exposed individual. Exposure of older child recreational users to soil and sediment results in PbBs of less than 10 µg/dL and 5 µg/dL.

Table 1e and 1i present the modeling results for the adolescent trespasser. Similar to the older child recreational user, the ALM was only used to estimate the geometric mean of PbB for the exposed individual. Exposure of the adolescent trespasser to soil and sediment results in PbBs of less than 10 µg/dL and 5 µg/dL.

4.0 Summary and Conclusions

Estimated lead risks for future recreational users, current trespassers, and construction workers were less than the USEPA targets.

References:

ARCADIS. 2009. *Baseline Human Health Risk Assessment, Peterson Puritan Site – Operable Unit 2, Cumberland and Lincoln, Rhode Island.* April 2009.

CDC. 1991. Preventing Lead Poisoning in Young Children. http://www.cdc.gov/nceh/lead/publications/books/plpyc/contents.htm.

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USEPA. 2003b. Assessing Intermittent or Variable Exposures at Lead Sites. OSWER Directive #9285.7-76. November 2003.

USEPA. 2004. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. EPA/540/R/99/005. July 2004.

USEPA. 2007. Frequent Questions from Risk Assessors on the ALM. Available at http://www.epa.gov/superfund/programs/lead/almfaq.htm#shortest. Updated August 2, 2007.

USEPA. 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters. OSWER 9200.2-82. June 2009. Available at: http://www.epa.gov/superfund/health/contaminants/lead/products.htm#almupdate.

Table 1a. Summary of Parameter Values Used in the Adult Lead Model (ALM) for Evaluation of Non-Residential Lead Risks Associated with Site-Related Soil, Sediment, and Groundwater Baseline Human Health Risk Assessment

Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Exposure Variable	Description	Units	Receptor Scenarios			
			Construction Worker [1]	Adult Recreational User [2]	Older Child Recreational User [2,3]	Adolescent Trespasser [2,4]
			Table 1b	Table 1c	Table 1d	Table 1e
PbS	Lead concentration in medium of interest	ppm	Site-specific	Site-specific	Site-specific	Site-specific
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9 [a]	0.9 [a]	1.0 [b]	1.0 [b]
$BKSF_S$	Biokinetic Slope Factor (soil, sediment, and food)	µg/dL per µg/day	0.4 [a]	0.4 [a]	0.4 [a]	0.4 [a]
$BKSF_W$	Biokinetic Slope Factor (groundwater)	µg/dL per µg/day	0.4 [a]	NA	NA	NA
GSD_i	Geometric standard deviation PbB	--	1.8 [c]	1.8 [c]	1.8 [c]	1.8 [c]
PbB_0	Baseline PbB	µg/dL	1.0 [c]	1.0 [c]	1.0 [c]	1.0 [c]
IR_S	Soil/sediment ingestion rate (including soil-derived indoor dust)	g/day	0.10 [o]	0.05 [d]	0.05 [d]	0.05 [d]
IR_f	Food ingestion rate (fish)	g/day	NA	NA	NA	NA
IR_w	Shallow groundwater ingestion rate	L/day	0.05 [m]	NA	NA	NA
$AF_{S, D, W}$	Absorption fraction, Pb in soil, dust, sediment, and groundwater	--	0.12 [a]	0.12 [a]	0.12 [a]	0.12 [a]
AF_f	Absorption fraction, Pb in food	--	NA	NA	NA	NA
$EF_{S, D, W}$	Exposure frequency, Pb pathway	days/yr	62 [h]	2 [g]	2 [g]	2 [g]
$AT_{S, D, W}$	Averaging time, Pb pathway	days/yr	84 [l]	7 [n]	7 [n]	7 [n]

Notes:

[1] Lead exposures for these receptors were evaluated individually for each applicable subarea. Consistent with the ALM guidance (USEPA, 2003a; 2007), the arithmetic mean of lead concentrations

[2] A time-weighted approach was used to evaluate potential lead risks for these receptors in the ALM, consistent with Example 6 in Appendix A in USEPA (2003b).

[3] Older child = 6 - 12 years of age

[4] Adolescent = 9 - 18 years of age

[5] Consistent with USEPA (2003a; 2004; 2007) guidance, dermal exposures to lead in aqueous and non-aqueous media were not quantitatively evaluated with the ALM due to the uncertainty in assigning a dermal absorption fraction that would apply to the numerous inorganic forms of lead that are typically found in environmental settings.

[a] Default value (USEPA, 2003a).

[b] Fetal/maternal PbB ratio does not apply because receptor is assumed to be an older child (6-12 years) or adolescent (9-18 years); risks to fetus of pregnant women are evaluated in adult receptor

[c] Updated default value for women 17-45 years of age (USEPA, 2009).

[d] Default CTE value for soil ingestion (USEPA, 2003a; 2007). Value for commercial worker assumes non-contact-intensive activities.

[e] CTE fish ingestion rate based on the 50th percentile for Maine anglers (Ebert et al., 1993. Estimating Consumption of Freshwater Fish among Maine Anglers. *North American Journal of Fisheries Management* 13:737-745.). Assumes 100% of fish consumed are from on-site sources.

Table 1a. Summary of Parameter Values Used in the Adult Lead Model (ALM) for Evaluation of Non-Residential Lead Risks Associated with Site-Related Soil, Sediment, and Groundwater
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Notes (continued):

[f] Value considered protective for bioavailable fraction of lead in fish (USEPA, 2007).
[g] Reflects the same CTE value used in baseline human health risk assessment (2 days per week for approximately 6 months). Applying the time-weighted approach consistent with note [2] above, the resulting exposure frequency is set equal to 2 days/week.
[h] Same CTE value used in baseline human health risk assessment (5 days per week for approximately 12 weeks).
[i] Default central tendency estimate of exposure frequency for commercial/industrial workers from USEPA (2007).
[j] Fish ingestion rate reflects a longterm average daily intake assuming 100% of fish are obtained from the site; therefore, EF is 365 days/year.
[k] Averaging time appropriate for chronic exposure scenario (USEPA, 2003a; 2007).
[l] Averaging time is based on EF to avoid diluting exposures over the entire year (7 days per week x 12 weeks/year = 84 days/year).
[m] Default surface water contact rate for recreational swimmers (USEPA, 1989). Assumed to provide a conservative estimate of incidental ingestion by construction workers exposed to shallow groundwater.
[n] Applying the time-weighted approach consistent with note [2] above, the resulting averaging time is set equal to 7 days/week.
[o] Default CTE for construction worker soil ingestion (USEPA, 2007) - Value is revised from BHHRA based on EPA comments to the draft Feasability Study, February 6 (USEPA, 2013).
µg/dL = micrograms per deciliter
g/day = grams per day
L/day = liters per day
NA = not applicable

References:

USEPA, 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameter. OSWER Dir #9200.2-82. June 2009.
USEPA. 2007. Frequent Questions from Risk Assessors on the ALM. Accessed on-line 4/23/08 at http://www.epa.gov/superfund/health/contaminants/lead/almfaq.htm. Updated August 2, 2007.
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USEPA. 2003a. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. EPA-540-R-03-001. January 2003.
USEPA. 2003b. Assessing Intermittent or Variable Exposures at Lead Sites. OSWER Directive #9285.7-76. EPA-540-R-03-008. November 2003.
USEPA. 2002. Blood Lead Concentrations of U.S. Adult Females: Summary Statistics From Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). OSWER #9285.7-52. March 2002.
USEPA. 1989. Risk Assessment Guidance for Superfund, Part A, Interim Final. EPA/540/1-89/002. December 1989.

Table 1b. Adult Lead Model (ALM) for Evaluation of Lead Risks for Construction Workers Exposed to Site-Related Soil and Shallow Groundwater
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Construction Workers	
			Site-Wide Shallow Groundwater [1]	Unnamed Island Surface and Subsurface Soil [1]
PbS	Lead concentration in medium of interest (arithmetic mean) [a]	ppm	0.0097	540
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.8
PbB_0	Baseline PbB	µg/dL	1.0	1.0
$IR_{S,W}$	Ingestion rate (soil, groundwater)	g/day	0.050	0.100
AF	Absorption fraction (Pb in soil, dust, and groundwater)	--	0.12	0.12
EF	Exposure frequency, Pb pathway	days/yr	62	62
AT	Averaging time, Pb pathway	days/yr	84	84
PbB_{adult}	**PbB of adult worker, geometric mean**	**µg/dL**	**1.0**	**2.9**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	2.4	6.9
PbB_t	Target PbB level of concern	µg/dL	10.0	10.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.0021%**	**1.1%**

Notes:
ALM Version date 5/19/05
[1] Future scenario, as indicated in Table 1 of the baseline HHRA.
[a] Arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1c. Adult Lead Model (ALM) for Evaluation of Lead Risks for Adult Recreational Users Exposed to Site-Related Soil and Sediment
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Adult Recreational Users	
			Unnamed Island Surface and Subsurface Soil [1]	Unnamed Island Sediment [1,2]
PbS	Lead concentration in media of interest (arithmetic mean) [a]	mg/kg or ppm	540	260
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.8
PbB_0	Baseline PbB	µg/dL	1.0	1.0
IR_S	Soil/sediment ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050
AF	Absorption fraction (Pb in soil, dust, and sediment)	--	0.12	0.12
EF	Exposure frequency, Pb pathway	days/week	2	2
AT	Averaging time, Pb pathway	days/week	7	7
PbB_{adult}	**PbB of adult recreational user, geometric mean**	**µg/dL**	**1.4**	**1.2**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adults	µg/dL	3.2	2.8
PbB_t	Target PbB level of concern	µg/dL	10.0	10.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.018%**	**0.0067%**

Notes:
ALM Version date 5/19/05
[1] Future scenario, as indicated in Table 1 of the baseline HHRA.
[2] Sediment data represent those collected from the Unnamed Island ponds.
[a] Arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1d. Adult Lead Model (ALM) for Evaluation of Lead Risks for Older Child Recreational Users Exposed to Site-Related Soil and Sediment
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Older Child Recreational Users	
			Unnamed Island Surface and Subsurface Soil [1]	Unnamed Island Sediment [1,2]
PbS	Lead concentration in media of interest (arithmetic mean) [a]	mg/kg or ppm	540	260
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	1.0	1.0
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.8
PbB_0	Baseline PbB	µg/dL	1.0	1.0
IR_S	Soil/sediment ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050
AF	Absorption fraction (Pb in soil, dust, and sediment)	--	0.12	0.12
EF	Exposure frequency, Pb pathway	days/week	2	2
AT	Averaging time, Pb pathway	days/week	7	7
PbB_{adult}	**PbB of older child recreational user, geometric mean**	**µg/dL**	**1.4**	**1.2**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adults	µg/dL	--	--
PbB_t	Target PbB level of concern	µg/dL	10.0	10.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**--**	**--**

Notes:
ALM Version date 5/19/05
[1] Future scenario, as indicated in Table 1 of the baseline HHRA.
[2] Sediment data represent those collected from the Unnamed Island ponds.
[a] Arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1e. Adult Lead Model (ALM) for Evaluation of Lead Risks for Adolescent Trespassers Exposed to Site-Related Soil and Sediment
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Adolescent Trespassers	
			Unnamed Island Surface Soil [1]	Unnamed Island Sediment [1,2]
PbS	Lead concentration in media of interest (arithmetic mean) [a]	mg/kg or ppm	360	260
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	1.0	1.0
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.8
PbB_0	Baseline PbB	µg/dL	1.0	1.0
IR_S	Soil/sediment ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050
AF	Absorption fraction (Pb in soil, dust, and sediment)	--	0.12	0.12
EF	Exposure frequency, Pb pathway	days/week	2	2
AT	Averaging time, Pb pathway	days/week	7	7
PbB_{adult}	**PbB of adolescent trespasser, geometric mean**	**µg/dL**	**1.2**	**1.2**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adults	µg/dL	--	--
PbB_t	Target PbB level of concern	µg/dL	10.0	10.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**--**	**--**

Notes:
ALM Version date 5/19/05
[1] Current scenario, as indicated in Table 1 of the baseline HHRA.
[2] Sediment data represent those collected from the Unnamed Island ponds.
[a] Arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1f. Adult Lead Model (ALM) for Evaluation of Lead Risks for Construction Workers Exposed to Site-Related Soil and Shallow Groundwater (PbB of 5 ug/dL)
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Construction Workers	
			Site-Wide Shallow Groundwater [1]	Unnamed Island Surface and Subsurface Soil [1]
PbS	Lead concentration in medium of interest (arithmetic mean) [a]	ppm	0.0097	540
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.8
PbB_0	Baseline PbB	µg/dL	1.0	1.0
$IR_{S,W}$	Ingestion rate (soil, groundwater)	g/day	0.050	0.100
AF	Absorption fraction (Pb in soil, dust, and groundwater)	--	0.12	0.12
EF	Exposure frequency, Pb pathway	days/yr	62	62
AT	Averaging time, Pb pathway	days/yr	84	84
PbB_{adult}	**PbB of adult worker, geometric mean**	**µg/dL**	**1.0**	**2.9**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	2.4	6.9
PbB_t	Target PbB level of concern	µg/dL	5.0	5.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.18%**	**13.6%**

Notes:
ALM Version date 5/19/05
[1] Future scenario, as indicated in Table 1 of the baseline HHRA.
[a] Arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1g. Adult Lead Model (ALM) for Evaluation of Lead Risks for Adult Recreational Users Exposed to Site-Related Soil and Sediment (PbB of 5 ug/dL)
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Adult Recreational Users	
			Unnamed Island Surface and Subsurface Soil [1]	Unnamed Island Sediment [1,2]
PbS	Lead concentration in media of interest (arithmetic mean) [a]	mg/kg or ppm	540	260
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.8
PbB_0	Baseline PbB	µg/dL	1.0	1.0
IR_S	Soil/sediment ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050
AF	Absorption fraction (Pb in soil, dust, and sediment)	--	0.12	0.12
EF	Exposure frequency, Pb pathway	days/week	2	2
AT	Averaging time, Pb pathway	days/week	7	7
PbB_{adult}	**PbB of adult recreational user, geometric mean**	**µg/dL**	**1.4**	**1.2**
$PbB_{fetal,\ 0.95}$	95th percentile PbB among fetuses of adults	µg/dL	3.2	2.8
PbB_t	Target PbB level of concern	µg/dL	5.0	5.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.862%**	**0.4167%**

Notes:
ALM Version date 5/19/05
[1] Future scenario, as indicated in Table 1 of the baseline HHRA.
[2] Sediment data represent those collected from the Unnamed Island ponds.
[a] Arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1h. Adult Lead Model (ALM) for Evaluation of Lead Risks for Older Child Recreational Users Exposed to Site-Related Soil and Sediment (PbB of 5 ug/dL)
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Older Child Recreational Users	
			Unnamed Island Surface and Subsurface Soil [1]	Unnamed Island Sediment [1,2]
PbS	Lead concentration in media of interest (arithmetic mean) [a]	mg/kg or ppm	540	260
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	1.0	1.0
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.8
PbB_0	Baseline PbB	µg/dL	1.0	1.0
IR_S	Soil/sediment ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050
AF	Absorption fraction (Pb in soil, dust, and sediment)	--	0.12	0.12
EF	Exposure frequency, Pb pathway	days/week	2	2
AT	Averaging time, Pb pathway	days/week	7	7
PbB_{adult}	**PbB of older child recreational user, geometric mean**	**µg/dL**	**1.4**	**1.2**
$PbB_{fetal,\ 0.95}$	95th percentile PbB among fetuses of adults	µg/dL	--	--
PbB_t	Target PbB level of concern	µg/dL	5.0	5.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**--**	**--**

Notes:
ALM Version date 5/19/05
[1] Future scenario, as indicated in Table 1 of the baseline HHRA.
[2] Sediment data represent those collected from the Unnamed Island ponds.
[a] Arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table 1i. Adult Lead Model (ALM) for Evaluation of Lead Risks for Adolescent Trespassers Exposed to Site-Related Soil and Sediment (PbB of 5 ug/dL)
Baseline Human Health Risk Assessment
Peterson Puritan (OU2), Cumberland and Lincoln, Rhode Island

Calculations of Blood Lead Concentrations (PbBs)

Exposure Variable	Description	Units	Adolescent Trespassers	
			Unnamed Island Surface Soil [1]	Unnamed Island Sediment [1,2]
PbS	Lead concentration in media of interest (arithmetic mean) [a]	mg/kg or ppm	360	260
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	1.0	1.0
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.8
PbB_0	Baseline PbB	µg/dL	1.0	1.0
IR_S	Soil/sediment ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050
AF	Absorption fraction (Pb in soil, dust, and sediment)	--	0.12	0.12
EF	Exposure frequency, Pb pathway	days/week	2	2
AT	Averaging time, Pb pathway	days/week	7	7
PbB_{adult}	**PbB of adolescent trespasser, geometric mean**	**µg/dL**	**1.2**	**1.2**
$PbB_{fetal,\ 0.95}$	95th percentile PbB among fetuses of adults	µg/dL	--	--
PbB_t	Target PbB level of concern	µg/dL	5.0	5.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**--**	**--**

Notes:
ALM Version date 5/19/05
[1] Current scenario, as indicated in Table 1 of the baseline HHRA.
[2] Sediment data represent those collected from the Unnamed Island ponds.
[a] Arithmetic means were calculated using one-half the laboratory detection limit for non-detects.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

APPENDIX C.3

HUMAN HEALTH RISK REFINEMENT: EPA'S TECHNICAL MEMORANDUM ON DIOXIN TOXICITY VALUES

Memorandum

Date: February 21, 2013

From: Chau Vu, Human Health Risk Assessor, Technical & Enforcement Support Section

To: File – Peterson/Puritan Superfund Site, Inc. Operable Unit 2 (OU 2)

Subj: Updates on Dioxin Toxicity Values and their Implication on the Baseline Human Health Risk Assessment

In the 2007/Updated 2009 Agency Review Baseline Human Health Risk Assessment (BHHRA) for the Peterson/Puritan Superfund Site, Inc. Superfund Site, OU2 (the Site), the dioxin cancer toxicity values used were from California EPA and no non-cancer toxicity values were identified. While acceptable at the time, these values are no longer consistent with EPA's current approach on evaluating dioxin. Therefore, the purpose of this memorandum is to identify the discrepancy of dioxin toxicity values used and dioxin risks in the risk assessment.

In 2003, the EPA Office of Solid Waste and Emergency Response (OSWER) developed a memorandum on recommended hierarchy (EPA 2003) for the selection of toxicity values to be used in risk assessments. As discussed in the 2003 memorandum, the preferred tier of toxicological information is as follows:

- Tier 1 – EPA's Integrated Risk Information System (IRIS), developed by EPA's Office of Research and Development National Center for Environmental Assessment (ORD NCEA);
- Tier 2 – EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs), developed by NCEA; and
- Tier 3 – Other toxicity values, including additional EPA and non-EPA sources of toxicity information.

Due to the lack of cancer toxicity values in Tier 1 and Tier 2 for dioxin, EPA reviewed available cancer slope factors to determine whether they would meet EPA's Tier 3 criteria. Although five primary candidate values were identified to meet Tier 3 criteria, EPA suggests use of the slope factor of 1.56E+05 $(mg/kg\text{-}day)^{-1}$ derived in 1985 by EPA's Office of Health and Environmental Assessment (OHEA; EPA 1985). This value is preferred because it is based on the incidence of all significant tumors combined, rather than based on the incidence of liver tumors alone as is the case with the California EPA cancer slope factor of 1.3E+05 $(mg/kg\text{-}day)^{-1}$ (CalEPA 1986).

On February 17, 2012, EPA finalized its final *Reanalysis of Key Issues Related to Dioxin Toxicity and Response to NAS Comments, Volume 1*. This document provides hazard identification and dose-response information on 2,3,7,8- tetrachlorodibenzo-p-dioxin (TCDD) and the most up-to-date analysis of non-cancer health effects from TCDD exposure. The report also includes an oral reference dose (RfD) value of 7E-10 mg/kg-day. Non-cancer health effects from TCDD exposure were not evaluated in the 2007/Updated 2009 Agency Review BHHRA due to the lack of non-cancer toxicity value for dioxin at the time of developing that document.

The 2010 Supplemental HHRA for Unnamed Island utilized an oral RfD value of 1E-09 mg/kg-day developed by the Agency for Toxic Substances and Disease Registry (ATSDR) as recommended at that time.

Tables 1 and 2 below show different dioxin toxicity values used in the 2009 Updated BHHRA, the 2010 Supplemental HHRA, and the toxicity values in EPA's current approach on evaluating dioxin:

Table 1
Cancer toxicity data for dioxin – oral/dermal and inhalation

Source	Oral/Dermal CSF[(1)]	Unit	Source	Inhalation Unit Risk	Unit	Source
2009 Updated BHHRA	1.3E+05	$(mg/kg\text{-}day)^{-1}$	CalEPA	3.8E+01	$(\mu g/m^3)^{-1}$	CalEPA
2010 Supp. HHRA	1.56E+05	$(mg/kg\text{-}day)^{-1}$	EPA OHEA	3.8E+01	$(\mu g/m^3)^{-1}$	CalEPA
Current approach	1.56E+05	$(mg/kg\text{-}day)^{-1}$	EPA OHEA	3.8E+01	$(\mu g/m^3)^{-1}$	CalEPA

Table 2
Non-cancer toxicity data for dioxin – oral/dermal and inhalation

Source	Oral/Dermal RfD[(1)]	Unit	Source	Inhalation Reference Concentration	Unit	Source
2009 Updated BHHRA	N/A	N/A	N/A	N/A	N/A	N/A
2010 Supp. HHRA	1E-09	mg/kg-day	ATSDR	4E-05	$\mu g/m^3$	CalEPA
Current approach	7E-10	mg/kg-day	IRIS	4E-05	$\mu g/m^3$	CalEPA

Note:
(1) There are no dermal toxicity values for dioxin. Since the oral absorption efficiency to dermal for dioxin exceeds 50%, no adjustment of the oral toxicity values is necessary.
N/A Not Applicable/Not Available

Applying the recommended toxicity values to the same exposure scenarios and exposure parameters as used in the 2009 Updated BHHRA and using the toxicity values for the current approach from Tables 1 and 2 above, dioxin cancer and non-cancer risks would be revised as in Table 3 below. Also included in this table for comparison purpose are the dioxin cancer risks calculated for Unnamed Island as presented in the 2010 Supplemental Human Health Risk Assessment for Unnamed Island. Non-cancer hazards for Unnamed Island are also re-calculated using the current RfD and presented in Table 3 below.

Table 3

Summary of dioxin TEQ cancer risks and non-cancer hazards (for RME scenario)

Exposure Point	Exposure Media	Scenario/ Receptor	Exposure Route	Cancer Risks		Non-cancer Hazards	
				2009 BHHRA	Revised Risks	2009 BHHRA	Revised Hazards
Nunes Parcel	Surface soil	Commercial Worker	Ingestion	2.0E-6	2.5E-6	N/A	6.3E-2
			Dermal	4.0E-7	4.9E-7	N/A	1.2E-2
			Total	*2E-6*	*3E-6*	*N/A*	*8E-2*
		Trespasser	Ingestion	4.8E-7	5.7E-7	N/A	3.7E-2
			Dermal	5.9E-8	7.1E-8	N/A	4.6 E-2
			Total	*5E-7*	*6E-7*	*N/A*	*8E-2*
	Surface and subsurface soil	Adult recreational user (swimming & wading)	Ingestion	8.2E-7	9.8E-7	N/A	2.6E-2
			Dermal	9.8E-8	1.2E-7	N/A	3.1E-3
			Total	*9E-7*	*1E-6*	*N/A*	*3E-2*
		Older child recreational user (swimming & wading)	Ingestion	4.1E-7	4.9E-7	N/A	5.3E-2
			Dermal	1.1E-7	1.3E-7	N/A	1.4 E-2
			Total	*5E-7*	*6E-7*	*N/A*	*7E-2*
		Commercial Worker	Ingestion	2.0E-6	2.5E-6	N/A	6.3E-2
			Dermal	4.0E-7	4.9E-7	N/A	1.2E-2
			Total	*2E-6*	*3E-6*	*N/A*	*8E-2*
		Construction Worker	Ingestion	1.3E-7	1.6E-7	N/A	5.1E-3
			Dermal	1.2E-8	1.5E-8	N/A	4.7E-4
			Inhalation	2.1E-12	2.1E-12	NA	9.4E-8
			Total	*1E-7*	*2E-7*	*N/A*	*6E-3*
		Adult Resident	Ingestion	2.7E-6	3.3E-6	N/A	8.9E-2
			Dermal	3.3E-7	3.9E-7	N/A	1.1E-2
			Total	*3E-6*	*4E-6*	*N/A*	*1E-1*
		Young child Resident	Ingestion	6.4E-6	7.7E-6	N/A	8.3E-1
			Dermal	5.4E-7	6.5E-7	N/A	6.9E-2
			Total	*7E-6*	*8E-6*	*N/A*	*9E-1*
Landfill	Surface soil	Trespasser	Ingestion	6.2E-7	7.5E-7	N/A	4.9E-2
			Dermal	7.7E-8	9.3E-8	N/A	6.0E-3
			Total	*7E-7*	*8E-7*	*N/A*	*5E-2*
		Adult recreational user (swimming & wading)	Ingestion	1.1E-6	1.3E-6	N/A	3.4E-2
			Dermal	1.3E-7	1.5E-7	N/A	4.1E-3
			Total	*1E-6*	*1E-6*	*N/A*	*4E-2*
		Older child recreational user (swimming & wading)	Ingestion	5.4E-7	6.4E-7	N/A	6.9E-2
			Dermal	1.4E-7	1.7E-7	N/A	1.9E-2
			Total	*7E-7*	*8E-7*	*N/A*	*9E-2*

Exposure Point	**Exposure Media**	**Scenario/ Receptor**	**Exposure Route**	**Cancer Risks**		**Non-cancer Hazards**	
				2010 Supp. HHRA	**Not Revised**	**2010 Supp. HHRA**	**Revised Risks**
Unnamed Island	Surface soil	Trespasser	Ingestion	6.5E-7	N/A	2.9E-2	4.1E-2
			Dermal	8.1E-8	N/A	3.6E-3	5.1E-3
			Total	*7E-7*	N/A	*3.0E-2*	*5E-2*
	Surface and subsurface soil	Adult recreational user (wading)	Ingestion	1.3E-6	N/A	2.5E-2	3.6E-2
			Dermal	1.6E-7	N/A	3.0E-3	4.3E-3
			Total	*1E-6*	N/A	*3E-2*	*4E-2*
		Older child recreational user (wading)	Ingestion	6.7E-7	N/A	5.0E-2	7.1E-2
			Dermal	1.8E-7	N/A	1.3E-2	1.9E-2
			Total	*9E-7*	N/A	*6E-2*	*9E-2*
		Construction worker	Ingestion	2.2E-7	N/A	5.0E-3	7.1E-3
			Dermal	2.0E-8	N/A	4.5E-4	6.4E-4
			Inhalation	2.8E-11	N/A	1.3E-7	1.3E-7
			Total	*2E-7*	N/A	*5E-3*	*8E-3*

Although dioxin cancer risks and non-cancer hazards are changed and slightly increased from those calculated in the 2009 Updated BHHRA and 2010 Supplemental HHRA, the changes are minimal and the revised risks and hazards are within EPA's acceptable risk range. Therefore, the revised risks would not change the total site risk results for the scenarios and receptors identified for the Site.

Please also note that at this time, EPA is working on updating the dioxin cancer reassessment. When this cancer reassessment is finalized, the dioxin cancer risks for the Site would need to be re-evaluated based on the new cancer toxicity values.

References

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APPENDIX C.4

HUMAN HEALTH RISK REFINEMENT: TECHNICAL MEMORANDUM ON PCE TOXICITY VALUES

Peterson Puritan FS, Appendix F – PCE Toxicity Values

In the 2007/Updated 2009 Agency Review Baseline Human Health Risk Assessment (BHHRA) for the Peterson/Puritan Superfund Site, Inc. Superfund Site, OU2 (the Site), the tetrachloroethylene (PCE) cancer toxicity values used were from California Environmental Protection Agency (CalEPA), the oral/dermal non-cancer toxicity values used were from EPA's Integrated Risk Information System (IRIS), and the inhalation non-cancer toxicity values were from the Agency for Toxic Substances and Disease Registry (ATSDR). While acceptable at the time, these values are no longer consistent with EPA's current approach on evaluating PCE. Therefore, the purpose of this memorandum is to identify the changes in PCE toxicity values and the resulting effects on estimated risks and hazards in the risk assessments.

In 2003, the EPA Office of Solid Waste and Emergency Response (OSWER) developed a memorandum on recommended hierarchy (EPA 2003) for the selection of toxicity values to be used in risk assessments. As discussed in the 2003 memorandum, the preferred tier of toxicological information is as follows:

- Tier 1 – EPA's Integrated Risk Information System (IRIS);
- Tier 2 – EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs), developed by EPA's National Center for Environmental Assessment (NCEA); and
- Tier 3 – Other toxicity values, including additional EPA and non-EPA sources of toxicity information.

Toxicity values were selected for the 2007/Updated 2009 BHHRA and the 2010 Supplemental HHRA for Unnamed Island following the EPA recommended hierarchy. Cancer toxicity values from the CalEPA's Office of Environmental Health Hazard Assessment (OEHHA) represented Tier 3 values. Non-cancer toxicity values from IRIS represented Tier 1 values, and the ATSDR minimal risk levels (MRLs) represented Tier 3 values.

Tables 1 and 2 below show the different PCE toxicity values used in the 2009 Updated BHHRA, the 2010 Supplemental HHRA, and the toxicity values in EPA's current approach on evaluating PCE (EPA 2012):

Table 1

Cancer toxicity data for PCE – oral/dermal and inhalation

Source	Oral/Dermal CSF[(1)]	Unit	Source	Inhalation Unit Risk	Unit	Source
2009 Updated BHHRA	5.4E-01	$(mg/kg\text{-}day)^{-1}$	CalEPA	5.9E-06	$(\mu g/m^3)^{-1}$	CalEPA
2010 Supp. HHRA	5.4E-01	$(mg/kg\text{-}day)^{-1}$	CalEPA	5.9E-06	$(\mu g/m^3)^{-1}$	CalEPA
Current approach	2.1E-03	$(mg/kg\text{-}day)^{-1}$	IRIS	2.6E-07	$(\mu g/m^3)^{-1}$	IRIS

Table 2

Non-cancer toxicity data for PCE – oral/dermal and inhalation

Source	Oral/Dermal RfD[(1)]	Unit	Source	Inhalation Reference Concentration	Unit	Source
2009 Updated BHHRA	1.0E-01	mg/kg-day	IRIS	2.7E+02	µg/m^3	ATSDR
2010 Supp. HHRA	N/A	N/A	N/A	N/A	N/A	N/A
Current approach	4.0E-02	mg/kg-day	IRIS	6.0E-03	µg/m^3	IRIS

Notes:

(1) There are no dermal toxicity values for PCE. Since the oral absorption efficiency to dermal for PCE exceeds 50%, no adjustment of the oral toxicity values is necessary.

CSF = Cancer Slope Factor
RfD = Reference Dose
N/A = Not Applicable/Not Available

The cancer toxicity values under the current approach compared to old values indicate PCE is 250 times less potent for the oral pathway (i.e., CSF) and 20 times less potent for the inhalation pathway (i.e., inhalation unit risk [IUR]). The non-cancer toxicity values under the current approach compared to old values indicate PCE is 2 times more toxic for the oral pathway (i.e., RfD) and 7 times more toxic for the inhalation pathway (i.e., RfC).

The regional screening levels for PCE also changed as a result of the change in toxicity values. Table 3 shows the PCE Regional Screening Levels (RSLs) used in the 2009 Updated BHHRA, the 2010 Supplemental HHRA, and current approach RSLs (EPA 2012).

Table 3

RSLs for PCE – Soil, Air and Water

Source	Soil (Residential) (mg/kg)	Air (ug/m^3)	Water (ug/L)
2009 Updated BHHRA	0.57	0.41	0.11

2010 Supp. HHRA	0.55	0.41	0.11
Current approach	22	9.4	9.7

Applying the current approach RSLs to the selection process for constituents of potential concern (COPCs) results in fewer media for which PCE is identified as a COPC.

In the 2009 Updated BHHRA, PCE was a COPC for:

- Site-wide groundwater (adult and child Resident);
- Nunes Parcel outdoor (trench) air (construction worker); and
- Nunes Parcel indoor air (commercial worker and adult/child resident).

Use of the current RSL indicates PCE would only be identified as a COPC for Nunes Parcel outdoor and indoor air.

Generally speaking, using toxicity values recommended under the current approach would result in an increase in non-cancer hazards for PCE and a decrease in cancer risks for PCE for receptors of concern. However, based on the new RSLs, PCE would only be retained as a COPC in Nunes Parcel outdoor and indoor air. Because Nunes Parcel will be addressed as part of the presumptive remedy, no further evaluation of this chemical is warranted in the BHHRA.

References

Arcadis BBL. 2009. Agency Revision. Baseline Human Health Risk Assessment. Peterson Puritan Site – Operable Unit 2. Cumberland and Lincoln, Rhode Island.

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APPENDIX C.5

HUMAN HEALTH RISK REFINEMENT: TECHNICAL MEMORANDUM ON TCE TOXICITY VALUES

Peterson Puritan FS – Appendix G, TCE toxicity values

In the 2007/Updated 2009 Agency Review Baseline Human Health Risk Assessment (BHHRA) for the Peterson/Puritan Superfund Site, Inc. Superfund Site, OU2 (the Site), the trichloroethylene (TCE) cancer toxicity values used were from California Environmental Protection Agency (CalEPA), the oral/dermal non-cancer toxicity values used were from EPA's Integrated Risk Information System (IRIS), and the inhalation non-cancer toxicity values were from the Agency for Toxic Substances and Disease Registry (ATSDR). While acceptable at the time, these values are no longer consistent with EPA's current approach on evaluating TCE. Therefore, the purpose of this memorandum is to identify the changes in TCE toxicity values and how they would affect the results of the risk assessment.

In 2003, the EPA Office of Solid Waste and Emergency Response (OSWER) developed a memorandum on recommended hierarchy (EPA 2003) for the selection of toxicity values to be used in risk assessments. As discussed in the 2003 memorandum, the preferred tier of toxicological information is as follows:

- Tier 1 – EPA's Integrated Risk Information System (IRIS);
- Tier 2 – EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs), developed by EPA's National Center for Environmental Assessment (NCEA); and
- Tier 3 – Other toxicity values, including additional EPA and non-EPA sources of toxicity information.

Toxicity values were selected for the 2007/Updated 2009 BHHRA and the 2010 Supplemental HHRA for Unnamed Island following the EPA recommended hierarchy. Cancer toxicity values represent Tier 3 values from the CalEPA's Office of Environmental Health Hazard Assessment (OEHHA). Non-cancer toxicity values were from the New York State Department of Health (NYSDOH) and represent Tier 3 values.

Tables 1 and 2 below show the different TCE toxicity values used in the 2009 Updated BHHRA, the 2010 Supplemental HHRA, and the toxicity values in EPA's current approach on evaluating TCE (EPA 2011).

Table 1

Cancer toxicity data for TCE – oral/dermal and inhalation

Source	Oral/Dermal CSF[(1)]	Unit	Source	Inhalation Unit Risk	Unit	Source
2009 Updated BHHRA	1.3E-02	$(mg/kg\text{-}day)^{-1}$	CalEPA	2.0E-06	$(\mu g/m^3)^{-1}$	CalEPA
2010 Supp. HHRA	N/A	$(mg/kg\text{-}day)^{-1}$	CalEPA	2.0E-06	$(\mu g/m^3)^{-1}$	CalEPA
Current approach	4.6E-02	$(mg/kg\text{-}day)^{-1}$	IRIS	4.1E-06	$(\mu g/m^3)^{-1}$	IRIS

Table 2

Non-cancer toxicity data for TCE – oral/dermal and inhalation

Source	Oral/Dermal RfD[(1)]	Unit	Source	Inhalation Reference Concentration	Unit	Source
2009 Updated BHHRA	N/A	N/A	N/A	10	µg/m^3	NYSDOH
2010 Supp. HHRA	N/A	N/A	N/A	10	µg/m^3	NYSDOH
Current approach	5.0E-04	mg/kg-day	IRIS	2	µg/m^3	IRIS

Notes:
(1) There are no dermal toxicity values for TCE. Since the oral absorption efficiency to dermal for TCE exceeds 50%, no adjustment of the oral toxicity values is necessary.
N/A = Not Applicable/Not Available

The current approach indicates the cancer toxicity values increase in potency 2-fold for the inhalation pathway (i.e., inhalation unit risk [IUR]) and 8-fold for the oral pathway (i.e., CSF). For non-cancer toxicity values, the current approach indicates toxicity is 2-fold higher for the inhalation pathway (i.e., reference concentration [RfC]). The RfD of 5 x 10^{-4} mg/kg/day is a new value.

The regional screening levels for TCE changed as a result of the changes in toxicity values. Table 3 shows the TCE Regional Screening Levels (RSLs) used in the 2009 Updated BHHRA, the 2010 Supplemental HHRA, and current approach RSLs (EPA 2012).

Table 3

RSLs for TCE – Soil, Air and Water

Source	Soil (Residential) (mg/kg)	Air (ug/m^3)	Water (ug/L)
2009 Updated BHHRA	2.8	1.2	1.7
2010 Supp. HHRA	2.8	1.2	1.7

Current approach	0.91	0.43	0.44

In the 2009 Updated BHHRA, TCE was a COPC for site-wide groundwater (exposure of adult/child residents and construction workers) and ambient air at the J.M. Mills Landfill (older child and adult recreational users). TCE was identified as a primary risk driver for site-wide groundwater, i.e., risks were above 1×10^{-6}. However, even using the toxicity values recommended under the current approach, cancer risks and non-cancer hazards for TCE in site-wide groundwater would still be within the USEPA target risk range of 1×10^{-6} and 1×10^{-4}. Therefore, use of the revised toxicity values for TCE would not significantly change the conclusions of the BHHRA.

In the 2010 Supplemental HHRA, TCE was identified as a COPC for outdoor (trench) air (exposure of construction workers). However, risks and hazards associated with TCE were within USEPA targets. Therefore, use of these revised toxicity values for TCE would not be expected to significantly change the conclusions of the BHHRA.

References

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APPENDIX C.6

SOIL PRG DEVELOPMENT AND CALCULATION OF RESIDUAL RISK

TABLE 1

RISK SUMMARY - COMMERCIAL WORKER

REASONABLE MAXIMUM EXPOSURE

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Scenario Timeframe: Future
Receptor Population: Commercial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Surface + Subsurface Soil	Nunes Parcel											
			Benzo(a)anthracene	1E-06	- -	1E-06	- -	3E-06					
			Benzo(a)pyrene	1E-05	- -	1E-05	- -	2E-05					
			Benzo(b)fluoranthene	2E-06	- -	1E-06	- -	3E-06					
			bis(2-Ethylhexyl)phthalate	2E-06	- -	1E-06	- -	3E-06					
			Dibenz(a,h)anthracene	2E-06	- -	2E-06	- -	3E-06					
			Dieldrin	1E-06	- -	6E-07	- -	2E-06					
			Dioxin TEQ[1]	2E-06	- -	5E-07	- -	3E-06					
			Arsenic	7E-06	- -	1E-06	- -	8E-06					
			Chemical Total	3E-05	- -	2E-05	- -	5E-05		- -	- -	- -	N/A
			Radionuclide Total										
		Exposure Point Total						5E-05					N/A
	Exposure Medium Total							5E-05					N/A
	Indoor Air	Nunes Parcel											
			Naphthalene	- -	3E-06	- -	- -	3E-06					
			Benzene	- -	1E-04	- -	- -	1E-04					
			Chemical Total	- -	1E-04	- -	- -	1E-04		- -	- -	- -	N/A
			Radionuclide Total										
		Exposure Point Total						1E-04					N/A
	Exposure Medium Total							1E-04					N/A
Medium Total								1E-04					N/A
Receptor Total								1E-04					N/A

TABLE 1

RISK SUMMARY - COMMERCIAL WORKER

REASONABLE MAXIMUM EXPOSURE

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Scenario Timeframe: Future
Receptor Population: Commercial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total

- - = Not Evaluated

N/A = Not Applicable

Total Risk Across All Media: 1E-04

Total Hazard Across All Media: N/A

1. Dioxin values have been revised from what was presented in the BHHRA (2007/Updated 2009) based on changes to toxicity values.

Note that tetrachloroethene was previously presented as a primary risk driver in the BHHRA (2007/Updated 2009), but has been removed based on changes to toxicity values.

Total Blood HI =	N/A
Total Cardiovascular HI =	N/A
Total Reproductive HI =	N/A
Total General Toxicity HI =	N/A
Total GI System HI =	N/A
Total Immune System HI =	N/A
Total Kidney HI =	N/A
Total Liver HI =	N/A
Total CNS HI =	N/A
Total Skin HI =	N/A
Total Spleen HI =	N/A
Total Respiratory HI =	N/A
Total Developmental HI =	N/A
Total Endocrine HI =	N/A

TABLE 2

VALUES USED FOR DAILY INTAKE CALCULATIONS - COMMERCIAL WORKER

REASONABLE MAXIMUM EXPOSURE

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Surface + Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion/Dermal	Commercial Worker	Adult	Nunes Parcel						Preliminary Remediation Goal (PRG) cancer = $\frac{1}{\frac{1}{caPRG_{ingestion}} + \frac{1}{caPRG_{dermal}}}$
				IR	Ingestion Rate of Soil	100	mg/day	USEPA, 1997; 2002	where:
				EF	Exposure Frequency	250	days/year	USEPA, 2002	$caPRG_{ingestion} = \frac{TR \times BW \times AT\text{-}C}{SF_O \times IR \times EF \times ED \times CF \times RBA}$
				ED	Exposure Duration	25	years	USEPA, 2004	
				BW	Body Weight	70	kg	USEPA, 1989	$caPRG_{dermal} = \frac{TR \times BW \times AT\text{-}C}{SF_D \times SA \times AF \times ABS \times EF \times ED \times CF}$
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	USEPA, 1989	
				CF	Conversion Factor	0.000001	kg/mg	- -	
				RfD_O	Oral Reference Dose	see Table 3	mg/kg-day	- -	
				RfD_D	Dermal Reference Dose	see Table 3	mg/kg-day	- -	
				THQ	Target Hazard Quotient	1	- -	- -	
				SF_O	Oral Slope Factor	see Table 5	$(mg/kg\text{-}day)^{-1}$	- -	Preliminary Remediation Goal (PRG) non-cancer = $\frac{1}{\frac{1}{ncPRG_{ingestion}} + \frac{1}{ncPRG_{dermal}}}$
				SF_D	Dermal Slope Factor	see Table 5	$(mg/kg\text{-}day)^{-1}$	- -	
				TR	Target ILCR	10^{-6} to 10^{-4}	- -	- -	where:
				SA	Surface Area	3,300	cm^2	USEPA, 2004	$ncPRG_{ingestion} = \frac{THQ \times RfD_D \times BW \times AT\text{-}N}{IR \times EF \times ED \times CF \times RBA}$
				AF	Adherence Factor	0.20	$mg/cm^2\text{-}day$	USEPA, 2004	
				ABS	Dermal absorption fraction	see Table 7	unitless	USEPA, 2004	$ncPRG_{dermal} = \frac{THQ \times RfD_D \times BW \times AT\text{-}N}{SA \times AF \times ABS \times EF \times ED \times CF}$
				RBA	Relative Bioavailability	0.6 for Arsenic/1 for all other analytes	- -	USEPA, 2012	

TABLE 2

VALUES USED FOR DAILY INTAKE CALCULATIONS - COMMERCIAL WORKER

REASONABLE MAXIMUM EXPOSURE

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Surface + Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Commercial Worker	Adult	Nunes Parcel	ET	Exposure Time	8	hours/day		Preliminary Remediation Goal (PRG) cancer = $\frac{TR \times AT\text{-}C \times CF}{UR \times ET \times EF \times ED \times InhF}$
				EF	Exposure frequency	250	days/year	USEPA, 2002	where InhF (ug/m^3) = Soil-to-indoor air factor determined through modeling (see BHHRA)
				ED	Exposure Duration	25	years	USEPA, 2002	
				CF	Conversion factor	24	hours/day	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 2002	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	USEPA, 2002	Preliminary Remediation Goal (PRG) non-cancer = $\frac{THQ \times AT\text{-}N \times RfC \times CF}{ET \times EF \times ED \times InhF}$
				UR	Unit Risk	see Table 6	$(ug/m^3)^{-1}$	- -	
				RfC	Inhalation Reference Concentration	see Table 4	ug/m^3	- -	
				THQ	Target Hazard Quotient	1	- -	- -	where InhF (ug/m^3) = Soil-to-indoor air factor determined through modeling (see BHHRA)
				TR	Target ILCR	10^{-6} to 10^{-4}	- -	- -	

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USEPA. 2004. Risk Assessment Guidance for Superfund, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005. July 2004.

USEPA. 2012. Compilation and Review of Data on Relative Bioavailability of Arsenic in Soil and Recommendations for Default Value for Relative Bioavailability of Arsenic in Soil Documents, OSWER Directive 9200.1-113, December 31, 2012.

TABLE 3

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal (2)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Benzo(a)anthracene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(a)pyrene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bis(2-ethylhexyl)phthalate	Chronic	2E-02	mg/kg-day	(3)	2E-02	mg/kg-day	Liver	1000	IRIS	06/01/13
Dibenz(a,h)anthracene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dieldrin	Chronic	5E-05	mg/kg-day	(3)	5E-05	mg/kg-day	Liver	100	IRIS	06/01/13
Dioxin TEQ	Chronic	7E-10	mg/kg-day	(4)	7E-10	mg/kg-day	Developmental	100	IRIS	06/01/13
Arsenic	Chronic	3E-04	mg/kg-day	(3)	3E-04	mg/kg-day	Skin	3	IRIS	06/01/13

(1) Oral Absorption Efficiencies from Exhibit 4-1, RAGS Part E, USEPA 2004b.

Oral absorption efficiencies for aluminum, cobalt, copper and iron obtained from ATSDR Toxicological Profiles.

(2) Calculated as: (oral RfD) x (oral to dermal adjustment factor).

(3) Oral absorption efficiency exceeds 50%. Therefore, no adjustment of the oral reference dose is necessary (USEPA, 2001).

IRIS = Integrated Risk Information System

N/A = Not Applicable/Not Available

ATSDR = Agency for Toxic Substances and Disease Registry

TABLE 4

NON-CANCER TOXICITY DATA -- INHALATION

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD[(1)]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units	Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Benzene	Chronic	3.0E+01	ug/m^3	N/A	N/A	Immune System	300	IRIS	06/01/13
Naphthalene	Chronic	3.0E+00	ug/m^3	N/A	N/A	Respiratory	3000	IRIS	06/01/13

IRIS = Integrated Risk Information System

N/A = Not Applicable or Not Available

TABLE 5

CANCER TOXICITY DATA -- ORAL/DERMAL

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern (3)	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (1)	Absorbed Cancer Slope Factor for Dermal (2)		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Benzo(a)anthracene	7.3E-01	$(mg/kg\text{-}day)^{-1}$	(1)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	06/01/13
Benzo(a)pyrene	7.3E+00	$(mg/kg\text{-}day)^{-1}$	(1)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	06/01/13
Benzo(b)fluoranthene	7.3E-01	$(mg/kg\text{-}day)^{-1}$	(1)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	06/01/13
Bis(2-ethylhexyl)phthalate	1.4E-02	$(mg/kg\text{-}day)^{-1}$	(1)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	06/01/13
Dibenz(a,h)anthracene	7.3E+00	$(mg/kg\text{-}day)^{-1}$	(1)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	06/01/13
Dieldrin	1.6E+01	$(mg/kg\text{-}day)^{-1}$	(1)	1.6E+01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	06/01/13
Dioxin TEQ	1.56E+05	$(mg/kg\text{-}day)^{-1}$	(1)	1.56E+05	$(mg/kg\text{-}day)^{-1}$	B2	OHEA (3)	1985
Arsenic	1.5E+00	$(mg/kg\text{-}day)^{-1}$	(1)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	06/01/13

IRIS = Integrated Risk Information System

N/A = Not Applicable/Not Available

CalEPA = California Environmental Protection Agency, Office of Environmental Health Hazard Assessment Slope factor for benzo(a)pyrene, along with the appropriate relative potency factor (USEPA, 1993), used for the other carcinogenic PAHs.

(1) Oral absorption efficiency exceeds 50%. Therefore, no adjustment of the oral slope factor is necessary.

(2) Calculated as: (oral slope factor) / (oral to dermal adjustment factor)

(3) EPA. 1985. Health Assessment Document for Polychlorinated Dibenzo-p-Dioxins. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. EPA 600/8-84-014F.

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen (by the oral route)

E - Evidence of noncarcinogenicity

TABLE 6

CANCER TOXICITY DATA -- INHALATION

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description	Unit Risk : Inhalation CSF	
	Value	Units	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Benzene	7.8E-06	$(ug/m^3)^{-1}$	N/A	N/A	A	IRIS	06/01/13
Naphthalene	3.40E-05	$(ug/m^3)^{-1}$	N/A	N/A	C	CalEPA	06/01/13

IRIS = Integrated Risk Information System

CalEPA = California Environmental Protection Agency, Office of Environmental Health Hazard Assessment

N/A = Not Applicable

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen (by the oral route)

E - Evidence of noncarcinogenicity

The unit risk presented for benzene is the high end of the range from 2.2E-06 to 7E-06 per ug/m^3.

Table 7. Dermal Worksheet
Intermediate Variables for Calculating DA(event)
PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2 - SOIL/SEDIMENT

Timeframe	Receptor	Exposure Point	Chemical of Potential Concern	Media	Dermal Absorption Fraction (soil)	FA	Kp		T(event)		Tau		T*		B
						Value	Value	Units	Value	Units	Value	Units	Value	Units	Value
All	All	All													
			Benzo(a)anthracene	Sediment/Soil	0.13	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data
			Benzo(a)pyrene	Sediment/Soil	0.13	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data
			Benzo(b)fluoranthene	Sediment/Soil	0.13	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data
			Bis(2-ethylhexyl)phthalate	Sediment/Soil	0.1	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data
			Dibenz(a,h)anthracene	Sediment/Soil	0.13	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data
			Dieldrin	Sediment/Soil	0.1	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data
			Arsenic	Sediment/Soil	0.03	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data

FA = Fraction Absorbed Water
Kp = Dermal Permeability Coefficient of Compound in Water

T(event) = Event Duration
Tau = Lag Time

T* = Time to Reach Steady-State
B = Dimensionless Ratio of the Permeability Coefficient of a Compound Through the Stratum Corneum Relative to its Permeability Coefficient Across the Viable Epidermis

TABLE 8. HUMAN HEALTH PRELIMINARY REMEDIATION GOALS (PRGs) FOR SOIL

Media/ Scenario	Contaminant	Regulatory Criteria			Risk-Based PRGs[2]					Additional Information		Selected PRG	Basis
		RIDEM Rem. Regs [1]			ILCR			HQ = 1	Lead [5]	Site-specific Range of Reference Levels[3]	RI Background[4]		
		Leachability	I/C DEC	Res. DEC	10^{-6}	10^{-5}	10^{-4}						
Site-wide Soil - mg/kg (Recreational User Scenario)													
	Benzene[6]	0.2	NA	2.5	NA	NA	NA	NA	NA	- -	- -	0.2	Leachability
	Benzo(a)anthracene[6]	--	NA	0.9	NA	NA	NA	NA	NA	0.28	- -	0.9	Res. DEC
	Benzo(a)pyrene[6]	240	NA	0.4	NA	NA	NA	NA	NA	0.30	- -	0.4	Res. DEC
	Benzo(b)fluoranthene[6]	--	NA	0.9	NA	NA	NA	NA	NA	0.42	- -	0.9	Res. DEC
	Benzo(g,h,i)perylene[6]	--	NA	0.8	NA	NA	NA	NA	NA	0.23	- -	0.8	Res. DEC
	Benzo(k)fluoranthene[6]	--	NA	0.9	NA	NA	NA	NA	NA	0.15	- -	0.9	Res. DEC
	bis(2-Ethylhexyl)phthalate[6]	120	NA	46	NA	NA	NA	NA	NA	0.17	- -	46	Res. DEC
	Chrysene[6]	--	NA	0.4	NA	NA	NA	NA	NA	0.30	- -	0.4	Res. DEC
	Dibenz(a,h)anthracene[6]	--	NA	0.4	NA	NA	NA	NA	NA	0.051		0.4	Res. DEC
	Fluoranthene[6]	--	NA	20	NA	NA	NA	NA	NA	0.44	- -	20	Res. DEC
	Indeno(1,2,3-cd)pyrene[6]	--	NA	0.9	NA	NA	NA	NA	NA	0.20	- -	0.9	Res. DEC
	Naphthalene[6]	0.8	NA	54	NA	NA	NA	NA	NA	0.050	- -	0.8	Leachability
	Pyrene[6]	--	NA	13	NA	NA	NA	NA	NA	0.60	- -	13	Res. DEC
	Chlordane[6]	1.4	NA	0.5	NA	NA	NA	NA	NA	0.002	- -	0.5	Res. DEC
	Dieldrin[6]	--	NA	0.04	NA	NA	NA	NA	NA	0.030	- -	0.04	Res. DEC
	PCBs[6]	10	NA	10	NA	NA	NA	NA	NA	0.089	- -	10	Res. DEC
	Antimony[6]	--	NA	10	NA	NA	NA	NA	NA	1.1	- -	10	Res. DEC
	Arsenic[6]	--	NA	7	NA	NA	NA	NA	NA	5.1	1.7	7	Res. DEC
	Beryllium[6]	--	NA	1.5	NA	NA	NA	NA	NA	0.27	- -	1.5	Res. DEC
	Lead[6]	--	NA	150	NA	NA	NA	NA	NA	58	- -	150	Res. DEC
	Manganese[6]	--	NA	390	NA	NA	NA	NA	NA	191	- -	390	Res. DEC
	Thallium[6]	--	NA	5.5	NA	NA	NA	NA	NA	0.20	- -	5.5	Res. DEC

TABLE 8. HUMAN HEALTH PRELIMINARY REMEDIATION GOALS (PRGs) FOR SOIL

Media/ Scenario	Contaminant	Regulatory Criteria: RIDEM Rem. Regs [1] Leachability	Regulatory Criteria: RIDEM Rem. Regs [1] I/C DEC	Regulatory Criteria: RIDEM Rem. Regs [1] Res. DEC	Risk-Based PRGs [2]: ILCR 10^{-6}	ILCR 10^{-5}	ILCR 10^{-4}	HQ = 1	Lead [5]	Additional Information: Site-specific Range of Reference Levels [3]	Additional Information: RI Background [4]	Selected PRG	Basis
Nunes Parcel/RIDEM Removal Area Soil - mg/kg (Commercial Worker Scenario)													
	Benzene	0.2	200	NA	0.0012	0.012	0.12	0.10	NA	- -	- -	0.0012	ILCR = 10^{-6}
	Benzo(a)anthracene	--	7.8	NA	2.1	21	211	NA	NA	0.28	- -	2.1	ILCR = 10^{-6}
	Benzo(a)pyrene	240	0.8	NA	0.21	2.1	21	NA	NA	0.30	- -	0.30	Reference
	Benzo(b)fluoranthene	--	7.8	NA	2.1	21	211	NA	NA	0.42	- -	2.1	ILCR = 10^{-6}
	bis(2-Ethylhexyl)phthalate	120	410	NA	123	1231	12313	12313	NA	0.17	- -	120	Leachability
	Dibenz(a,h)anthracene	--	0.8	NA	0.21	2.1	21	NA	NA	0.051		0.21	ILCR = 10^{-6}
	Indeno(1,2,3-cd)pyrene [6]	--	7.8	NA	NA	NA	NA	NA	NA	0.20	- -	7.8	I/C DEC
	Naphthalene	0.8	10000	NA	0.13	1.3	13	4.9	NA	0.050	- -	0.13	ILCR = 10^{-6}
	Dioxin TEQ	--	--	NA	0.000015	0.00015	0.0015	0.00060	NA	0.000023	- -	0.000023	Reference
	Dieldrin	--	0.4	NA	0.11	1.1	11	31	NA	0.030	- -	0.11	ILCR = 10^{-6}
	Arsenic	--	7	NA	2.4	24	239	384	NA	5.1	1.7	5.1	Reference
	Beryllium [6]	--	1.5	NA	NA	NA	NA	NA	NA	0.27	- -	1.5	I/C DEC
	Lead	--	500	NA	NA	NA	NA	NA	2240	58	- -	500	I/C DEC
Nunes Parcel/RIDEM Removal Area Soil - mg/kg (Construction Worker Scenario)													
	Lead	--	NA	NA	NA	NA	NA	NA	910	58	- -	910	Lead

Notes

ILCR - Incremental Lifetime Cancer Risk

HQ - Hazard Quotient

NA - Not carcinogenic, or a carcinogen was not evaluated for potential non-carcinogenic effects; not applicable

1. RIDEM Rem. Regs. - RIDEM Remediation Regulations, DEM-DSR-01-93, February 2004, Table 1 (Residential Direct Exposure Criteria [DEC] and Industrial/Commercial [I/C] DEC) and Table 2 (GA Leachability Criteria); - - = no criterion
2. Risk-based PRGs are developed based on risk results from the human health risk assessment and consider the ingestion, dermal and inhalation routes of exposure, as applicable. Benzene, and naphthalene only consider the inhalation route of exposure, while all other analytes consider ingestion and dermal exposures. Note that revisions to toxicity data since the Baseline HHRA and Supplemental HHRA for Unnamed Island have resulted in tetrachloroethene no longer being a risk driver. Furthermore, dioxin previously did not have non-carcinogenic effects and arsenic previously did not account for relative bioavailability. PRG calculations are subject to change based on future changes to toxicity values.
3. Geometric mean of Quinnville Wellfield locations LQW-014 to -018, SO-001-BG to SO-005-BG, SO-075-QW, and SO-076-QW, except for Dioxin TEQ, which was taken from Appendix A of Supplemental BERA for Unnamed Island; - - = not detected
4. Arsenic background based on Office Of Waste Management Policy Memo 00-01, Guidance for Arsenic in Soil, September 22, 2000
5. Risk-based soil lead PRGs were calculated utilizing EPA child and adult lead models for the appropriate exposure scenarios - See Table 10
6. Analyte included only due to detections in exceedance of RIDEM Regulatory Criteria. As this analyte was not determined to be a risk driver in the Baseline Human Health Risk Assessment, risk-based PRG calculations are not included for this analyte/exposure scenario.

TABLE 9. RESIDUAL RISK - SOIL

Media/ Scenario	Contaminant	Regulatory Criteria: RIDEM Rem. Regs [1] Leachability	I/C DEC	Res. DEC	Risk-Based PRGs [2] ILCR 10^{-6}	10^{-5}	10^{-4}	HQ = 1	Lead [5]	Additional Information: Site-specific Range of Reference Levels [3]	RI Background [4]	Selected PRG	Basis	Residual Risk At PRG: Estimated ILCR	Estimated HQ
Site-wide Soil - mg/kg (Recreational User Scenario)															
	Benzene[6]	0.2	NA	2.5	NA	NA	NA	NA	NA	- -	- -	0.2	Leachability	<1E-06	
	Benzo(a)anthracene[6]	--	NA	0.9	NA	NA	NA	NA	NA	0.28	- -	0.9	Res. DEC	4E-07	N/A
	Benzo(a)pyrene[6]	240	NA	0.4	NA	NA	NA	NA	NA	0.30	- -	0.4	Res. DEC	2E-06	N/A
	Benzo(b)fluoranthene[6]	--	NA	0.9	NA	NA	NA	NA	NA	0.42	- -	0.9	Res. DEC	4E-07	N/A
	Benzo(g,h,i)perylene[6]	--	NA	0.8	NA	NA	NA	NA	NA	0.23	- -	0.8	Res. DEC	N/A	5E-05
	Benzo(k)fluoranthene[6]	--	NA	0.9	NA	NA	NA	NA	NA	0.15	- -	0.9	Res. DEC	4E-08	N/A
	bis(2-Ethylhexyl)phthalate[6]	120	NA	46	NA	NA	NA	NA	NA	0.17	- -	46	Res. DEC	2E-07	4E-03
	Chrysene[6]	--	NA	0.4	NA	NA	NA	NA	NA	0.30	- -	0.4	Res. DEC	2E-09	N/A
	Dibenz(a,h)anthracene[6]	--	NA	0.4	NA	NA	NA	NA	NA	0.051		0.4	Res. DEC	2E-06	N/A
	Fluoranthene[6]	--	NA	20	NA	NA	NA	NA	NA	0.44	- -	20	Res. DEC	<1E-06	
	Indeno(1,2,3-cd)pyrene[6]	--	NA	0.9	NA	NA	NA	NA	NA	0.20	- -	0.9	Res. DEC	4E-07	N/A
	Naphthalene[6]	0.8	NA	54	NA	NA	NA	NA	NA	0.050	- -	0.8	Leachability	N/A	
	Pyrene[6]	--	NA	13	NA	NA	NA	NA	NA	0.60	- -	13	Res. DEC	<1E-06	
	Chlordane[6]	1.4	NA	0.5	NA	NA	NA	NA	NA	0.002	- -	0.5	Res. DEC	4E-08	1E-03
	Dieldrin[6]	--	NA	0.04	NA	NA	NA	NA	NA	0.030	- -	0.04	Res. DEC	2E-07	1E-03
	PCBs[6]	10	NA	10	NA	NA	NA	NA	NA	0.089	- -	10	Res. DEC	7E-06	9E-01
	Antimony[6]	--	NA	10	NA	NA	NA	NA	NA	1.1	- -	10	Res. DEC	N/A	5E-03
	Arsenic[6]	--	NA	7	NA	NA	NA	NA	NA	5.1	1.7	7	Res. DEC	3E-06	2E-02
	Beryllium[6]	--	NA	1.5	NA	NA	NA	NA	NA	0.27	- -	1.5	Res. DEC	N/A	
	Lead[6]	--	NA	150	NA	NA	NA	NA	NA	58	- -	150	Res. DEC	N/A	N/A
	Manganese[6]	--	NA	390	NA	NA	NA	NA	NA	191	- -	390	Res. DEC	N/A	5E-03
	Thallium[6]	--	NA	5.5	NA	NA	NA	NA	NA	0.20	- -	5.5	Res. DEC	N/A	6E-02
														2E-05	

TABLE 9. RESIDUAL RISK - SOIL

Media/ Scenario	Contaminant	Regulatory Criteria: RIDEM Rem. Regs [1] Leachability	Regulatory Criteria: RIDEM Rem. Regs [1] I/C DEC	Regulatory Criteria: RIDEM Rem. Regs [1] Res. DEC	Risk-Based PRGs [2]: ILCR 10^{-6}	Risk-Based PRGs [2]: ILCR 10^{-5}	Risk-Based PRGs [2]: ILCR 10^{-4}	Risk-Based PRGs [2]: HQ = 1	Risk-Based PRGs [2]: Lead [5]	Additional Information: Site-specific Range of Reference Levels [3]	Additional Information: RI Background [4]	Selected PRG	Basis	Residual Risk At PRG: Estimated ILCR	Residual Risk At PRG: Estimated HQ
Nunes Parcel/RIDEM Removal Area Soil - mg/kg (Commercial Worker Scenario)															
	Benzene	0.2	200	NA	0.0012	0.012	0.12	0.10	NA	- -	- -	0.0012	ILCR = 10^{-6}	1E-06	1E-02
	Benzo(a)anthracene	--	7.8	NA	2.1	21	211	NA	NA	0.28	- -	2.1	ILCR = 10^{-6}	1E-06	N/A
	Benzo(a)pyrene	240	0.8	NA	0.21	2.1	21	NA	NA	0.30	- -	0.30	Reference	1E-06	N/A
	Benzo(b)fluoranthene	--	7.8	NA	2.1	21	211	NA	NA	0.42	- -	2.1	ILCR = 10^{-6}	1E-06	N/A
	bis(2-Ethylhexyl)phthalate	120	410	NA	123	1231	12313	12313	NA	0.17	- -	120	Leachability	1E-06	1E-02
	Dibenz(a,h)anthracene	--	0.8	NA	0.21	2.1	21	NA	NA	0.051		0.21	ILCR = 10^{-6}	1E-06	N/A
	Indeno(1,2,3-cd)pyrene [6]	--	7.8	NA	NA	NA	NA	NA	NA	0.20	- -	7.8	I/C DEC	4E-06	N/A
	Naphthalene	0.8	10000	NA	0.13	1.3	13	4.9	NA	0.050	- -	0.13	ILCR = 10^{-6}	1E-06	3E-02
	Dioxin TEQ	--	--	NA	0.000015	0.00015	0.0015	0.00060	NA	0.000023	- -	0.000023	Reference	1E-06	4E-02
	Dieldrin	--	0.4	NA	0.11	1.1	11	31	NA	0.030	- -	0.11	ILCR = 10^{-6}	1E-06	4E-03
	Arsenic	--	7	NA	2.4	24	239	384	NA	5.1	1.7	5.1	Reference	2E-06	1E-02
	Beryllium [6]	--	1.5	NA	NA	NA	NA	NA	NA	0.27	- -	1.5	I/C DEC	N/A	
	Lead	--	500	NA	NA	NA	NA	NA	2240	58	- -	500	I/C DEC	N/A	N/A
														2E-05	
Nunes Parcel/RIDEM Removal Area Soil - mg/kg (Construction Worker Scenario)															
	Lead	--	NA	NA	NA	NA	NA	NA	910	58	- -	910	Lead	N/A	N/A

Notes

ILCR - Incremental Lifetime Cancer Risk

HQ - Hazard Quotient

NA - Not carcinogenic, or a carcinogen was not evaluated for potential non-carcinogenic effects; not applicable

1. RIDEM Rem. Regs. - RIDEM Remediation Regulations, DEM-DSR-01-93, February 2004, Table 1 (Residential Direct Exposure Criteria [DEC] and Industrial/Commercial [I/C] DEC) and Table 2 (GA Leachability Criteria); - - = no criterion
2. Risk-based PRGs are developed based on risk results from the human health risk assessment and consider the ingestion, dermal and inhalation routes of exposure, as applicable. Benzene, and naphthalene only consider the inhalation route of exposure, while all other analytes consider ingestion and dermal exposures. Note that revisions to toxicity data since the Baseline HHRA and Supplemental HHRA for Unnamed Island have resulted in tetrachloroethene no longer being a risk driver. Furthermore, dioxin previously did not have non-carcinogenic effects. PRG calculations are subject to change based on future changes to toxicity values.
3. Geometric mean of Quinnville Wellfield locations LQW-014 to -018, SO-001-BG to SO-005-BG, SO-075-QW, and SO-076-QW, except for Dioxin TEQ, which was taken from Appendix A of Supplemental BERA for Unnamed Island; - - = not detected
4. Arsenic background based on Office Of Waste Management Policy Memo 00-01, Guidance for Arsenic in Soil, September 22, 2000
5. Risk-based soil lead PRGs were calculated utilizing EPA child and adult lead models for the appropriate exposure scenarios - See Table 10
6. Analyte included only due to detections in exceedance of RIDEM Regulatory Criteria. As this analyte was not determined to be a risk driver in the Baseline Human Health Risk Assessment, risk-based PRG calculations are not included for this analyte/exposure scenario.

TABLE 10

Calculations of Preliminary Remediation Goals (PRGs) For Lead - Soil

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/05

Exposure Variable	Description of Exposure Variable	Units	Construction Worker	Commercial Worker
$PbB_{fetal,\ 0.95}$	95th percentile PbB in fetus	ug/dL	10 [a]	10 [a]
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9 [a]	0.9 [a]
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4 [a]	0.4 [a]
GSD_i	Geometric standard deviation PbB	--	1.8 [b]	1.8 [b]
PbB_0	Baseline PbB	ug/dL	1.0 [b]	1.0 [b]
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.1 [c]	0.050 [d]
$AF_{S,\ D}$	Absorption fraction (same for soil and dust)	--	0.12 [a]	0.12 [a]
$EF_{S,\ D}$	Exposure frequency (same for soil and dust)	days/yr	62 [e]	219 [f]
$AT_{S,\ D}$	Averaging time (same for soil and dust)	days/yr	84 [g]	365 [h]
PRG		**ppm**	**910**	**2,240**

Notes:

***Equation 1, based on Eq. 4 in USEPA (2003).**

$$PRG = \frac{([PbB_{95}fetal/(R*(GSD_i^{1.645})])-PbB_0)*AT_{S,D}}{BKSF*(IR_{S+D}*AF_{S,D}*EF_{S,D})}$$

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same PRG.

[a] Default value (USEPA, 2003); Note that ongoing discussions in the EPA Technical Review Workgroup for Lead may result in reducing the target blood lead level to 5 ug/dL.
[b] Updated default value for women 17-45 years of age (USEPA, 2009).
[c] http://www.epa.gov/superfund/lead/almfaq.htm
[d] Default CTE value for soil ingestion (USEPA, 2003; 2007). Value for commercial worker assumes non-contact-intensive activities.
[e] CTE value used in baseline human health risk assessment (5 days per week for approximately 12 weeks); see BHHRA 2007/updated 2009
[f] Default central tendency estimate of exposure frequency for commercial/industrial workers from USEPA (2007).
[g] Averaging time is based on EF to avoid diluting exposures over the entire year (7 days per week x 12 weeks/year = 84 days/year); see BHHRA 2007/updated 2009
[h] Averaging time appropriate for chronic exposure scenario (USEPA, 2003; 2007).

µg/dL = micrograms per deciliter
g/day = grams per day

References:

USEPA, 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameter. OSWER Dir #9200.2-82. June 2009.
USEPA. 2007. Frequent Questions from Risk Assessors on the ALM. Accessed on-line 4/23/08 at http://www.epa.gov/superfund/health/contaminants/lead/almfaq.htm. Updated August 2, 2007.
USEPA. 2004. Risk Assessment Guidance for Superfund, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005. July 2004.
USEPA. 2003. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. EPA-540-R-03-001. January 2003.
USEPA. 2002. Blood Lead Concentrations of U.S. Adult Females: Summary Statistics From Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). OSWER #9285.7-52. March 2002.
USEPA. 1989. Risk Assessment Guidance for Superfund, Part A, Interim Final. EPA/540/1-89/002. December 1989.

APPENDIX C.7

GROUNDWATER PERFORMANCE STANDARDS (PSs) DEVELOPMENT

TABLE 1

RISK SUMMARY

REASONABLE MAXIMUM EXPOSURE

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Young Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk Young Child + Adult					Non-Carcinogenic Hazard Quotient Young Child				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	On-site Monitoring Wells											
			1,4-Dioxane	1E-05	N/A	N/A	- -	1E-05					
			4-Chloroaniline	5E-06	N/A	N/A	- -	5E-06					
			Atrazine	1E-05	N/A	9E-07	- -	1E-05					
			Benzo(a)anthracene	1E-05	N/A	N/A	- -	1E-05					
			Benzo(a)pyrene	1E-04	N/A	N/A	- -	1E-04					
			Benzo(b)fluoranthene	1E-05	N/A	N/A	- -	1E-05					
			bis(2-Ethylhexyl)phthalate	1E-05	N/A	2E-05	- -	3E-05					
			Indeno(1,2,3-cd)pyrene	5E-06	N/A	N/A	- -	5E-06					
			Naphthalene	N/A	1E-04	N/A	- -	1E-04	General Toxicity	7E-02	2E+00	3E-02	2E+00
			1,4-Dichlorobenzene	8E-07	2E-05	4E-07	- -	2E-05					
			Benzene	1E-03	2E-03	9E-05	- -	3E-03	Immune System	3E+01	2E+01	N/A	4E+01
			Chloroform	2E-06	2E-05	N/A	- -	2E-05					
			Ethylbenzene	3E-06	9E-06	2E-06	- -	1E-05					
			Methyl tert-butyl ether	7E-07	1E-06	N/A	- -	2E-06					
			Trichloroethene	9E-07	2E-06	8E-08	- -	3E-06					
			Vinyl Chloride	1E-04	1E-06	N/A	- -	1E-04					
			Aroclor-1242	1E-05	N/A	N/A	- -	1E-05	General Toxicity/Immune System	2E+00	N/A	N/A	2E+00
			Aroclor-1248	6E-06	N/A	N/A	- -	6E-06					
			Aroclor-1254	2E-05	N/A	N/A	- -	2E-05	General Toxicity/Immune System	3E+00	N/A	N/A	3E+00
			Aldrin	2E-06	N/A	N/A	- -	2E-06					
			Dieldrin	2E-06	N/A	1E-06	- -	4E-06					
			Aluminum						Developmental	1E+00	N/A	6E-01	2E+00
			Arsenic	3E-03	N/A	N/A	- -	3E-03	Skin	4E+01	N/A	N/A	4E+01
			Cadmium (drinking water)						Kidney	5E+00	N/A	5E-01	6E+00
			Cobalt						Endocrine	1E+01	N/A	N/A	1E+01
			Iron						Liver/GI System	1E+01	N/A	N/A	1E+01
			Manganese (drinking water)						CNS	2E+01	N/A	N/A	2E+01
			Thallium						Blood	1E+01	N/A	N/A	1E+01
			Chemical Total	5E-03	2E-03	1E-04	- -	7E-03		1E+02	2E+01	1E+00	2E+02
			Radionuclide Total										
		Exposure Point Total						7E-03					2E+02
	Exposure Medium Total							7E-03					2E+02
Medium Total								7E-03					2E+02
Receptor Total								7E-03					2E+02

TABLE 1

RISK SUMMARY

REASONABLE MAXIMUM EXPOSURE

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Young Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk Young Child + Adult					Non-Carcinogenic Hazard Quotient Young Child				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total

- - = Not Evaluated

N/A = Not Applicable

Total Risk Across All Media: 7E-03

Total Hazard Across All Media: 2E+02

Total Blood HI =	1E+01
Total Cardiovascular HI =	N/A
Total Reproductive HI =	N/A
Total General Toxicity HI =	7E+00
Total GI System HI =	1E+01
Total Immune System HI =	5E+01
Total Kidney HI =	6E+00
Total Liver HI =	1E+01
Total CNS HI =	2E+01
Total Skin HI =	4E+01
Total Spleen HI =	N/A
Total Respiratory HI =	N/A
Total Developmental HI =	2E+00
Total Endocrine HI =	1E+01

TABLE 2

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion/Dermal/ Inhalation	Resident	Adult/Young Child						
			IR_A	Ingestion Rate of Water - adult	2	liters/day	USEPA, 1989	See attached
			EF	Exposure Frequency	350	days/year	USEPA, 2004	
			ED_A	Exposure Duration - adult	24	years	USEPA, 1989	
			BW_A	Body Weight - adult	70	kg	USEPA, 1989	
			AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
			AT-N	Averaging Time (Non-Cancer)	2190	days	USEPA, 1989	
			CF1	Conversion Factor 1	0.001	mg/ug	- -	
			BW_C	Body Weight - child	15	kg	USEPA, 2004	
			IR_C	Ingestion Rate of Water - child	1	liters/day	USEPA, 1997	
			RfD_o	Oral Reference Dose	see Table 3	mg/kg-day	- -	
			RfD_d	Dermal Reference Dose	see Table 3	mg/kg-day	- -	
			RfC	Inhalation Reference Concentration	see Table 4	ug/m^3	- -	
			CF2	Conversion Factor 2	0.001	cm^3/mg	- -	
			CF3	Conversion Factor 3	0.001	$liters/cm^3$	- -	
			K	Volatilization Factor	0.5	L/m^3	USEPA, 1991	
			EV	Event Frequency	1	events/day	USEPA, 2004	
			THQ	Target Hazard Quotient	1	- -	- -	
			ED_C	Exposure Duration - child	6	years	USEPA, 2004	
			SF_o	Oral Slope Factor	see Table 5	$(mg/kg-day)^{-1}$	- -	
			TR	Target ILCR	10^{-6} to 10^{-4}	- -	- -	
			SF_d	Dermal Slope Factor	see Table 5	$(mg/kg-day)^{-1}$	- -	
			UR	Unit Risk	see Table 6	$(ug/m^3)^{-1}$	- -	
			DA_{event}	Dose Absorbed per Unit Area per Event	see Table 8	mg/cm^2-event	USEPA, 2004	
			ET_C	Exposure Time - child	1	hr/event	USEPA, 2012	
			ET_A	Exposure Time - adult	0.58	hr/event	USEPA, 2012	
			GIABS	Gastrointestinal absorption	see Table 8	- -	USEPA, 2012	
			FA	Fraction Absorbed Water	see Table 8	- -	USEPA, 2012	
			MW	Molecular Weight	see Table 8	g/mol	- -	
			SA_A	Skin Surface Area Available for Contact - adult	18000	cm^2	USEPA, 2004	
			SA_C	Skin Surface Area Available for Contact - child	6600	cm^2	USEPA, 2004	

USEPA. 1989. Risk Assessment Guidance for Superfund, Part A, Interim Final. EPA/540/1-89/002. December 1989.

USEPA. 1991. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual, Part B - Interim Final.

USEPA. 1997. Exposure Factors Handbook. EPA/600/P-95/002Fa. August 1997.

USEPA. 2004. Risk Assessment Guidance for Superfund, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005. July 2004.

USEPA. 2012. Regional Screening Level tables (November 2012) and associated online calculator - http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

Intake Equation/
Model Name

Preliminary Remediation Goal (PRG) non-cancer:

Ingestion

$$PRG_{nc\text{-}ing}\ (ug/L) = \frac{THQ \times AT\text{-}N \times RfD_o \times BW_C}{EF \times CF1 \times ED_C \times IR_C}$$

Dermal - inorganics

$$PRG_{nc\text{-}derm}\ (ug/L) = \frac{DA_{event}}{Kp \times ET_C \times CF3}$$

where

$$DA_{event}\ (ug/cm2\text{-}event) = \frac{THQ \times AT\text{-}N \times RfD_o \times GIABS \times BW_C}{EV \times CF1 \times ED_C \times EF \times SA_C}$$

Dermal - organics

if $ET_C <= t^*$

$$PRG_{nc\text{-}derm}\ (ug/L) = \frac{DA_{event}}{2 \times FA \times Kp \times [6 \times tau \times ET_C / \pi]^{0.5} \times CF3}$$

if $ET_C > t^*$

$$PRG_{nc\text{-}derm}\ (ug/L) = \frac{DA_{event}}{FA \times Kp \times [ET_C / (1 + B) + 2 \times tau \times (1 + 3B + 3B^2)/(1 + B)^2] \times CF3}$$

where

$$DA_{event}\ (ug/cm2\text{-}event) = \frac{THQ \times AT\text{-}N \times RfD_o \times GIABS \times BW_C}{EV \times CF1 \times ED_C \times EF \times SA_C}$$

$$B = \frac{Kp \times MW^{0.5}}{2.6}$$

$$tau = \frac{I_{SC}^2}{6 \times D_{SC}}$$

I_{SC} = Skin Thickness (cm; assumed)
1.00E-03

$D_{SC} = I_{SC} \times 10\text{^}(-2.8 - 0.0056 \times MW)$

$t^* =$ If B <= 0.6
$2.4 \times tau$

If B > 0.6
$6 \times tau \times (b - (b^2 - c^2)^{0.5})$

$$b = \frac{2 \times (1 + B)^2}{\pi} - c$$

$$c = \frac{1 + 3 \times B + 3 \times B^2}{3 \times (1 + B)}$$

Inhalation

$$PRG_{nc\text{-}inh}\ (ug/L) = \frac{THQ \times AT\text{-}N \times RfC}{EF \times ED_C \times K}$$

Total

$$PRG_{nc\text{-}tot}\ (ug/L) = \frac{1}{1/PRG_{nc\text{-}ing} + 1/PRG_{nc\text{-}derm} + 1/PRG_{nc\text{-}inh}}$$

Preliminary Remediation Goal (PRG) cancer:

Ingestion

$$PRG_{ca\text{-}ing}\ (ug/L) = \frac{TR \times AT\text{-}C}{EF \times CF1 \times SF_o \times IFW_{adj}}$$

$$IFW_{adj} = \frac{ED_C \times IR_C}{BW_C} + \frac{ED_A \times IR_A}{BW_A}$$

Dermal - inorganics

$$PRG_{ca\text{-}derm}\ (ug/L) = \frac{DA_{event}}{Kp \times ET_{adj} \times CF3}$$

where

$$ET_{adj} = ET_C \times ED_C/30 + ET_A \times ED_A/30$$

$$DA_{event}\ (ug/cm2\text{-}event) = \frac{TR \times AT\text{-}C \times GIABS}{SF_o \times CF1 \times EF \times DFW_{adj}}$$

$$DFW_{adj} = \frac{EV \times ED_C \times SA_C}{BW_C} + \frac{EV \times ED_A \times SA_A}{BW_A}$$

Dermal - organics

if ET_{adj} <= t*

$$PRG_{ca\text{-}derm}\ (ug/L) = \frac{DA_{event}}{2 \times FA \times Kp \times [6 \times tau \times ET_{adj} / \pi]^{0.5} \times CF3}$$

if ET_{adj} > t*

$$PRG_{ca\text{-}derm}\ (ug/L) = \frac{DA_{event}}{FA \times Kp \times [ET_{adj} / (1 + B) + 2 \times tau \times (1 + 3B + 3B^2)/(1 + B)^2] \times CF3}$$

where

$$DA_{event}\ (ug/cm2\text{-}event) = \frac{TR \times AT\text{-}C \times GIABS}{SF_o \times CF1 \times EF \times DFW_{adj}}$$

$$B = \frac{Kp \times MW^{0.5}}{2.6}$$

$$tau = \frac{I_{SC}^2}{6 \times D_{SC}}$$

$$I_{SC} = \frac{\text{Skin Thickness (cm; assumed)}}{1.00E\text{-}03}$$

$$D_{SC} = I_{SC} \times 10\text{^}(-2.8 - 0.0056 \times MW)$$

$$t^* = \begin{cases} \text{If } B <= 0.6 \\ 2.4 \times tau \\ \\ \text{If } B > 0.6 \\ 6 \times tau \times (b - (b^2 - c^2)^{0.5}) \end{cases}$$

$$b = \frac{2 \times (1 + B)^2}{\pi} - c$$

$$c = \frac{1 + 3 \times B + 3 \times B^2}{3 \times (1 + B)}$$

Inhalation

$$PRG_{ca\text{-}inh}\ (ug/L) = \frac{TR \times AT\text{-}C}{EF \times (ED_C + ED_{A)} \times UR \times K}$$

Total

$$PRG_{ca\text{-}tot}\ (ug/L) = \frac{1}{1/PRG_{ca\text{-}ing} + 1/PRG_{ca\text{-}derm} + 1/PRG_{ca\text{-}inh}}$$

Preliminary Remediation Goal (PRG) mutagenic:

Ingestion

$$PRG_{mu\text{-}ing}\ (ug/L) = \frac{TR \times AT\text{-}C}{EF \times CF1 \times SF_o \times IFWM_{adj}}$$

$$IFWM_{adj} = \frac{ED_{0\text{-}2} \times IR_C \times 10}{BW_C} + \frac{ED_{2\text{-}6} \times IR_C \times 3}{BW_C} + \frac{ED_{6\text{-}16} \times IR_A \times 3}{BW_A} + \frac{ED_{16\text{-}30} \times IR_A}{BW_A}$$

Dermal - inorganics

$$PRG_{mu\text{-}derm}\ (ug/L) = \frac{DA_{event}}{Kp \times ET_{madj} \times CF3}$$

where

$$ET_{madj} = \frac{ET_C \times ED_{0\text{-}2} + ET_C \times ED_{2\text{-}6} + ET_A \times ED_{6\text{-}16} + ET_A \times ED_{16\text{-}30}}{ED_{0\text{-}2} + ED_{2\text{-}6} + ED_{6\text{-}16} + ED_{16\text{-}30}}$$

$$DA_{event}\ (ug/cm2\text{-}event) = \frac{TR \times AT\text{-}C \times GIABS}{SF_o \times CF1 \times EF \times DFWM_{adj}}$$

$$DFWM_{adj} = \frac{ED_{0\text{-}2} \times SA_C \times 10}{BW_C} + \frac{ED_{2\text{-}6} \times SA_C \times 3}{BW_C} + \frac{ED_{6\text{-}16} \times SA_A \times 3}{BW_A} + \frac{ED_{16\text{-}30} \times SA_A}{BW_A}$$

Dermal - organics

if $ET_{madj} <= t^*$

$$PRG_{mu\text{-}derm}\ (ug/L) = \frac{DA_{event}}{2 \times FA \times Kp \times [6 \times tau \times ET_{madj} / \pi]^{0.5} \times CF3}$$

if $ET_{madj} > t^*$

$$PRG_{mu\text{-}derm}\ (ug/L) = \frac{DA_{event}}{FA \times Kp \times [ET_{madj} / (1 + B) + 2 \times tau \times (1 + 3B + 3B^2)/(1 + B)^2] \times CF3}$$

where

$$DA_{event}\ (ug/cm2\text{-}event) = \frac{TR \times AT\text{-}C \times GIABS}{SF_o \times CF1 \times EF \times DFWM_{adj}}$$

$$B = \frac{Kp \times MW^{0.5}}{2.6}$$

$$tau = \frac{I_{SC}^2}{6 \times D_{SC}}$$

$$I_{SC} = \frac{\text{Skin Thickness (cm; assumed)}}{1.00E\text{-}03}$$

$$D_{SC} = I_{SC} \times 10\text{^}(-2.8 - 0.0056 \times MW)$$

$$t^* = \begin{cases} \text{If } B <= 0.6 \\ 2.4 \times tau \\ \text{If } B > 0.6 \\ 6 \times tau \times (b - (b^2 - c^2)^{0.5}) \end{cases}$$

$$b = \frac{2 \times (1 + B)^2}{\pi} - c$$

$$c = \frac{1 + 3 \times B + 3 \times B^2}{3 \times (1 + B)}$$

Inhalation

$$PRG_{mu\text{-}inh}\ (ug/L) = \frac{TR \times AT\text{-}C}{EF \times K \times INFM_{adj}}$$

$$INFM_{adj} = ED_{0\text{-}2} \times UR \times 10 + ED_{2\text{-}6} \times UR \times 3 + ED_{6\text{-}16} \times UR \times 3 + ED_{16\text{-}30} \times UR$$

Total

$$PRG_{mu\text{-}tot}\ (ug/L) = \frac{1}{1/PRG_{mu\text{-}ing} + 1/PRG_{mu\text{-}derm} + 1/PRG_{mu\text{-}inh}}$$

Preliminary Remediation Goal (PRG) vinyl chloride:

Ingestion

$$PRG_{vc\text{-}ing}\ (ug/L) = \frac{TR}{CF1 \times SF_o \times ((EF \times IFW_{adj}) / AT\text{-}C + (IR_C / BW_C))}$$

$$IFW_{adj} = \frac{ED_C \times IR_C}{BW_C} + \frac{ED_A \times IR_A}{BW_A}$$

Dermal - organics

$$ET_{adj} = ET_C \times ED_C/30 + ET_A \times ED_A/30$$

$$DFW_{adj} = \frac{EV \times ED_C \times SA_C}{BW_C} + \frac{EV \times ED_A \times SA_A}{BW_A}$$

if ET_{adj} <= t*

$$PRG_{vc\text{-}derm}\ (ug/L) = \frac{DA_{event}}{2 \times FA \times Kp \times [6 \times tau \times ET_{madj} / \pi]^{0.5} \times CF3}$$

if ET_{adj} > t*

$$PRG_{vc\text{-}derm}\ (ug/L) = \frac{DA_{event}}{FA \times Kp \times [ET_{adj} / (1 + B) + 2 \times tau \times (1 + 3B + 3B^2)/(1 + B)^2] \times CF3}$$

where

$$DA_{event}\ (ug/cm2\text{-}event) = \frac{TR \times GIABS}{SF_o \times CF1 \times ((EF \times DFW_{adj}) / AT\text{-}C + SA_C / BW_C)}$$

$$B = \frac{Kp \times MW^{0.5}}{2.6}$$

$$tau = \frac{l_{SC}^2}{6 \times D_{SC}}$$

l_{SC} = Skin Thickness (cm; assumed) = 1.00E-03

$$D_{SC} = l_{SC} \times 10^{(-2.8 - 0.0056 \times MW)}$$

$$t^* = \begin{cases} \text{If } B <= 0.6: & 2.4 \times tau \\ \text{If } B > 0.6: & 6 \times tau \times (b - (b^2 - c^2)^{0.5}) \end{cases}$$

$$b = \frac{2 \times (1 + B)^2}{\pi} - c$$

$$c = \frac{1 + 3 \times B + 3 \times B^2}{3 \times (1 + B)}$$

Inhalation

$$PRG_{vc\text{-}inh}\ (ug/L) = \frac{TR}{UR \times K \times (EF \times (ED_C + ED_A))/AT\text{-}C + 1)}$$

Total

$$PRG_{vc\text{-}tot}\ (ug/L) = \frac{1}{1/PRG_{vc\text{-}ing} + 1/PRG_{vc\text{-}derm} + 1/PRG_{vc\text{-}inh}}$$

TABLE 3

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern (3)	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal (2)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
1,4-Dichlorobenzene	Chronic	7E-02	mg/kg-day	(4)	7E-02	mg/kg-day	Liver	100	ATSDR	05/20/13
Benzene	Chronic	4E-03	mg/kg-day	(4)	4E-03	mg/kg-day	Immune System	300	IRIS	05/20/13
Chloroform	Chronic	1E-02	mg/kg-day	(4)	1E-02	mg/kg-day	Liver	100	IRIS	05/20/13
Ethylbenzene	Chronic	1E-01	mg/kg-day	(4)	1E-01	mg/kg-day	Liver/Kidney	1000	IRIS	05/20/13
Methyl tert-butyl ether	Chronic	3E-01	mg/kg-day	(4)	3E-01	mg/kg-day	Liver	300	ATSDR	05/20/13
Trichloroethene	Chronic	5E-04	mg/kg-day	(4)	5E-04	mg/kg-day	Developmental/ Immune System	10 (Dev.) / 100 (Immune System)	IRIS	05/20/13
Vinyl Chloride	Chronic	3E-03	mg/kg-day	(4)	3E-03	mg/kg-day	Liver	30	IRIS	05/20/13
1,4-Dioxane	Chronic	3E-02	mg/kg-day	(4)	3E-02	mg/kg-day	Liver/Kidney	300	IRIS	05/20/13
4-Chloroaniline	Chronic	4E-03	mg/kg-day	(4)	4E-03	mg/kg-day	Spleen	3000	IRIS	05/20/13
Atrazine	Chronic	3.5E-02	mg/kg-day	(4)	3.5E-02	mg/kg-day	General Toxicity/Cardiovascular	100	IRIS	05/20/13
Benzo(a)anthracene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(a)pyrene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bis(2-ethylhexyl)phthalate	Chronic	2E-02	mg/kg-day	(4)	2E-02	mg/kg-day	Liver	1000	IRIS	05/20/13
Indeno(1,2,3-cd)pyrene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Naphthalene	Chronic	2E-02	mg/kg-day	(4)	2E-02	mg/kg-day	General Toxicity	3000	IRIS	05/20/13
Aroclor-1242	Chronic	2E-05	mg/kg-day	(4)	2E-05	mg/kg-day	General Toxicity/Immune System	300	IRIS	05/20/13
Aroclor-1248	Chronic	2E-05	mg/kg-day	(4)	2E-05	mg/kg-day	General Toxicity/Immune System	300	IRIS	05/20/13
Aroclor-1254	Chronic	2E-05	mg/kg-day	(4)	2E-05	mg/kg-day	General Toxicity/Immune System	300	IRIS	05/20/13
Aldrin	Chronic	3E-05	mg/kg-day	(4)	3E-05	mg/kg-day	Liver	1000	IRIS	05/20/13
Dieldrin	Chronic	5E-05	mg/kg-day	(4)	5E-05	mg/kg-day	Liver	100	IRIS	05/20/13
Aluminum	Chronic	1E+00	mg/kg-day	0.01	1.0E-02	mg/kg-day	Developmental	100	PPRTV	05/20/13
Arsenic	Chronic	3E-04	mg/kg-day	(4)	3E-04	mg/kg-day	Skin	3	IRIS	05/20/13
Cadmium (drinking water)	Chronic	5E-04	mg/kg-day	0.05	2.5E-05	mg/kg-day	Kidney	10	IRIS	05/20/13
Cobalt	Chronic	3E-04	mg/kg-day	(4)	3E-04	mg/kg-day	Endocrine	3000	PPRTV	05/20/13
Iron	Chronic	7E-01	mg/kg-day	(4)	7E-01	mg/kg-day	Liver/GI System	1.5	PPRTV	05/20/13
Manganese (drinking water)	Chronic	2.4E-02	mg/kg-day	0.04	9.6E-04	mg/kg-day	CNS	9	IRIS	05/20/13
Thallium	Chronic	1E-05	mg/kg-day	(4)	1E-05	mg/kg-day	Blood	3000	PPRTV	05/20/13

TABLE 3

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern (3)	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal (2)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)

(1) Oral Absorption Efficiencies from Exhibit 4-1, RAGS Part E, USEPA 2004b.
Oral absorption efficiencies for aluminum, cobalt, and iron obtained from ATSDR Toxicological Profiles.

(2) Calculated as: (oral RfD) x (oral to dermal adjustment factor).

(3) RfD for Aroclor 1254 used as a surrogate for Aroclor 1242 and Aroclor 1248 (High risk and persistence; upper-bound slope factor).
RfD for manganese is based on total allowable intake (10 mg/day) minus the background intake (5 mg/day). The remaining intake (5 mg/day) is divided by 70 kg.
RfD for thallium is based on thallium, soluble salts and is based on IRIS discussion and Regional Screening Level table (November 2012). Different than BHHRA.
RfD for 1,4-dioxane is different than that used in the BHHRA.

(4) Oral absorption efficiency exceeds 50%. Therefore, no adjustment of the oral reference dose is necessary (USEPA, 2001).
When the chronic RfD is based on a subchronic study, a subchronic RfD has been developed by the elimination of the 10-fold uncertainty factor for subchronic to chronic adjustment.

IRIS = Integrated Risk Information System
HEAST = Health Effects Assessment Summary Tables
N/A = Not Applicable/Not Available
NOAEL = No Observed Adverse Effects Level
STSC = Superfund Technical Support Center
ATSDR = Agency for Toxic Substances and Disease Registry
PPRTV = Provisional Peer Reviewed Toxicity Values developed by STSC

TABLE 4

NON-CANCER TOXICITY DATA -- INHALATION

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD[(1)]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units	Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
1,4-Dichlorobenzene	Chronic	8.0E+02	ug/m^3	N/A	N/A	Liver	100	IRIS	05/20/13
Benzene	Chronic	3.0E+01	ug/m^3	N/A	N/A	Immune System	300	IRIS	05/20/13
Chloroform	Chronic	9.8E+01	ug/m^3	N/A	N/A	Liver	100	ATSDR	05/20/13
Ethylbenzene	Chronic	1.0E+03	ug/m^3	N/A	N/A	Developmental	300	IRIS	05/20/13
Methyl tert-butyl ether	Chronic	3.0E+03	ug/m^3	N/A	N/A	Liver/Kidney	100	IRIS	05/20/13
Trichloroethene	Chronic	2.0E+00	ug/m^3	N/A	N/A	Developmental, Immune System	10 (Dev.) / 100 (Immune System)	IRIS	05/20/13
Vinyl Chloride	Chronic	1.0E+02	ug/m^3	N/A	N/A	Liver	30	IRIS	05/20/13
Benzo(a)anthracene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(a)pyrene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bis(2-ethylhexyl)phthalate	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Indeno(1,2,3-cd)pyrene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Naphthalene	Chronic	3.0E+00	ug/m^3	N/A	N/A	Respiratory	3000	IRIS	05/20/13
Aroclor-1248	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Aroclor-1254	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dieldrin	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Aluminum	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	Chronic	1.5E-03	ug/m^3	N/A	N/A	Developmental	30	CalEPA	05/20/13
Cadmium (drinking water)	Chronic	1.0E-02	ug/m^3	N/A	N/A	Kidney	9	ATSDR	05/20/13
Cobalt	Chronic	6.0E-03	ug/m^3	N/A	N/A	Respiratory	300	PPRTV	05/20/13
Iron	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manganese (drinking water)	Chronic	5.0E-02	ug/m^3	N/A	N/A	CNS	1000	IRIS	05/20/13
Thallium	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 4

NON-CANCER TOXICITY DATA -- INHALATION

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD[(1)]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units	Value	Units			Source(s)	Date(s) (MM/DD/YYYY)

IRIS = Integrated Risk Information System

STSC = Superfund Technical Support Center

PPRTV = Provisional Peer Reviewed Toxicity Value developed by STSC

CalEPA = California Environmental Protection Agency, Office of Environmental Health Hazard Assessment

ATSDR = Agency for Toxic Substances and Disease Registry

N/A = Not Applicable or Not Available

Chloroform RfC different from that used in the BHHRA (which was rounded).

TABLE 5

CANCER TOXICITY DATA -- ORAL/DERMAL

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal	Absorbed Cancer Slope Factor for Dermal (2)		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units	(1)	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
1,4-Dichlorobenzene	5.4E-03	(mg/kg-day)$^{-1}$	(1)	5.4E-03	(mg/kg-day)$^{-1}$	C	CalEPA	05/20/13
Benzene	5.5E-02	(mg/kg-day)$^{-1}$	(1)	5.5E-02	(mg/kg-day)$^{-1}$	A	IRIS	05/20/13
Chloroform	3.10E-02	(mg/kg-day)$^{-1}$	(1)	3.10E-02	(mg/kg-day)$^{-1}$	B2	CalEPA	05/20/13
Ethylbenzene	1.10E-02	(mg/kg-day)$^{-1}$	(1)	1.10E-02	(mg/kg-day)$^{-1}$	B2	CalEPA	05/20/13
Methyl tert-butyl ether	1.8E-03	(mg/kg-day)$^{-1}$	(1)	1.8E-03	(mg/kg-day)$^{-1}$	B2	CalEPA	05/20/13
Trichloroethene	4.6E-02	(mg/kg-day)$^{-1}$	(1)	4.6E-02	(mg/kg-day)$^{-1}$	A	IRIS	05/20/13
Vinyl Chloride	7.2E-01	(mg/kg-day)$^{-1}$	(1)	7.2E-01	(mg/kg-day)$^{-1}$	A	IRIS	05/20/13
1,4-Dioxane	1.0E-01	(mg/kg-day)$^{-1}$	(1)	1.0E-01	(mg/kg-day)$^{-1}$	B2	IRIS	05/20/13
4-Chloroaniline	2.0E-01	(mg/kg-day)$^{-1}$	(1)	2.0E-01	(mg/kg-day)$^{-1}$	C	PPRTV	05/20/13
Atrazine	2.3E-01	(mg/kg-day)$^{-1}$	(1)	2.3E-01	(mg/kg-day)$^{-1}$	C	CalEPA	05/20/13
Benzo(a)anthracene	7.3E-01	(mg/kg-day)$^{-1}$	(1)	7.3E-01	(mg/kg-day)$^{-1}$	B2	IRIS	05/20/13
Benzo(a)pyrene	7.3E+00	(mg/kg-day)$^{-1}$	(1)	7.3E+00	(mg/kg-day)$^{-1}$	B2	IRIS	05/20/13
Benzo(b)fluoranthene	7.3E-01	(mg/kg-day)$^{-1}$	(1)	7.3E-01	(mg/kg-day)$^{-1}$	B2	IRIS	05/20/13
Bis(2-ethylhexyl)phthalate	1.4E-02	(mg/kg-day)$^{-1}$	(1)	1.4E-02	(mg/kg-day)$^{-1}$	B2	IRIS	05/20/13
Indeno(1,2,3-cd)pyrene	7.3E-01	(mg/kg-day)$^{-1}$	(1)	7.3E-01	(mg/kg-day)$^{-1}$	B2	IRIS	05/20/13
Naphthalene	N/A	N/A	N/A	N/A	N/A	C	IRIS	05/20/13
Aroclor-1242	2E+00	(mg/kg-day)$^{-1}$	(1)	2E+00	(mg/kg-day)$^{-1}$	B2	IRIS	05/20/13
Aroclor-1248	2E+00	(mg/kg-day)$^{-1}$	(1)	2E+00	(mg/kg-day)$^{-1}$	B2	IRIS	05/20/13
Aroclor-1254	2E+00	(mg/kg-day)$^{-1}$	(1)	2E+00	(mg/kg-day)$^{-1}$	B2	IRIS	05/20/13
Aldrin	1.7E+01	(mg/kg-day)$^{-1}$	(1)	1.7E+01	(mg/kg-day)$^{-1}$	B2	IRIS	05/20/13
Dieldrin	1.6E+01	(mg/kg-day)$^{-1}$	(1)	1.6E+01	(mg/kg-day)$^{-1}$	B2	IRIS	05/20/13
Aluminum	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	1.5E+00	(mg/kg-day)$^{-1}$	(1)	1.5E+00	(mg/kg-day)$^{-1}$	A	IRIS	05/20/13
Cadmium (drinking water)	N/A	N/A	N/A	N/A	N/A	D	IRIS	05/20/13
Cobalt	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Iron	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manganese (drinking water)	N/A	N/A	N/A	N/A	N/A	D	IRIS	05/20/13
Thallium	N/A	N/A	N/A	N/A	N/A	D	IRIS	05/20/13

TABLE 5

CANCER TOXICITY DATA -- ORAL/DERMAL

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (1)	Absorbed Cancer Slope Factor for Dermal (2)		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)

IRIS = Integrated Risk Information System

STSC = Superfund Technical Support Center

PPRTV = Provisional Peer Reviewed Toxicity Value developed by STSC

N/A = Not Applicable/Not Available

CalEPA = California Environmental Protection Agency, Office of Environmental Health Hazard Assessment

Slope factor for benzo(a)pyrene, along with the appropriate relative potency factor (USEPA, 1993), used for the other carcinogenic PAHs.

The slope factor presented for benzene is the high end of the range from 0.015 to 0.055 per mg/kg-day.

For PCBs, the RME slope factor presented represents the upper-bound slope factor for high risk and persistence situations.

Slope factor for 1,4-dioxane is different than that used in the BHHRA.

(1) Oral absorption efficiency exceeds 50%. Therefore, no adjustment of the oral slope factor is necessary.

(2) Calculated as: (oral slope factor) / (oral to dermal adjustment factor)

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen (by the oral route)

E - Evidence of noncarcinogenicity

TABLE 6

CANCER TOXICITY DATA -- INHALATION

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description	Unit Risk : Inhalation CSF	
	Value	Units	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
1,4-Dichlorobenzene	1.10E-05	$(ug/m^3)^{-1}$	N/A	N/A	C	CalEPA	05/20/13
Benzene	7.8E-06	$(ug/m^3)^{-1}$	N/A	N/A	A	IRIS	05/20/13
Chloroform	2.3E-05	$(ug/m^3)^{-1}$	N/A	N/A	B2	IRIS	05/20/13
Ethylbenzene	2.50E-06	$(ug/m^3)^{-1}$	N/A	N/A	B2	CalEPA	05/20/13
Methyl tert-butyl ether	2.6E-07	$(ug/m^3)^{-1}$	N/A	N/A	B2	CalEPA	05/20/13
Trichloroethene	4.1E-06	$(ug/m^3)^{-1}$	N/A	N/A	A	IRIS	05/20/13
Vinyl Chloride	4.4E-06	$(ug/m^3)^{-1}$	N/A	N/A	A	IRIS	05/20/13
Benzo(a)anthracene	1.1E-04	$(ug/m^3)^{-1}$	N/A	N/A	B2	CalEPA	05/20/13
Benzo(a)pyrene	1.1E-03	$(ug/m^3)^{-1}$	N/A	N/A	B2	CalEPA	05/20/13
Benzo(b)fluoranthene	1.1E-04	$(ug/m^3)^{-1}$	N/A	N/A	B2	CalEPA	05/20/13
Bis(2-ethylhexyl)phthalate	NA	N/A	N/A	N/A	B2	IRIS	05/20/13
Indeno(1,2,3-cd)pyrene	1.1E-04	$(ug/m^3)^{-1}$	N/A	N/A	B2	CalEPA	05/20/13
Naphthalene	3.40E-05	$(ug/m^3)^{-1}$	N/A	N/A	C	CalEPA	05/20/13
Aroclor-1248	5.7E-04	$(ug/m^3)^{-1}$	N/A	N/A	B2	IRIS	05/20/13
Aroclor-1254	5.7E-04	$(ug/m^3)^{-1}$	N/A	N/A	B2	IRIS	05/20/13
Dieldrin	4.6E-03	$(ug/m^3)^{-1}$	N/A	N/A	B2	IRIS	05/20/13
Aluminum	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	4.30E-03	$(ug/m^3)^{-1}$	N/A	N/A	A	IRIS	05/20/13
Cadmium (drinking water)	1.80E-03	$(ug/m^3)^{-1}$	N/A	N/A	B1	IRIS	05/20/13
Cobalt	9.00E-03	$(ug/m^3)^{-1}$	N/A	N/A	B2	PPRTV	05/20/13
Iron	N/A	N/A	N/A	N/A	N/A	N/A	05/20/13
Manganese (drinking water)	N/A	N/A	N/A	N/A	D	IRIS	05/20/13
Thallium	N/A	N/A	N/A	N/A	D	IRIS	05/20/13

TABLE 6

CANCER TOXICITY DATA -- INHALATION

PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description	Unit Risk : Inhalation CSF	
	Value	Units	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)

IRIS = Integrated Risk Information System

STSC = Superfund Technical Support Center

PPRTV = Provisional Peer Reviewed Toxicity Values developed by STSC

CalEPA = California Environmental Protection Agency, Office of Environmental Health Hazard Assessment

N/A = Not Applicable

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen (by the oral route)

E - Evidence of noncarcinogenicity

The unit risk presented for benzene is the high end of the range from 2.2E-06 to 7E-06 per ug/m^3.

The unit risk presented for trichloroethene is the adult-based value. For early-life exposures, tumor-specific unit risk values of 1E-06 $(ug/m^3)^{-1}$ for kidney tumors and 3.1E-06 $(ug/m^3)^{-1}$ for combined liver tumors and non-Hodgkins lymphoma (NHL) are used in conjuction with age-dependent adjustment factors, as appropriate.

TABLE 7. INTERMEDIATE GROUNDWATER PERFORMANCE STANDARD CALCULATIONS - INGESTION

Chemical	Mutagenic?	EF days	ED_C yrs	ED_A yrs	BW_C kg	BW_A kg	IR_C L/day	IR_A L/day	AT-N days	AT-C days	CF1 mg/ug	SF_o $(mg/kg\text{-}day)^{-1}$	RfD_o mg/kg-day	THQ	TR	IFW_{adj} (L-yr/kg-day)	$IFWM_{adj}$ (L-yr/kg-day)	$PRG_{ca\text{-}ing}$ ug/L	$PRG_{nc\text{-}ing}$ ug/L
1,4-Dioxane		350	6	24	15	70	1	2	2190	25550	0.001	1.0E-01	3E-02	1	1E-06	1.08571429	3.39047619	**6.7E-01**	**4.7E+02**
4-Chloroaniline		350	6	24	15	70	1	2	2190	25550	0.001	2.0E-01	4E-03	1	1E-06	1.08571429	3.39047619	**3.4E-01**	**6.3E+01**
Atrazine		350	6	24	15	70	1	2	2190	25550	0.001	2.3E-01	3.5E-02	1	1E-06	1.08571429	3.39047619	**2.9E-01**	**5.5E+02**
Benzo(a)anthracene	Y	350	6	24	15	70	1	2	2190	25550	0.001	7.3E-01	N/A	1	1E-06	1.08571429	3.39047619	**2.9E-02**	**N/A**
Benzo(a)pyrene	Y	350	6	24	15	70	1	2	2190	25550	0.001	7.3E+00	N/A	1	1E-06	1.08571429	3.39047619	**2.9E-03**	**N/A**
Benzo(b)fluoranthene	Y	350	6	24	15	70	1	2	2190	25550	0.001	7.3E-01	N/A	1	1E-06	1.08571429	3.39047619	**2.9E-02**	**N/A**
bis(2-Ethylhexyl)phthalate		350	6	24	15	70	1	2	2190	25550	0.001	1.4E-02	2E-02	1	1E-06	1.08571429	3.39047619	**4.8E+00**	**3.1E+02**
Indeno(1,2,3-cd)pyrene	Y	350	6	24	15	70	1	2	2190	25550	0.001	7.3E-01	N/A	1	1E-06	1.08571429	3.39047619	**2.9E-02**	**N/A**
Naphthalene		350	6	24	15	70	1	2	2190	25550	0.001	N/A	2E-02	1	1E-06	1.08571429	3.39047619	**N/A**	**3.1E+02**
1,4-Dichlorobenzene		350	6	24	15	70	1	2	2190	25550	0.001	5.4E-03	7E-02	1	1E-06	1.08571429	3.39047619	**1.2E+01**	**1.1E+03**
Benzene		350	6	24	15	70	1	2	2190	25550	0.001	5.5E-02	4E-03	1	1E-06	1.08571429	3.39047619	**1.2E+00**	**6.3E+01**
Chloroform		350	6	24	15	70	1	2	2190	25550	0.001	3.1E-02	1E-02	1	1E-06	1.08571429	3.39047619	**2.2E+00**	**1.6E+02**
Ethylbenzene		350	6	24	15	70	1	2	2190	25550	0.001	1.1E-02	1E-01	1	1E-06	1.08571429	3.39047619	**6.1E+00**	**1.6E+03**
Methyl tert-butyl ether		350	6	24	15	70	1	2	2190	25550	0.001	1.8E-03	3E-01	1	1E-06	1.08571429	3.39047619	**3.7E+01**	**4.7E+03**
Trichloroethene	Y	350	6	24	15	70	1	2	2190	25550	0.001	4.6E-02	5E-04	1	1E-06	1.08571429	3.39047619	**1.0E+00**	**7.8E+00**
kidney	Y	350	6	24	15	70	1	2	2190	25550	0.001	9.3E-03	N/A	1	1E-06	1.08571429	3.39047619	**2.3E+00**	
non-kidney		350	6	24	15	70	1	2	2190	25550	0.001	3.7E-02	N/A	1	1E-06	1.08571429	3.39047619	**1.8E+00**	
Vinyl Chloride	Y	350	6	24	15	70	1	2	2190	25550	0.001	7.2E-01	3E-03	1	1E-06	1.08571429	3.39047619	**1.7E-02**	**4.7E+01**
Aroclor-1242		350	6	24	15	70	1	2	2190	25550	0.001	2E+00	2E-05	1	1E-06	1.08571429	3.39047619	**3.4E-02**	**3.1E-01**
Aroclor-1248		350	6	24	15	70	1	2	2190	25550	0.001	2E+00	2E-05	1	1E-06	1.08571429	3.39047619	**3.4E-02**	**3.1E-01**
Aroclor-1254		350	6	24	15	70	1	2	2190	25550	0.001	2E+00	2E-05	1	1E-06	1.08571429	3.39047619	**3.4E-02**	**3.1E-01**
Aldrin		350	6	24	15	70	1	2	2190	25550	0.001	1.7E+01	3E-05	1	1E-06	1.08571429	3.39047619	**4.0E-03**	**4.7E-01**
Dieldrin		350	6	24	15	70	1	2	2190	25550	0.001	1.6E+01	5E-05	1	1E-06	1.08571429	3.39047619	**4.2E-03**	**7.8E-01**
Aluminum		350	6	24	15	70	1	2	2190	25550	0.001	N/A	1E+00	1	1E-06	1.08571429	3.39047619	**N/A**	**1.6E+04**
Arsenic		350	6	24	15	70	1	2	2190	25550	0.001	1.5E+00	3E-04	1	1E-06	1.08571429	3.39047619	**4.5E-02**	**4.7E+00**
Cadmium (drinking water)		350	6	24	15	70	1	2	2190	25550	0.001	N/A	5E-04	1	1E-06	1.08571429	3.39047619	**N/A**	**7.8E+00**
Cobalt		350	6	24	15	70	1	2	2190	25550	0.001	N/A	3E-04	1	1E-06	1.08571429	3.39047619	**N/A**	**4.7E+00**
Iron		350	6	24	15	70	1	2	2190	25550	0.001	N/A	7E-01	1	1E-06	1.08571429	3.39047619	**N/A**	**1.1E+04**
Manganese (drinking water)		350	6	24	15	70	1	2	2190	25550	0.001	N/A	2.4E-02	1	1E-06	1.08571429	3.39047619	**N/A**	**3.8E+02**
Thallium		350	6	24	15	70	1	2	2190	25550	0.001	N/A	1E-05	1	1E-06	1.08571429	3.39047619	**N/A**	**1.6E-01**

Notes

See Tables 2 through 6 for input parameters and equations

While these spreadsheets are used to calculate PSs related to the site, the term "PRG" is used in the calculations as this is the variable presented in equations.

Note that the BHHRA conservatively used 1.5 L/day as the ingestion rate for a child. However, the default value of 1 L/day has been used in PRG development.

Trichloroethene calculated to account for mutagenic contributions during early life. Slope factors for kidney and non-kidney (liver and non-Hodgkin lymphoma) presented in spreadsheet.

(source - http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/faq.htm#FAQ19)

Final TCE cancer PRG shown calculated by 1/(1/kidney conc + 1/non-kidney conc)

TABLE 8. INTERMEDIATE GROUNDWATER PERFORMANCE STANDARD CALCULATIONS - DERMAL

Chemical	MWT g/mol	logKow	Kp (cm/hr) predicted	B	Isc cm	Dsc cm^2/hr	tau (hr)	c	b	t_star1 B>0.6	t_star3 B<=0.6	t_star (hr)	GIABS	Mutagenic?	FA for tau>3	ET_C hr/event	ET_A hr/event	ET_{adj} hr/event	ET_{madj} hr/event	EV event/day	EF days	ED_C yrs	ED_A yrs	BW_C kg	BW_A kg	SA_C cm^2	SA_A cm^2	AT-N days	AT-C days	CF1 mg/ug	CF3 L/cm^3	SF_o $(mg/kg\text{-}day)^{-1}$	RfD_o mg/kg-day	THQ	TR	DFW_{adj} cm^2-evt-day/kg	$DFWM_{adj}$ evt-cm^2/kg	DA_{event} - ca ug/cm^2-evt	DA_{event} - nc ug/cm^2-evt	$PRG_{ca\text{-}derm}$ ug/L	$PRG_{nc\text{-}derm}$ ug/L
1,4-Dioxane	88.1	-0.27	3.3E-04	0.001	1.0E-03	5.09E-07	0.33	3.3E-01	3.0E-01	N/A	0.79	0.79	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	1.0E-01	3E-02	1	1E-06	8811	25394	8.3E-05	7.1E-02	**1.9E+02**	**1.3E+05**
4-Chloroaniline	127.6	1.83	5.0E-03	0.022	1.0E-03	3.06E-07	0.55	3.5E-01	3.2E-01	N/A	1.31	1.31	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	2.0E-01	4E-03	1	1E-06	8811	25394	4.1E-05	9.5E-03	**5.0E+00**	**9.4E+02**
Atrazine	215.7	2.61	5.2E-03	0.030	1.0E-03	9.82E-08	1.70	3.5E-01	3.2E-01	N/A	4.07	4.07	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	2.3E-01	3.5E-02	1	1E-06	8811	25394	3.6E-05	8.3E-02	**2.3E+00**	**4.4E+03**
Benzo(a)anthracene	228.3	5.76	NA	N/A	1.0E-03	8.35E-08	2.00	N/A	N/A	N/A	4.79	N/A	1	Y	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	7.3E-01	N/A	1	1E-06	8811	25394	N/A	N/A	**N/A**	**N/A**
Benzo(a)pyrene	250.0	6.13	NA	N/A	1.0E-03	6.31E-08	2.64	N/A	N/A	N/A	6.34	N/A	1	Y	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	7.3E+00	N/A	1	1E-06	8811	25394	N/A	N/A	**N/A**	**N/A**
Benzo(b)fluoranthene	252.3	5.78	NA	N/A	1.0E-03	6.13E-08	2.72	N/A	N/A	N/A	6.53	N/A	1	Y	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	7.3E-01	N/A	1	1E-06	8811	25394	N/A	N/A	**N/A**	**N/A**
bis(2-Ethylhexyl)phthalate	391.0	7.60	NA	N/A	1.0E-03	1.02E-08	16.27	N/A	N/A	N/A	39.05	N/A	1		0.8	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	1.4E-02	2E-02	1	1E-06	8811	25394	N/A	N/A	**N/A**	**N/A**
Indeno(1,2,3-cd)pyrene	276.3	6.70	NA	N/A	1.0E-03	4.49E-08	3.71	N/A	N/A	N/A	8.90	N/A	1	Y	0.6	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	7.3E-01	N/A	1	1E-06	8811	25394	N/A	N/A	**N/A**	**N/A**
Naphthalene	128.2	3.30	4.7E-02	0.203	1.0E-03	3.03E-07	0.55	4.8E-01	4.4E-01	N/A	1.32	1.32	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	N/A	2E-02	1	1E-06	8811	25394	N/A	4.7E-02	**N/A**	**5.0E+02**
1,4-Dichlorobenzene	147.0	3.44	4.5E-02	0.211	1.0E-03	2.38E-07	0.70	4.9E-01	4.5E-01	N/A	1.68	1.68	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	5.4E-03	7E-02	1	1E-06	8811	25394	1.5E-03	1.7E-01	**1.8E+01**	**1.6E+03**
Benzene	78.1	2.13	1.5E-02	0.051	1.0E-03	5.79E-07	0.29	3.7E-01	3.3E-01	N/A	0.69	0.69	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	5.5E-02	4E-03	1	1E-06	8811	25394	1.5E-04	9.5E-03	**8.4E+00**	**4.1E+02**
Chloroform	119.4	1.97	6.8E-03	0.029	1.0E-03	3.40E-07	0.49	3.5E-01	3.2E-01	N/A	1.18	1.18	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	3.1E-02	1E-02	1	1E-06	8811	25394	2.7E-04	2.4E-02	**2.5E+01**	**1.8E+03**
Ethylbenzene	106.2	3.15	4.9E-02	0.195	1.0E-03	4.03E-07	0.41	4.7E-01	4.4E-01	N/A	0.99	0.99	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	1.1E-02	1E-01	1	1E-06	8811	25394	7.5E-04	2.4E-01	**1.1E+01**	**2.6E+03**
Methyl tert-butyl ether	88.1	0.94	2.1E-03	0.008	1.0E-03	5.09E-07	0.33	3.4E-01	3.1E-01	N/A	0.79	0.79	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	1.8E-03	3E-01	1	1E-06	8811	25394	4.6E-03	7.1E-01	**1.7E+03**	**2.0E+05**
Trichloroethene	131.4	2.42	1.2E-02	0.051	1.0E-03	2.91E-07	0.57	3.7E-01	3.4E-01	N/A	1.37	1.37	1	Y	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	4.6E-02	5E-04	1	1E-06	8811	25394	6.2E-05	1.2E-03	**6.5E+00**	**4.9E+01**
kidney	131.4	2.42	1.2E-02	0.051	1.0E-03	2.91E-07	0.57	3.7E-01	3.4E-01	N/A	1.37	1.37	1	Y	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	9.3E-03	N/A	1	1E-06	8811	25394	3.1E-04	N/A	**1.6E+01**	
non-kidney	131.4	2.42	1.2E-02	0.051	1.0E-03	2.91E-07	0.57	3.7E-01	3.4E-01	N/A	1.37	1.37	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	3.7E-02	N/A	1	1E-06	8811	25394	2.2E-04	N/A	**1.1E+01**	
Vinyl Chloride	62.5	1.62	8.4E-03	0.025	1.0E-03	7.08E-07	0.24	3.5E-01	3.2E-01	N/A	0.57	0.57	1	Y	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	7.2E-01	3E-03	1	1E-06	8811	25394	2.5E-06	7.1E-03	**2.6E-01**	**5.8E+02**
Aroclor-1242	327.0	6.29	NA	N/A	1.0E-03	2.34E-08	7.13	N/A	N/A	N/A	17.11	N/A	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	2E+00	2E-05	1	1E-06	8811	25394	N/A	N/A	**N/A**	**N/A**
Aroclor-1248	327.0	6.20	NA	N/A	1.0E-03	2.34E-08	7.13	N/A	N/A	N/A	17.11	N/A	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	2E+00	2E-05	1	1E-06	8811	25394	N/A	N/A	**N/A**	**N/A**
Aroclor-1254	327.0	6.50	NA	N/A	1.0E-03	2.34E-08	7.13	N/A	N/A	N/A	17.11	N/A	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	2E+00	2E-05	1	1E-06	8811	25394	N/A	N/A	**N/A**	**N/A**
Aldrin	365.0	6.50	NA	N/A	1.0E-03	1.43E-08	11.64	N/A	N/A	N/A	27.93	N/A	1		1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	1.7E+01	3E-05	1	1E-06	8811	25394	N/A	N/A	**N/A**	**N/A**
Dieldrin	381.0	5.40	3.3E-02	0.245	1.0E-03	1.17E-08	14.30	5.1E-01	4.7E-01	N/A	34.33	34.33	1		0.8	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	1.6E+01	5E-05	1	1E-06	8811	25394	5.2E-07	1.2E-04	**2.3E-03**	**4.3E-01**
Aluminum	--	--	1.0E-03	--	1.0E-03	--	--	--	--	--	--	--	1	--	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	N/A	1E+00	1	1E-06	8811	25394	N/A	2.4E+00	**N/A**	**2.4E+06**
Arsenic	--	--	1.0E-03	--	1.0E-03	--	--	--	--	--	--	--	1	--	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	1.5E+00	3E-04	1	1E-06	8811	25394	5.5E-06	7.1E-04	**8.3E+00**	**7.1E+02**
Cadmium (drinking water)	--	--	1.0E-03	--	1.0E-03	--	--	--	--	--	--	--	0.05	--	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	N/A	5E-04	1	1E-06	8811	25394	N/A	5.9E-05	**N/A**	**5.9E+01**
Cobalt	--	--	4.0E-04	--	1.0E-03	--	--	--	--	--	--	--	1	--	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	N/A	3E-04	1	1E-06	8811	25394	N/A	7.1E-04	**N/A**	**1.8E+03**
Iron	--	--	1.0E-03	--	1.0E-03	--	--	--	--	--	--	--	1	--	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	N/A	7E-01	1	1E-06	8811	25394	N/A	1.7E+00	**N/A**	**1.7E+06**
Manganese (drinking water)	--	--	1.0E-03	--	1.0E-03	--	--	--	--	--	--	--	0.04	--	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	N/A	2.4E-02	1	1E-06	8811	25394	N/A	2.3E-03	**N/A**	**2.3E+03**
Thallium	--	--	1.0E-03	--	1.0E-03	--	--	--	--	--	--	--	1	--	1	1	0.58	0.664	0.664	1	350	6	24	15	70	6600	18000	2190	25550	0.001	0.001	N/A	1E-05	1	1E-06	8811	25394	N/A	2.4E-05	**N/A**	**2.4E+01**

Notes

See Tables 2 through 6 for input parameters and equations

While these spreadsheets are used to calculate PSs related to the site, the term "PRG" is used in the calculations as this is the variable presented in equations.

log Kow, GIABS, and FA - From Regional Screening Level (November 2012) tables

Kp - predicted values utilize formula from RAGs part E Eq. 3.8: log Kp = -2.805603 + 0.6645865 log Kow - 0.0056118 MW (Equation more accurate in spreadsheet than in report) (Final - EPA/540/R/99/005, July 2004)

NA: Outside of Effective Predictive Domain (EPD). Calculated based on RAGS Part E criteria for MW and log Kow.

Inorganics: Rags Part E, Exhibit 3-1; Final - EPA/540/R/99/005, July 2004

Dieldrin: Kp from online RSL calculator, as log Kow from RSL tables does not result in concentration matching screening level on RSL table

Trichloroethene calculated to account for mutagenic contributions during early life. Slope factors for kidney and non-kidney (liver and non-Hodgkin lymphoma) presented in spreadsheet.
(source - http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/faq.htm#FAQ19)

Final TCE cancer PRG shown calculated by 1/(1/kidney conc + 1/non-kidney conc)

TABLE 9. INTERMEDIATE GROUNDWATER PERFORMANCE STANDARD CALCULATIONS - INHALATION

Chemical	Mutagenic?	EF days	ED_C yrs	ED_A yrs	K L/m^3	AT-N days	AT-C days	UR $(ug/m^3)^{-1}$	RfC ug/m^3	THQ	TR	$INWM_{adj}$ yr-ug/m^3	$PRG_{ca\text{-}inh}$ ug/L	$PRG_{nc\text{-}inh}$ ug/L
1,4-Dioxane		350	6	24	0.5	2190	25550	N/A	N/A	1	1E-06	N/A	**N/A**	**N/A**
4-Chloroaniline		350	6	24	0.5	2190	25550	N/A	N/A	1	1E-06	N/A	**N/A**	**N/A**
Atrazine		350	6	24	0.5	2190	25550	N/A	N/A	1	1E-06	N/A	**N/A**	**N/A**
Benzo(a)anthracene	Y	350	6	24	0.5	2190	25550	1.1E-04	N/A	1	1E-06	8.4E-03	**N/A**	**N/A**
Benzo(a)pyrene	Y	350	6	24	0.5	2190	25550	1.1E-03	N/A	1	1E-06	8.4E-02	**N/A**	**N/A**
Benzo(b)fluoranthene	Y	350	6	24	0.5	2190	25550	1.1E-04	N/A	1	1E-06	8.4E-03	**N/A**	**N/A**
bis(2-Ethylhexyl)phthalate		350	6	24	0.5	2190	25550	NA	N/A	1	1E-06	N/A	**N/A**	**N/A**
Indeno(1,2,3-cd)pyrene	Y	350	6	24	0.5	2190	25550	1.1E-04	N/A	1	1E-06	8.4E-03	**N/A**	**N/A**
Naphthalene		350	6	24	0.5	2190	25550	3.4E-05	3E+00	1	1E-06	2.6E-03	**1.4E-01**	**6.3E+00**
1,4-Dichlorobenzene		350	6	24	0.5	2190	25550	1.1E-05	8E+02	1	1E-06	8.4E-04	**4.4E-01**	**1.7E+03**
Benzene		350	6	24	0.5	2190	25550	7.8E-06	3E+01	1	1E-06	5.9E-04	**6.2E-01**	**6.3E+01**
Chloroform		350	6	24	0.5	2190	25550	2.3E-05	1E+02	1	1E-06	1.7E-03	**2.1E-01**	**2.0E+02**
Ethylbenzene		350	6	24	0.5	2190	25550	2.5E-06	1E+03	1	1E-06	1.9E-04	**1.9E+00**	**2.1E+03**
Methyl tert-butyl ether		350	6	24	0.5	2190	25550	2.6E-07	3E+03	1	1E-06	2.0E-05	**1.9E+01**	**6.3E+03**
Trichloroethene	Y	350	6	24	0.5	2190	25550	4.1E-06	2E+00	1	1E-06	3.1E-04	**8.6E-01**	**4.2E+00**
kidney	Y	350	6	24	0.5	2190	25550	1.0E-06	N/A	1	1E-06	7.6E-05	**1.9E+00**	
non-kidney		350	6	24	0.5	2190	25550	3.1E-06	N/A	1	1E-06	2.4E-04	**1.6E+00**	
Vinyl Chloride	Y	350	6	24	0.5	2190	25550	4.4E-06	1E+02	1	1E-06	3.3E-04	**3.2E-01**	**2.1E+02**
Aroclor-1242		350	6	24	0.5	2190	25550	N/A	N/A	1	1E-06	N/A	**N/A**	**N/A**
Aroclor-1248		350	6	24	0.5	2190	25550	5.7E-04	N/A	1	1E-06	4.3E-02	**N/A**	**N/A**
Aroclor-1254		350	6	24	0.5	2190	25550	5.7E-04	N/A	1	1E-06	4.3E-02	**N/A**	**N/A**
Aldrin		350	6	24	0.5	2190	25550	N/A	N/A	1	1E-06	N/A	**N/A**	**N/A**
Dieldrin		350	6	24	0.5	2190	25550	4.6E-03	N/A	1	1E-06	3.5E-01	**N/A**	**N/A**
Aluminum		350	6	24	0.5	2190	25550	N/A	N/A	1	1E-06	N/A	**N/A**	**N/A**
Arsenic		350	6	24	0.5	2190	25550	4.3E-03	1.5E-03	1	1E-06	3.3E-01	**N/A**	**N/A**
Cadmium (drinking water)		350	6	24	0.5	2190	25550	1.8E-03	1E-02	1	1E-06	1.4E-01	**N/A**	**N/A**
Cobalt		350	6	24	0.5	2190	25550	9.0E-03	6E-03	1	1E-06	6.8E-01	**N/A**	**N/A**
Iron		350	6	24	0.5	2190	25550	N/A	N/A	1	1E-06	N/A	**N/A**	**N/A**
Manganese (drinking water)		350	6	24	0.5	2190	25550	N/A	5E-02	1	1E-06	N/A	**N/A**	**N/A**
Thallium		350	6	24	0.5	2190	25550	N/A	N/A	1	1E-06	N/A	**N/A**	**N/A**

Notes

See Tables 2 through 6 for input parameters and equations

While these spreadsheets are used to calculate PSs related to the site, the term "PRG" is used in the calculations as this is the variable presented in equations.

PRGs shown as "N/A" are due to either lack of inhalation toxicity values or because the analyte is non-volatile.

Trichloroethene calculated to account for mutagenic contributions during early life. Slope factors for kidney and non-kidney (liver and non-Hodgkin lymphoma) presented in spreadsheet.
(source - http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/faq.htm#FAQ19)
Final TCE cancer PRG shown calculated by 1/(1/kidney conc + 1/non-kidney conc)

TABLE 10. INTERMEDIATE GROUNDWATER PERFORMANCE STANDARD CALCULATIONS - RESULTS

	Carcinogenic Risk Level = 1E-06				Non-Cancer Hazard Quotient = 1			
Chemical	$PRG_{ca\text{-}ing}$ ug/L	$PRG_{ca\text{-}derm}$ ug/L	$PRG_{ca\text{-}inh}$ ug/L	Result ug/L	$PRG_{nc\text{-}ing}$ ug/L	$PRG_{nc\text{-}derm}$ ug/L	$PRG_{nc\text{-}inh}$ ug/L	Result ug/L
1,4-Dioxane	6.7E-01	1.9E+02	N/A	**6.7E-01**	4.7E+02	1.3E+05	N/A	**4.7E+02**
4-Chloroaniline	3.4E-01	5.0E+00	N/A	**3.2E-01**	6.3E+01	9.4E+02	N/A	**5.9E+01**
Atrazine	2.9E-01	2.3E+00	N/A	**2.6E-01**	5.5E+02	4.4E+03	N/A	**4.9E+02**
Benzo(a)anthracene	2.9E-02	N/A	N/A	**2.9E-02**	N/A	N/A	N/A	**N/A**
Benzo(a)pyrene	2.9E-03	N/A	N/A	**2.9E-03**	N/A	N/A	N/A	**N/A**
Benzo(b)fluoranthene	2.9E-02	N/A	N/A	**2.9E-02**	N/A	N/A	N/A	**N/A**
bis(2-Ethylhexyl)phthalate	4.8E+00	N/A	N/A	**4.8E+00**	3.1E+02	N/A	N/A	**3.1E+02**
Indeno(1,2,3-cd)pyrene	2.9E-02	N/A	N/A	**2.9E-02**	N/A	N/A	N/A	**N/A**
Naphthalene	N/A	N/A	1.4E-01	**1.4E-01**	3.1E+02	5.0E+02	6.3E+00	**6.1E+00**
1,4-Dichlorobenzene	1.2E+01	1.8E+01	4.4E-01	**4.2E-01**	1.1E+03	1.6E+03	1.7E+03	**4.7E+02**
Benzene	1.2E+00	8.4E+00	6.2E-01	**3.9E-01**	6.3E+01	4.1E+02	6.3E+01	**2.9E+01**
Chloroform	2.2E+00	2.5E+01	2.1E-01	**1.9E-01**	1.6E+02	1.8E+03	2.0E+02	**8.4E+01**
Ethylbenzene	6.1E+00	1.1E+01	1.9E+00	**1.3E+00**	1.6E+03	2.6E+03	2.1E+03	**6.7E+02**
Methyl tert-butyl ether	3.7E+01	1.7E+03	1.9E+01	**1.2E+01**	4.7E+03	2.0E+05	6.3E+03	**2.6E+03**
Trichloroethene	1.0E+00	6.5E+00	8.6E-01	**4.4E-01**	7.8E+00	4.9E+01	4.2E+00	**2.6E+00**
Vinyl Chloride	1.7E-02	2.6E-01	3.2E-01	**1.5E-02**	4.7E+01	5.8E+02	2.1E+02	**3.6E+01**
Aroclor-1242	3.4E-02	N/A	N/A	**3.4E-02**	3.1E-01	N/A	N/A	**3.1E-01**
Aroclor-1248	3.4E-02	N/A	N/A	**3.4E-02**	3.1E-01	N/A	N/A	**3.1E-01**
Aroclor-1254	3.4E-02	N/A	N/A	**3.4E-02**	3.1E-01	N/A	N/A	**3.1E-01**
Aldrin	4.0E-03	N/A	N/A	**4.0E-03**	4.7E-01	N/A	N/A	**4.7E-01**
Dieldrin	4.2E-03	2.3E-03	N/A	**1.5E-03**	7.8E-01	4.3E-01	N/A	**2.8E-01**
Aluminum	N/A	N/A	N/A	**N/A**	1.6E+04	2.4E+06	N/A	**1.6E+04**
Arsenic	4.5E-02	8.3E+00	N/A	**4.5E-02**	4.7E+00	7.1E+02	N/A	**4.7E+00**
Cadmium (drinking water)	N/A	N/A	N/A	**N/A**	7.8E+00	5.9E+01	N/A	**6.9E+00**
Cobalt	N/A	N/A	N/A	**N/A**	4.7E+00	1.8E+03	N/A	**4.7E+00**
Iron	N/A	N/A	N/A	**N/A**	1.1E+04	1.7E+06	N/A	**1.1E+04**
Manganese (drinking water)	N/A	N/A	N/A	**N/A**	3.8E+02	2.3E+03	N/A	**3.2E+02**
Thallium	N/A	N/A	N/A	**N/A**	1.6E-01	2.4E+01	N/A	**1.6E-01**

Notes

See Table 2 for equations

While these spreadsheets are used to calculate PSs related to the site, the term "PRG" is used in the calculations as this is the variable presented in equations.

TABLE 11. HUMAN HEALTH PERFORMANCE STANDARDS (PSs) FOR GROUNDWATER

Media/ Scenario	Contaminant	Regulatory Criteria			Risk-Based PSs - Ingestion/Dermal/Inhalation				Additional Information				Selected PS	Basis
		Federal MCLs	RIDEM Rem. Regs.	RI GQS	ILCR 10^{-6}	ILCR 10^{-5}	ILCR 10^{-4}	HQ = 1	Site-specific Range of Background Levels[1]	RI Background[2]	Health Advisory[3]	Non-zero MCLGs		
Groundwater - ug/L Site-wide (Residential Scenario)														
	1,4-Dichlorobenzene	75	75	75	0.42	4.2	42	466	- -	- -	- -	- -	75	MCL
	Benzene	5	5	5	0.39	3.9	39	29	- -	- -	- -	- -	5	MCL
	Chloroform	- -	- -	- -	0.19	1.9	19	84	- -	- -	- -	- -	0.19	ILCR=10^{-6}
	Ethylbenzene	700	700	700	1.3	13	130	668	- -	- -	- -	700	700	MCL
	Methyl tert-butyl ether	- -	40	40	12	124	1238	2647	- -	- -	- -	- -	40	GQS
	Trichloroethene	5	5	5	0.44	4.4	44	2.6	- -	- -	- -	- -	5	MCL
	Vinyl chloride	2	2	2	0.015	0.15	1.5	36	- -	- -	- -	- -	2	MCL
	1,4-Dioxane	- -	- -	- -	0.67	6.7	67	468	- -	- -	- -	- -	0.67	ILCR=10^{-6}
	4-Chloroaniline	- -	- -	- -	0.32	3.2	32	59	- -	- -	- -	- -	0.32	ILCR=10^{-6}
	Atrazine	3	- -	3	0.26	2.6	26	487	- -	- -	- -	3	3	MCL
	Benzo(a)anthracene	- -	- -	- -	0.029	0.29	2.9	N/A	- -	- -	- -	- -	0.029	ILCR=10^{-6}
	Benzo(a)pyrene	0.2	0.2	0.2	0.0029	0.029	0.29	N/A	- -	- -	- -	- -	0.2	MCL
	Benzo(b)fluoranthene	- -	- -	- -	0.029	0.29	2.9	N/A	- -	- -	- -	- -	0.029	ILCR=10^{-6}
	bis(2-Ethylhexyl)phthalate	6	- -	6	4.8	48	480	313	- -	- -	- -	- -	6	MCL
	Indeno(1,2,3-cd)pyrene	- -	- -	- -	0.029	0.29	2.9	N/A	- -	- -	- -	- -	0.029	ILCR=10^{-6}
	Naphthalene	- -	20	100	0.14	1.4	14	6.1	- -	- -	- -	- -	20	RIDEM Rem. Regs.
	Aroclor-1242	0.5	0.5	0.5	0.034	0.34	3.4	0.31	- -	- -	- -	- -	0.5	MCL
	Aroclor-1248	0.5	0.5	0.5	0.034	0.34	3.4	0.31	- -	- -	- -	- -	0.5	MCL
	Aroclor-1254	0.5	0.5	0.5	0.034	0.34	3.4	0.31	- -	- -	- -	- -	0.5	MCL
	Aldrin	- -	- -	- -	0.0040	0.040	0.40	0.47	- -	- -	- -	- -	0.0040	ILCR=10^{-6}
	Dieldrin	- -	- -	- -	0.0015	0.015	0.15	0.28	- -	- -	- -	- -	0.0015	ILCR=10^{-6}
	Aluminum	- -	- -	- -	N/A	N/A	N/A	15540	- -	- -	- -	- -	15540	HQ = 1
	Arsenic	10	- -	10	0.045	0.45	4.5	4.7	- -	- -	- -	- -	10	MCL
	Cadmium	5	5	5	N/A	N/A	N/A	6.9	- -	- -	- -	5	5	MCL
	Cobalt	- -	- -	- -	N/A	N/A	N/A	4.7	- -	- -	- -	- -	4.7	HQ = 1
	Iron	- -	- -	- -	N/A	N/A	N/A	10878	- -	- -	- -	- -	10878	HQ = 1
	Lead[4]	15	15	15	N/A	N/A	N/A	N/A	- -	- -	- -	- -	15	Fed Actn Lvl
	Manganese	- -	- -	- -	N/A	N/A	N/A	322	- -	- -	300	- -	300	Health Adv.
	Thallium	2	2	2	N/A	N/A	N/A	0.16	- -	- -	- -	0.5	0.5	non-zero MCLG

Notes

MCL - Maximum Contaminant Level

MCLG - Maximum Contaminant Level Goal

GQS - Rhode Island Groundwater Quality Standards, June 2010

RIDEM Rem. Regs. - RIDEM Remediation Regulations, DEM-DSR-01-93, February 2004, Table 3 (GA Objectives)

ILCR - Incremental Lifetime Cancer Risk

HQ - Hazard Quotient

N/A - Not carcinogenic, or a carcinogen was not evaluated for potential non-carcinogenic effects

1. While there are some wells which may be considered site-specific background in the RI report, the data set covers multiple flow zones and is not robust enough to use as background for Ps development; - - = not applicable
2. No specific background values are currently available from Rhode Island; - - = not applicable
3. Health Advisory on Manganese (EPA-822-R-04-003; January 2004)
4. Lead was identified in the HHRA as a risk-driver, however, it was not quantitatively evaluated. Lead is regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps to correct that.

APPENDIX D

ECOLOGICAL RISK REFINEMENT AND PRG DEVELOPMENT

APPENDIX D.1

08/12/10 BERA SUMMARY MEMORANDUM

AECOM
701 Edgewater Drive
Wakefield, Massachusetts 01880

781-246-5200 tel
781-245-6293 fax

Technical Memorandum

August 12, 2010

ECOLOGICAL RISK SUMMARY

Peterson Puritan Superfund Site
Operable Unit 2
Cumberland and Lincoln, Rhode Island

EPA Contract No. EP-S1-06-01
EPA Task Order No. 0004-RS-BD-0140
EPA Project Officer: Heidi Horahan
EPA Task Order Project Officer: David Newton

INTRODUCTION

This memo has been prepared to summarize the results of the ecological risk assessment performed for the Peterson Puritan Superfund Site, Operable Unit 2 (OU2). The purpose of the memo is to present a summary of the ecological risks identified in the Baseline Ecological Risk Assessment (BERA) that are expected to be addressed in the Feasibility Study (FS) for the site. The memo has also been prepared to serve as a basis for the ecological risk summary for the Record of Decision (ROD) for the site.

A BERA was prepared for the Site in 2009 (EPA, 2009) based on risks first evaluated in the Screening-Level Ecological Risk Assessment (ARCADIS BBL, 2007). The BERA was based on data from previous site investigations conducted in phases between 2003 and 2005 (Shield Environmental Associates, Inc., 2004; BBL, 2006a; and BBL, 2006b). Following evaluation of previous studies, the effects-based investigations conducted by BBL in 2005 included fish community survey, fish tissue sampling, benthic invertebrate survey, sediment toxicity testing, and habitat assessment studies, and formed the basis of the BERA evaluation. The goal of the BERA was to evaluate potential ecological risks posed to ecological communities resulting from the exposure to site-related contaminants. A similar evaluation was performed specific to the Unnamed Island (AECOM, 2010) following the collection of additional soil samples on the island. Reference to the BERA below includes results of the supplemental evaluation performed for the Unnamed Island.

RISK SUMMARY

The study area consisted of the Blackstone River and its associated habitats, from approximately 1 mile below the Ashton Dam to the Pratt Dam. Habitats included the following:

Aquatic Habitats:

- Blackstone River (near site);
- Wetlands (A through D) located east of the Blackstone River and the J.M. Mills Landfill;
- Ponds on the Unnamed Island (Pond A, D, E, P, and Pond F [adjacent to Pratt Dam]);
- Ponds located adjacent to the river (Ponds B, C, I, and N)

Terrestrial Habitats:

- J.M. Mills Landfill
- Unnamed Island
- Nunes Parcel

- Quinnville Well Field
- Wetlands A through D
- Pratt dam

Reference areas were used, when available, to establish a basis for background risk estimates. The reference areas include a section of the Blackstone River upstream of the site and an off-site pond (Pond P-6). These habitats were divided into specific exposure units defined for each assessment endpoint. The ecological receptors evaluated in the BERA were selected based on the potential occurrence locally and in the habitats on site, and the potential for exposure to site-related media. Selected feeding guilds and representative species included:

- benthic macroinvertebrates
- amphibians
- fish
- small and large omnivorous birds
- small and large piscivorous birds
- small and large omnivorous mammals
- small and large piscivorous mammals

Main lines of evidence included:

- Comparisons of measured media concentrations (water, sediment) to benchmarks
- Assess the bioavailability of divalent metals by measuring the Acid Volatile Sulfides (AVS) and Simultaneously Extracted Metals (SEM)
- Benthic invertebrate community data
- Fish tissue data
- Fish community composition
- Food chain models for wildlife receptors

RISK CHARACTERIZATION

Residual Risks (RRs) specific for each Contaminant of Potential Ecological Concern (COPEC) were calculated during risk characterization in the BERA by subtracting the COPEC-specific background Hazard Quotients (HQs) from the COPEC-specific site HQs. The RRs above 1 represented the degree to which the site exposure, adjusted for background, exceeded its toxicity benchmark. An interpretive matrix was utilized in the BERA to evaluate the magnitude and confidence of the risk associated with each COPEC and receptor (Table 1).

The history of disposal in the study area, including both the landfills on the east side of the River and on the Unnamed Island, represents a potential source of contaminants to affect habitats in the vicinity. Due to the irregular nature of the disposal and buried waste on the Unnamed Island, the extent of the contamination in these habitats is particularly difficult to characterize. Consequently, the risks are also difficult to quantify due to the irregular nature of the distribution of contaminants and the history of alterations to the ecological communities on the Unnamed Island, including seasonal flooding and fluctuations in water levels.

Due to the high uncertainty related to risk, a conservative interpretation is presented here relative to the risk characterization. In any areas where elevated risks were indicated by one or more lines of evidence and the level of risk or extent of area affected is uncertain due to limited data, risk is concluded to be present, and it is recommended that these risks be considered in the FS.

Based on the calculated RRs and lines of evidence for the selected receptor groups, risks identified in the BERA are discussed below and summarized in Table 2. In general, if the magnitude of the risk in the BERA was assessed high (severe) based on available data and comparison of residual risk (RR) using the interpretive risk matrix utilized in the BERA, the risk is presented in Table 2 as potentially actionable and is recommended to be further evaluated in the FS. In addition, if more than one line of evidence

indicated potential risk to receptors, it is recommended for further consideration in the FS and is listed in Table 2.

Blackstone River

The data from the Blackstone River indicate that adverse effects to fish, amphibians, and large piscivorous birds are unlikely. The BERA identified potential adverse effects to the benthic community in the Blackstone River. However, no COPECs had RR values greater than 1, indicating that sediment concentrations of contaminants are not elevated above background. The only observed sediment toxicity was at station BR-006, and the observed toxicity at this location was not readily linked to site-related COPECs. Consequently, risk from exposure of aquatic and semi-aquatic organisms to surface water and sediment of the Blackstone River does not represent a significant ecological risk, and does not need to be further evaluated in the FS.

Wetlands A through D

No severe risks were identified in Wetlands A through D. Evaluation resulted in adverse effects being possible, but not expected, to the benthic invertebrate community in Wetlands A through D and unlikely to the fish and amphibian communities. Based on the low magnitude of risk to receptors evaluated in the wetlands, no significant risk was identified, and further evaluation in the FS is not recommended.

Ponds on the Unnamed Island (Ponds A, D, E, P, and F)

The triad study indicated that potential site-related impacts from exposure to sediment were evident primarily in Ponds A, D, and F. These sediment quality triad results were not clear-cut, however, because a consistent link was not found between chemistry, toxicity, and community structure. The weight of evidence indicates severe sediment toxicity in Ponds A and D, indicating a significant risk to be evaluated in the FS.

In Pond F, possible adverse effects were identified for benthic invertebrates (comparison to benchmarks), however, a single toxicity sample did not indicate adverse effects to benthic invertebrates in Pond F sediments. The evidence for effects on benthic invertebrates was therefore inconclusive. Surface water evaluations identified adverse effects possible, but not expected, to both the fish and amphibian communities in Pond F. Significant ecological risk in Pond F was not identified, and further evaluation in the Feasibility Study is not recommended.

Pond E, which is adjacent to Pond A on the Unnamed Island, is very small in size, and two sediment samples, but no toxicity samples, were evaluated. Several COPECs had elevated RR values (RR of 2 to 11), with the highest RR associated with Pb concentrations. Based on the high sediment concentrations equating to severe impairment (Table 2), further consideration in the FS of risks associated with sediments in Pond E is recommended.

The RR analysis shows that severe ecological risk is possible to fish exposed to surface water in Pond D and Pond P. Adverse risk was identified to fish from surface water exposure in Pond E. The major risk drivers at each of these aquatic exposure areas are as follows: Pond D shows a chronic RR for Pb equal to 77, Pond E shows a chronic RR for Ba equal to 55 (and 8 for Pb), and Pond P shows a chronic RR for Mn equal to 13. There were also possible adverse effects identified to fish and amphibians in Pond A; Mn was the only COPEC in Pond A with RR values greater than 1. These findings are generally consistent with the location and disposal history of these aquatic exposure areas. The risks associated with exposures to surface water in each of these ponds on the Unnamed Island require further consideration in the FS.

Ponds Adjacent to the Blackstone River (Ponds B, C, I, and N)

The severe risk to aquatic receptors (amphibians and fish) in Pond C and at the base of the J.M. Mills Landfill was based on a limited number of surface water samples and one line of evidence (comparison to

surface water benchmarks). Due to the magnitude of the identified risk (severe) to fish and amphibians in Pond C, the risk of exposure to surface water should be considered in the FS. Pre-design sampling would be valuable in verifying the frequency and duration of surface water COPEC concentrations related to benchmarks.

In Pond I, adverse effects were determined to be possible to benthic invertebrates, fish, and amphibians. The RR values were small in sediment; however, sediment toxicity was also observed in one of the samples from Pond I. In addition to these risks, the elevated Pb concentration in surface water resulted in RR of 10 for both fish and amphibians. Since more than one line of evidence indicated potential risk, further consideration in the FS is recommended for Pond I.

The only endpoint evaluated for Pond B was the comparison of COPEC concentrations to sediment benchmarks. Cadmium, silver, and 2-methylphenol were the only COPECs with RRs greater than 1. The magnitudes of these exceedances were low (based on three samples). Although adverse effects to the benthic invertebrate community were determined to be possible, no significant risk was identified, and further consideration in the FS is not recommended.

The endpoints evaluated for Pond N were comparisons to benchmarks for both surface water and sediment. For both media, RRs were greater than 1, indicating possible impairment to aquatic receptors. Based on these results, further consideration in the FS is recommended.

Terrestrial Habitats

Based on dietary modeling across all exposure areas, adverse effects were determined to be possible for large omnivorous birds feeding across the terrestrial areas of the site. COPECs with high residual risks included bis(2-ethylhexyl)phthalate (BEHP), Pb, and Zn; the RR for Cd was 1. In addition, adverse effects are possible to small omnivorous birds feeding at the J.M. Mills Landfill. COPECs with high residual risk included BEHP, Pb, and Zn; the RR for Cd was 1. Adverse effects are not expected for large omnivorous mammals feeding across all terrestrial areas of the site. Adverse effects are possible for small omnivorous mammals feeding at the J.M. Mills Landfill. COPECs with high RRs included Al and Zn. Adverse effects were determined to be possible for small or large omnivorous birds feeding at the Unnamed Island. COPECs with RR values greater than 1 included BEHP, Pb, and Zn. Due to possible risks to avian species from soil exposures on the Unnamed Island, further consideration in the FS is recommended.

CONCLUSIONS

- No unacceptable site-related ecological risks were identified in Wetlands A through D or in the main channel of the Blackstone River.

- The BERA identified the potential for adverse ecological risk to omnivorous birds feeding at the individual terrestrial exposure areas or at all the terrestrial exposure areas combined. Pb is the primary risk driver. Additional surface soil samples could be used to refine the risk evaluation for the Unnamed Island in the FS.

- The BERA has also identified the potential for severe/adverse ecological risk to fish and embryo-larval stages of amphibians exposed to surface water in Ponds A, C, D, E, I, N, and P. Pb is the primary risk driver in three of these exposure areas, and a secondary risk driver in two others. Limited numbers of water samples were collected from each of these habitats. Pre-design sampling could assist in refining the risk to aquatic receptors exposed to site-related COPECs in these habitats.

- Finally, some potential for ecological risk to the benthic invertebrate community is possible at one or more locations in Ponds A, D, E, I, and N from sediment exposure. Further consideration in the FS of sediment risk in these habitats is recommended.

REFERENCES

AECOM, 2010. Technical Memorandum - Supplemental Ecological Risk for Unnamed Island Soils. July 27, 2010.

ARCADIS U.S., Inc. (ARCADIS BBL) 2007. Screening-Level Ecological Risk Assessment. February 2, 2007.

Blasland, Bouck & Lee, Inc. (BBL) 2006a. Revised Phase 1A Database Summary Report. Remedial Investigation Feasibility Study for the Peterson Puritan Superfund Site – Operable Unit 2 Cumberland and Lincoln, Rhode Island (original report written by Shield). February 2006.

Blasland, Bouck & Lee, Inc. (BBL) 2006b. Phase 1B Database Summary Report. Remedial Investigation Feasibility Study for the Peterson Puritan Superfund Site – Operable Unit 2 Cumberland and Lincoln, Rhode Island. July 2006.

Shield Environmental Associates, Inc. 2004. RI/FS Phase 1A Initial Site Characterization Report, Peterson Puritan Superfund Site - Operable Unit 2. Report prepared for Peterson Puritan OU2 PRP Group. February 2004.

US Environmental Protection Agency (EPA), 2009. Baseline Ecological Risk Assessment (BERA) for the Peterson Puritan Superfund Site - Operable Unit 2. Agency Revision of the BERA prepared by Arcadis in September 2008.

TABLE 1. INTERPRETIVE RISK MATRIX FOR CHARACTERIZATION OF RISK IN THE BASELINE ECOLOGICAL RISK ASSESSMENT

[a]Interpretive Risk Matrix for sediment benchmarks, fish CBRs, and wildlife TRVs						
Risk Scenario	No effect (NOAEL)		Effect (LOAEL)		Potential for Adverse Population-level Effects	Confidence Level
	RME	CTE	RME	CTE		
1	RR ≤ 1	RR ≤ 1	RR ≤ 1	RR ≤ 1	Adverse effects are unlikely	High
2	RR > 1	RR ≤ 1	RR ≤ 1	RR ≤ 1	Adverse effects are unlikely	Moderate
3	RR > 1	RR > 1	RR ≤ 1	RR ≤ 1	Adverse effects are unlikely	Low
4	RR > 1	RR ≤ 1	RR > 1	RR ≤ 1	Adverse effects are possible	Low
5	RR > 1	RR > 1	RR > 1	RR ≤ 1	Adverse effects are possible	Moderate
6	RR > 1	RR > 1	RR > 1	RR > 1	Adverse effects are possible	High (increase with higher HQ)

[a]Interpretive Risk Matrix for surface water				
Risk Scenario	Chronic Toxicity		Potential for Adverse Population-level Effects	Confidence Level
	RME	CTE		
1,2 & 3	RR ≤ 1	RR ≤ 1	Adverse effects are unlikely	High
4 & 5	RR > 1	RR ≤ 1	Adverse effects are possible	Moderate
6	RR > 1	RR > 1	Adverse effects are possible	High (increase with higher HQs)

[a] Residual risks (RR) were calculated by subtracting reference Hazard Quotients (HQs) from site HQs for each COPEC. This matrix was used to characterize the relative risk represented by each RR value for the various risk scenarios.
CTE = central tendency exposure
CBR = critical body residue
COPEC = Contaminant of potential ecological concern
HQ = Hazard Quotient
LOAEL = lowest observed adverse effect level
NOAEL = no observed adverse effect level
RME = reasonable maximum exposure
RR = residual risk
TRV = toxicity reference value

TABLE 2. SUMMARY OF ECOLOGICAL RISK BY EXPOSURE AREA

Area	Media	Basis	Primary COCs
Ponds on the Unnamed Island			
Pond A	Sediment	Severe sediment toxicity	Cd
	Surface Water	Adverse effects possible to amphibians	Mn
Pond D	Sediment	Severe sediment toxicity	Cd, pyrene
	Surface Water	Severe risk to fish and amphibians	Al, Ba, Cd, Pb
Pond E	Sediment	Severe risk to benthic invertebrates	Pb
	Surface water	Adverse risk to fish and amphibians	Pb, Ba, Mn
Pond P	Surface Water	Severe risk to fish and amphibians	Mn
Ponds Adjacent to the Blackstone River			
Pond C	Surface Water	Severe risk to fish and amphibians	Al, Cd, Ba, Cu, Pb
Pond I	Surface Water	Adverse risk to fish and amphibians	Pb
	Sediment	Adverse effects possible	Cd, Cu, PAHs
Pond N	Surface Water	Adverse risk to fish and amphibians	Al, Pb
	Sediment	Adverse effects possible	4,4'-DDD, Cd, Cr
Terrestrial Habitats			
Site-wide	Soil	Adverse risks to omnivorous birds	BEHP, Cd, Pb, Zn
J.M. Mills Landfill	Soil	Adverse risks to omnivorous birds Possible adverse effects to small omnivorous mammals	BEHP, Cd, Pb, Zn Al, Zn
Unnamed Island	Soil	Adverse risks to omnivorous birds	BEHP, Pb, Zn

APPENDIX D.2

04/11/12 SEDIMENT REFINEMENT

DRAFT

Memorandum

From: Bart Hoskins, EPA Ecological Risk Assessor
To: David Newton, EPA Remedial Project Manager, Peterson Puritan Site
Cc: Peterson Puritan Site File
Date: April 11, 2012
RE: Sediment COC Refinement and PRG Development, Peterson Puritan OU 2

This memorandum provides backup information to support developing sediment Preliminary Remediation Goals (PRGs) for the ponds at the Peterson Puritan OU-2 site. As presented in AECOM's Ecological Risk Summary Technical Memorandum (August 12, 2010), initial evaluation of the sediment chemistry and toxicity data resulted in selecting primary risk drivers for the site-related water bodies. Refinement of these chemicals of concern (COCs) is performed in this memorandum to further clarify those COCs which should be used as a basis for cleanup.

While toxicity testing was not performed in each water body, this memorandum reviews available site toxicity data presented in the BERA (USEPA, 2009, Revision of Arcadis, 2008) to develop appropriate site-specific PRGs, applicable to the primary COCs, for use in the Record of Decision (ROD).

COC Refinement

In the Ecological Risk Summary memorandum prepared for EPA (AECOM, 2010), a conservative interpretation was presented relative to the risk characterization. In any areas where elevated risks were indicated by one or more lines of evidence and the level of risk or extent of area affected was uncertain due to limited data, risk was concluded to be present and it was recommended that these risks be considered in the FS. In general, if the magnitude of the risk in the BERA was assessed high (severe) based on available data (See BERA Executive Summary Tables ES 1b to ES-1j) and comparison of residual risk (RR) using the interpretive risk matrix utilized in the BERA, the risk was identified as potentially actionable and was recommended to be further evaluated in the FS. In addition, if more than one line of evidence indicated potential risk to receptors, it was recommended for further consideration in the FS.

This process resulted in the identification of a preliminary list of "Primary COCs" in Table 2 of the Ecological Risk Summary memorandum. The selection of the primary COCs was based on looking at the BERA chemistry data RR evaluation presented in Tables 7- 6(c, f, g, i & j). In cases where the toxicity tests concluded risk to benthic invertebrates, and/or surface water also indicated elevated concentrations of the same COCs, these locations were selected as potentially significant risk to receptors and recommended for further evaluation.

This process took into consideration first the presence of contaminants in areas of documented risk (based on toxicity testing, if available), the association with toxicity, or in the locations without toxicity tests, elevated surface water concentrations of the COCs. Because the selection of COCs was based on RR, contaminants at or near levels observed in reference locations were eliminated in order to identify COCs as risk drivers that were likely site-related. Contaminants at this step were also eliminated if they were determined not likely to be site-related (e.g., acetone). Further refinement of the COCs, is performed to below, prior to the development of ecological PRGs.

Further review of the BERA chemistry and toxicity data was performed to confirm/refine the list of COCs to be used as a basis for cleanup. Using the same BERA data (sediment chemistry for the ponds and the toxicity testing data set), a consistent method was applied for COC selection in the ponds (A, D, E, I, and N) which showed potential risk in sediment (see Attachment A for tables showing evaluation):

- Using the BERA "chemistry" tables showing calculated hazard quotients and residual risks for benthic invertebrates (Tables 7-6c, f, g, i, and j), each analyte was placed into a "risk scenario" category, as defined in the BERA interpretive risk matrix.
- Any analytes in risk scenarios 1, 2, or 3 were removed from further evaluation, as adverse effects due to site contributions of that contaminant are considered less likely than contributions from analytes in higher risk scenarios. Analytes in risk scenarios 4, 5, or 6 were evaluated further with respect to toxicity and/or relationship to site waste.
- Using the BERA "toxicity" tables showing triad sediment chemistry and toxicity results (Tables 7-9b and c), chemistry data were compared to effects criteria to generate a Hazard Quotient (HQ) for each analyte, both in the site and reference ponds, using the highest site concentration and lowest reference concentration for ponds with multiple samples. For any site HQs greater than 1, the reference HQ was subtracted from the site HQ to generate a RR comparable to that on the "chemistry" tables. Analytes with a "toxicity" RR greater than 1 were evaluated further with respect to the "chemistry" results and/or relationship to site waste.

Pond A (Unnamed Island) Evaluation

In Table A-1, the only analytes with a risk scenario greater than or equal to 4 included acetone, heptachlor epoxide, and cadmium. There are multiple PAHs and metals with risk scenarios equal to 3, but in attempting to limit the list of COCs to the primary risk drivers (as well as understanding that most of these contaminants are co-located since the number of samples is limited), they have been removed from this evaluation. In Table A-2, the only analyte with a toxicity RR greater than 1 is cadmium.

Information from both tables was then evaluated together to develop pond-specific primary risk-drivers:

- Acetone - Volatile contaminants are generally considered having low toxicity. Acetone is a known laboratory and preservative contaminant and is not considered site-related. Furthermore, toxicity RR was less than 1. **Not a COC.**
- Heptachlor epoxide is not considered site-related and only had one detection out of 12 samples. **Not a COC.**
- Cadmium appears to be related to site waste and is the only analyte with a toxicity RR greater than 1. **COC.**

Pond D (Unnamed Island) Evaluation

In Table A-3, the analytes with a risk scenario greater than or equal to 4 included the PAHs anthracene, benzo(a)pyrene, chrysene, fluoranthene, phenanthrene, and pyrene (the most significant risk driver), and the metal cadmium. Similar to Pond A, there are additional/similar metals with risk scenarios equal to 3, but they have been removed from this evaluation. In Table A-4, the only analytes with a toxicity RR greater than 1 are the PAHs listed above, as well as benzo(k)fluoranthene and, while not included in the original BERA evaluation, Total PAHs.

Information from both tables was then evaluated together to develop pond-specific primary risk-drivers:

- PAHs – Pyrene was previously listed in the Ecological Risk Summary memorandum as the primary risk driver (as evidenced by the highest residual risk in both Tables A-3 and A-4). However, multiple PAHs appear to be potential risk drivers in this pond. **Therefore, Total PAHs should be considered a COC.**
- Cadmium appears to be related to site waste. **COC.**

Pond E (Unnamed Island) Evaluation
In Table A-5, the analytes with a risk scenario greater than or equal to 4 included acetone, carbon disulfide, cadmium, chromium, copper, lead, and zinc, with lead being the most significant risk driver. Similar to Pond A, there are additional PAHs with risk scenarios equal to 3, but they have been removed from this evaluation. There were no toxicity samples collected in this pond.

Information from the single table was then evaluated to develop pond-specific primary risk-drivers:

- Acetone - Volatile contaminants are generally considered having low toxicity. Acetone is a known laboratory and preservative contaminant and is not considered site-related. **Not a COC.**
- Carbon disulfide - Volatile contaminants are generally considered having low toxicity and carbon disulfide is not considered site-related. **Not a COC.**
- Cadmium, chromium, copper, lead, and zinc all appear to be related to site waste and are in the highest risk scenario. **COCs.**

Pond I (Next to Nunes Parcel) Evaluation
In Table A-6, the analytes with a risk scenario greater than or equal to 4 included acetone, the PAHs benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, fluoranthene, and pyrene, and the metals cadmium, chromium, copper, and silver. Similar to the Unnamed Island Ponds, there are additional PAHs and metals with risk scenarios equal to 3, but they have been removed from this evaluation. In Table A-7, the only analytes with a toxicity RR greater than 1 are the PAHs benzo(g,h,i)perylene, chrysene, fluoranthene, phenanthrene, and pyrene.

Information from both tables was then evaluated together to develop pond-specific primary risk-drivers:

- Acetone - Volatile contaminants are generally considered having low toxicity. Acetone is a known laboratory and preservative contaminant and is not considered site-related. Furthermore, toxicity RR was not greater than 1. **Not a COC.**
- PAHs – Looking at both tables, multiple PAHs appear to be potential risk drivers in this pond. **Therefore, Total PAHs should be considered a COC.**
- Based on a review of soil data in the area, cadmium, chromium, and copper appear to be related to site waste and all have evidence of elevated toxicity. **COCs.**
- Silver in Pond I is not clearly site-related and does not have evidence of elevated toxicity. **Not a COC.**

Pond N (Drainage Ditch) Evaluation
In Table A-8, the only analyte with a risk scenario greater than or equal to 4 was cadmium. There were a wide variety of additional analytes with risk scenarios equal to 3, including 4,4'-DDD and chromium which were noted in the Ecological Risk Summary memorandum as primary COCs, but they have been removed from this evaluation. There were no toxicity samples collected in this pond.

Information from the single table was then evaluated to develop pond-specific primary risk-drivers:

- Cadmium appears to be related to site waste. **COC.**

Summary of COC Refinement

Table 1 presents the refined list of COCs for the site ponds. All three ponds on the Unnamed Island (Ponds A, D, and E) are in proximity to both the waste and each other. While the primary COCs noted above for those ponds were not exactly the same, the evaluations note that similar analytes in each pond were just out of the range for further evaluation. For these reasons, the COCs for those ponds have been combined.

Sediment PRGs

Review of the toxicity testing results shows varied results which are not conducive to developing numeric goals based on a comparison of lowest and no observed effects in site samples. With the limited amount of data available, the reference sample with the highest/best survival (T05BL-004) should be used to define numeric cleanup goals. These concentrations are presented in **Table 2** and presented by area/water body in **Table 3**.

TABLE 1. SUMMARY OF SEDIMENT ECOLOGICAL COCs BY EXPOSURE AREA

Area	Media	Primary COCs
Ponds on the Unnamed Island		
Ponds A, D, E	Sediment	Cd, Cr, Cu, Pb, Zn, Total PAHs,
Ponds Adjacent to the Blackstone River		
Pond I	Sediment	Cd, Cr, Cu, Total PAHs
Pond N	Sediment	Cd

Notes

COC - Contaminant of Concern

Cd - Cadmium

Pb - Lead

Cu - Copper

PAHs - Polycyclic aromatic hydrocarbons

Cr - Chromium

TABLE 2. ECOLOGICAL PRGs FOR SEDIMENT

PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RI

DRAFT

COC	PRG	
	TO5BL-004 Ref Pond	Basis
PAHs (mg/kg)		
Total PAHs	18	Reference - No Effects
Metals (mg/kg)		
Cadmium	9.8	Reference - No Effects
Chromium	120	Reference - No Effects
Copper	160	Reference - No Effects
Lead	300	Reference - No Effects
Zinc	490	Reference - No Effects

Notes

Concentrations taken from Table 7-9c of BERA. Page 24 of BERA defines the samples used as reference for pond sediment.

PRG - Preliminary Remediation Goal

COC - Contaminant of Concern

PAHs - Polycyclic aromatic hydrocarbons

TABLE 3. ECOLOGICAL PRGs FOR SEDIMENT BY AREA

DRAFT

Area	Contaminant	PRG (mg/kg)	PRG Basis
Ponds on the Unnamed Island			
Ponds A, D, and E	Cadmium (Cd)	9.8	Reference[(1)] - No Effects
	Chromium (Cr)	120	Reference - No Effects
	Copper (Cu)	160	Reference - No Effects
	Lead (Pb)	300	Reference - No Effects
	Zinc (Zn)	490	Reference - No Effects
	Total PAHs	18	Reference - No Effects
Ponds Adjacent to the Blackstone River			
Pond I	Cadmium (Cd)	9.8	Reference - No Effects
	Chromium (Cr)	120	Reference - No Effects
	Copper (Cu)	160	Reference - No Effects
	Total PAHs	18	Reference - No Effects
Pond N	Cadmium (Cd)	9.8	Reference - No Effects

Notes

(1) Sample TO5BL-004

PRG - Preliminary Remediation Goal

PAHs - Polycyclic aromatic hydrocarbons

ATTACHMENT A

Table A-1 - Pond A Chemistry Data Evaluation

Data from BERA Table 7-6c

COPECs (mg/kg dry wt)	FOD	RME	CTE	No Effect Sediment Benchmark	Effect Sediment Benchmark	No Effect HQ RME	No Effect HQ CTE	Effect HQ RME	Effect HQ CTE	No Effect RR RME	No Effect RR CTE	Effect RR RME	Effect RR CTE	March 2012 Evaluation Scenario	March 2012 Evaluation Comment
VOCs															
1,1,1-Trichloroethane	0/12	2.30E-02	7.87E-03	0.17	2.2	0.1	0.05	0.01	0.004	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
1,1,2,2-Tetrachloroethane	0/12	2.30E-02	7.87E-03	0.94	12.2	0.02	0.008	0.002	0.0006	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
1,1-Dichloroethene	0/12	2.30E-02	7.87E-03	0.031	0.4	0.7	0.3	0.06	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Butanone	10/12	2.66E-01	9.18E-02	0.27	3.5	0.99	0.3	0.08	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Hexanone	0/12	2.30E-02	7.87E-03	0.022	0.29	1	0.4	0.08	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4-Methyl-2-pentanone	0/12	2.30E-02	7.87E-03	0.033	0.43	0.7	0.2	0.05	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acetone	8/12	5.16E-01	2.54E-01	0.0087	0.11	59	29	5	2	49	23	4	2	6	Out - associated with preservation/lab analysis
Carbon disulfide	6/12	6.56E-03	6.07E-03	0.00085	0.011	8	7	0.6	0.5	2	2	<1	<1	3	Out - Scenario 1, 2, or 3
Chloromethane	0/12	2.30E-02	7.87E-03	--	--	--	--	--	--	--	--	--	--	NA	
cis-1,2-Dichloroethene	0/12	2.30E-02	7.87E-03	--	--	--	--	--	--	--	--	--	--	NA	
cis-1,3-Dichloropropene	0/12	2.30E-02	7.87E-03	--	--	--	--	--	--	--	--	--	--	NA	
Isopropylbenzene	0/12	2.30E-02	7.87E-03	--	--	--	--	--	--	--	--	--	--	NA	
Methyl acetate	1/12	3.80E-02	8.62E-03	--	--	--	--	--	--	--	--	--	--	NA	
Methylene chloride	2/12	6.10E-02	1.19E-02	0.37	4.8	0.2	0.03	0.01	0.002	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Styrene	1/12	2.30E-02	7.82E-03	--	--	--	--	--	--	--	--	--	--	NA	
Tetrachloroethene	0/12	2.30E-02	7.87E-03	0.41	5.3	0.06	0.02	0.004	0.001	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
trans-1,3-Dichloropropene	0/12	2.30E-02	7.87E-03	--	--	--	--	--	--	--	--	--	--	NA	
Trichlorofluoromethane	2/12	2.30E-02	7.29E-03	--	--	--	--	--	--	--	--	--	--	NA	
Xylene (total)	0/12	2.30E-02	8.34E-03	0.025	0.33	0.9	0.3	0.07	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
SVOCs															
1,1'-Biphenyl	1/12	3.30E-01	1.95E-01	--	--	--	--	--	--	--	--	--	--	NA	
2-Methylnaphthalene	8/12	1.96E-01	1.57E-01	0.33	4.3	0.6	0.5	0.05	0.04	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Methylphenol	0/12	3.30E-01	1.95E-01	0.012	0.16	28	16	2	1	8	6	<1	<1	3	Out - Scenario 1, 2, or 3
4-Bromophenyl-phenylether	0/12	3.30E-01	2.05E-01	1.3	16.9	0.3	0.2	0.02	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4-Chloroaniline	0/12	3.30E-01	2.05E-01	--	--	--	--	--	--	--	--	--	--	NA	
4-Methylphenol	1/12	3.30E-01	1.94E-01	--	--	--	--	--	--	--	--	--	--	NA	
4-Nitroaniline	0/12	8.50E-01	4.94E-01	--	--	--	--	--	--	--	--	--	--	NA	
Acenaphthene	9/12	1.11E-01	1.19E-01	0.62	8.1	0.2	0.2	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acenaphthylene	10/12	2.91E-01	2.08E-01	0.33	4.3	0.9	0.6	0.07	0.05	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acetophenone	1/12	3.30E-01	1.95E-01	--	--	--	--	--	--	--	--	--	--	NA	
Anthracene	11/12	5.55E-01	3.74E-01	0.057	0.85	10	7	0.7	0.4	2	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Benzaldehyde	6/12	5.51E-01	3.46E-01	--	--	--	--	--	--	--	--	--	--	NA	
Benzo(a)pyrene	11/12	1.84E+00	1.30E+00	0.15	1.5	12	9	1	0.9	3	2	<1	<1	3	Out - Scenario 1, 2, or 3
Benzo(b)fluoranthene	10/11	2.30E+00	1.55E+00	--	--	--	--	--	--	--	--	--	--	NA	
Benzo(g,h,i)perylene	11/12	9.38E-01	6.51E-01	0.17	0.32	6	4	3	2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Benzo(k)fluoranthene	11/12	1.00E+00	6.87E-01	--	--	--	--	--	--	--	--	--	--	NA	
bis(2-Ethylhexyl)phthalate	12/12	3.72E+00	1.58E+00	890	11570	0.004	0.002	0.0003	0.0001	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Carbazole	7/12	1.98E-01	1.69E-01	--	--	--	--	--	--	--	--	--	--	NA	
Chrysene	11/12	1.90E+00	1.33E+00	0.17	1.3	11	8	1	1	3	2	<1	<1	3	Out - Scenario 1, 2, or 3
Cyclohexane	0/12	2.30E-02	7.87E-03	--	--	--	--	--	--	--	--	--	--	NA	
Dibenzofuran	4/12	3.15E-01	1.54E-01	2	26	0.2	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Fluoranthene	11/12	3.14E+00	2.22E+00	0.42	2.2	7	5	1	1	2	1	<1	<1	3	Out - Scenario 1, 2, or 3
Fluorene	9/12	1.84E-01	1.58E-01	0.077	0.54	2	2	0.3	0.3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Hexachlorobenzene	0/12	3.30E-01	1.93E-01	0.02	0.26	17	10	1	0.7	5	4	<1	<1	3	Out - Scenario 1, 2, or 3
Hexachlorobutadiene	0/12	3.30E-01	2.05E-01	--	--	--	--	--	--	--	--	--	--	NA	
Indeno(1,2,3-cd)pyrene	11/12	1.41E+00	6.93E-01	0.2	2.6	7	3	0.5	0.3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Isophorone	0/12	3.30E-01	2.05E-01	--	--	--	--	--	--	--	--	--	--	NA	
Naphthalene	9/12	1.87E-01	1.51E-01	0.18	0.56	1	0.9	0.3	0.3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
N-Nitrosodiphenylamine	0/12	3.30E-01	2.05E-01	--	--	--	--	--	--	--	--	--	--	NA	

Table A-1 - Pond A Chemistry Data Evaluation

Data from BERA Table 7-6c

COPECs (mg/kg dry wt)	FOD	RME	CTE	No Effect Sediment Benchmark	Effect Sediment Benchmark	No Effect HQ RME	No Effect HQ CTE	Effect HQ RME	Effect HQ CTE	No Effect RR RME	No Effect RR CTE	Effect RR RME	Effect RR CTE	March 2012 Evaluation Scenario	March 2012 Evaluation Comment
Pentachlorophenol	0/11	1.50E+00	6.61E-01	--	--	--	--	--	--	--	--	--	--	NA	
Phenanthrene	11/12	1.51E+00	1.05E+00	0.2	1.2	7	5	1	1	1	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Phenol	3/12	3.30E-01	1.99E-01	--	--	--	--	--	--	--	--	--	--	NA	
Pyrene	11/12	2.58E+00	1.85E+00	0.2	1.52	13	9	2	1	2	1	<1	<1	3	Out - Scenario 1, 2, or 3
Pesticides/PCBs															
4,4'-DDD	6/10	9.86E-03	6.01E-03	0.0049	0.028	2	1	0.4	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4,4'-DDE	6/8	1.64E-02	9.64E-03	0.0032	0.031	5	3	0.5	0.3	2	2	<1	<1	3	Out - Scenario 1, 2, or 3
4,4'-DDT	2/8	4.05E-03	1.09E-03	0.0042	0.063	1	0.3	0.1	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
alpha-Chlordane	6/10	2.19E-02	9.26E-03	0.0032	0.018	7	3	1	0.5	6	2	1	<1	3	Out - Scenario 1, 2, or 3
Aroclor-1016	0/12	1.70E-02	6.16E-03	0.06	0.7	0.3	0.1	0.03	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1221	0/12	1.70E-02	9.83E-03	0.06	0.7	0.3	0.2	0.03	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1232	0/12	1.70E-02	6.16E-03	0.06	0.7	0.3	0.1	0.03	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1242	0/12	1.70E-02	6.16E-03	0.06	0.7	0.3	0.1	0.03	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1248	0/12	1.70E-02	6.16E-03	0.06	0.7	0.3	0.1	0.03	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1254	4/12	6.50E-01	8.67E-02	0.06	0.7	11	1	1	0.1	3	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Aroclor-1260	6/11	3.02E-01	1.54E-01	0.06	0.7	5	3	0.4	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Dieldrin	4/11	2.10E-02	4.28E-03	0.0019	0.062	11	2	0.3	0.07	8	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Endosulfan I	0/11	3.35E-04	2.36E-04	0.0029	0.073	0.1	0.1	0.005	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endosulfan II	0/11	6.50E-04	4.10E-04	0.0055	0.14	0.1	0.07	0.005	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endosulfan Sulfate	3/9	1.00E-02	2.28E-03	--	--	--	--	--	--	--	--	--	--	NA	
Endrin	1/12	8.60E-03	1.09E-03	0.002	0.21	4	0.5	0.04	0.005	4	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Endrin Aldehyde	3/9	5.80E-03	1.33E-03	--	--	--	--	--	--	--	--	--	--	NA	
Endrin Ketone	2/9	2.10E-03	6.16E-04	--	--	--	--	--	--	--	--	--	--	NA	
Gamma-Chlordane	4/10	3.50E-02	3.29E-03	--	--	--	--	--	--	--	--	--	--	NA	
Heptachlor Epoxide	1/12	2.70E-02	2.47E-03	0.0025	0.016	11	1	2	0.2	11	<1	2	<1	4	Out - One detection, not considered site-related
Methoxychlor	3/11	1.00E-02	3.31E-03	0.019	0.48	0.5	0.2	0.02	0.007	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Total PCBs	8/12	6.00E-01	3.75E-01	0.06	0.68	10	6	0.9	0.6	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Toxaphene	0/12	4.20E-02	2.47E-02	0.028	0.7	2	1	0.06	0.04	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Metals															
Aluminum	12/12	1.02E+04	7.44E+03	--	--	--	--	--	--	--	--	--	--	NA	
Antimony	7/12	2.01E+00	1.18E+00	12	60	0.2	0.1	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Arsenic	11/12	1.68E+01	1.21E+01	9.8	33	2	1	1	0.4	1	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Barium	9/12	1.24E+02	8.33E+01	--	--	--	--	--	--	--	--	--	--	NA	
Beryllium	8/12	9.26E-01	6.50E-01	--	--	--	--	--	--	--	--	--	--	NA	
Cadmium	12/12	1.82E+01	8.41E+00	1	5	18	8	4	2	11	5	2	<1	5	Potential COC - Site-related
Chromium	12/12	1.48E+02	1.02E+02	43	111	3	2	1	0.9	2	1	<1	<1	3	Out - Scenario 1, 2, or 3
Cobalt	4/12	1.60E+01	8.43E+00	--	--	--	--	--	--	--	--	--	--	NA	
Copper	11/12	1.83E+02	1.23E+02	32	149	6	4	1	0.8	2	2	<1	<1	3	Out - Scenario 1, 2, or 3
Cyanide	6/10	2.38E+00	1.05E+00	--	--	--	--	--	--	--	--	--	--	NA	
Iron	12/12	2.17E+04	1.59E+04	20,000	40,000	1	0.8	0.5	0.4	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Lead	12/12	1.76E+02	1.22E+02	36	128	5	3	1	0.95	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Manganese	12/12	4.88E+02	2.94E+02	460	5500	1	0.6	0.09	0.05	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Mercury	11/12	6.29E-01	4.41E-01	0.18	1.06	3	2	0.6	0.4	2	1	<1	<1	3	Out - Scenario 1, 2, or 3
Nickel	7/12	4.13E+01	2.41E+01	23	48.6	2	1	0.8	0.5	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Selenium	10/12	2.58E+00	1.77E+00	--	--	--	--	--	--	--	--	--	--	NA	
Silver	12/12	1.12E+01	6.05E+00	2	10	6	3	1.1	0.6	4	2	<1	<1	3	Out - Scenario 1, 2, or 3
Thallium	3/12	8.30E-01	2.68E-01	--	--	--	--	--	--	--	--	--	--	NA	
Vanadium	9/12	2.40E+01	1.69E+01	--	--	--	--	--	--	--	--	--	--	NA	
Zinc	12/12	6.92E+02	3.66E+02	120	459	6	3	2	0.8	3	2	<1	<1	3	Out - Scenario 1, 2, or 3

Table A-2 - Pond A Toxicity Data Evaluation

Data from BERA Table 7-9c

				Pond							
				Site			Background		March 2012 Evaluation		
			Sample Name:	T05PA-001	T05PA-003		T05BL-003	T05BL-004	Note that Highest HQ for site data is max conc divided by		
			Sample Depth (Feet):	0 - 0.5	0 - 0.5		0 - 0.5	0 - 0.5	Effect Criteria.		
			Date Collected:	6/21/2005	6/21/2005		6/23/2005	6/23/2005	Lowest HQ for Bkgd data is min conc divided by Effect		
			Location ID:	T05PA-001	T05PA-003		T05BL-003	T05BL-004	Criteria.		
									RR is Site HQ minus Bkgd HQ		
Species	Test	Lab control Result	Units			TOXICITY					
Chironomus dilutus	Survival	83.75	%	76.25	71.25		86.25	93.75			
Chironomus dilutus	Growth	1.79	mg/larvae	1.68	1.47		1.39	1.56			
Hyalella azteca	Survival	91.25	%	8.75	1.25		51.25	88.75			
Hyalella azteca	Growth	0.597	mg/amphipod	0.3	0.08		0.237	0.29			
Constituent	No Effect Criteria	Effect Criteria	Units			SEDIMENT CHEMISTRY Highest Site HQ			Lowest Bkgd HQ	RR	Comment
VOC											
2-Butanone	0.27	3.51	mg/kg dry wt	0.05	0.067		0.038 J	0.029 J			
Acetone	0.0087	0.1131	mg/kg dry wt	0.12 J	0.18 J	1.6	0.13 JEB	0.15 JEB	1.1	0.4	Out - RR<=1
Carbon disulfide	0.00085	0.01105	mg/kg dry wt	0.0032	0.0046		0.013 J	0.0057 J			
Ethylbenzene	3.6	46.8	mg/kg dry wt	0.0018 J	0.001 J		0.0053 J	0.0062 UJ			
Methyl tert butyl ether	-	-	mg/kg dry wt	0.0024 U	0.0035 U		0.0041 J	0.0062 UJ			
Styrene	-	-	mg/kg dry wt	0.00061 J	0.0035 U		0.002 J	0.0062 UJ			
Toluene	0.67	8.71	mg/kg dry wt	0.0024 U	0.0035 U		0.0068 UJ	0.0062 UJ			
Xylene (Total)	0.025	0.325	mg/kg dry wt	0.0071 U	0.01 U		0.02 UJ	0.019 UJ			
SVOC											
1,1'-Biphenyl	-	-	mg/kg dry wt	0.15 U	0.17 U		0.19 U	0.17 U			
2-Methylnaphthalene	0.33	4.29	mg/kg dry wt	0.24	0.4		0.36	0.43			
2-Methylphenol	0.012	0.156	mg/kg dry wt	0.037 U	0.042 U		0.046 U	0.043 U			
Acenaphthene	0.62	8.06	mg/kg dry wt	0.092	0.15		0.097	0.084			
Acenaphthylene	0.33	4.29	mg/kg dry wt	0.22	0.43		0.31	0.47			
Anthracene	0.0572	0.845	mg/kg dry wt	0.42	0.68		0.44	0.46			
Benzaldehyde	-	-	mg/kg dry wt	0.22 J	0.3 J		0.41 J	0.17 UJ			
Benzo(a)pyrene	0.15	1.45	mg/kg dry wt	1.2	2.3	1.6	1.7	1.5	1.0	0.6	Out - RR<=1
Benzo(b)fluoranthene	-	-	mg/kg dry wt	1.1	2.1		2.3	1.8			
Benzo(g,h,i)perylene	0.17	0.32	mg/kg dry wt	0.82	1.6	5	1.8	1.3	4.1	0.9	Out - RR<=1
Benzo(k)fluoranthene	-	-	mg/kg dry wt	0.95	1.9		1.8	1.6			
Benzo[a]anthracene	0.11	1.05	mg/kg dry wt	1	2	1.9	1.3	1.3	1.2	0.7	Out - RR<=1
bis(2-Ethylhexyl)phthalate	890	11,570	mg/kg dry wt	1.2	3.2		5.9	1.9			
Carbazole	-	-	mg/kg dry wt	0.15 U	0.2		0.22	0.17 U			
Chrysene	0.17	1.29	mg/kg dry wt	1.2	2.2	1.7	1.8	1.5	1.2	0.5	Out - RR<=1
Dibenz[a,h]anthracene	0.033	0.429	mg/kg dry wt	0.25	0.49	1.1	0.5	0.4	0.9	0.2	Out - RR<=1
Dibenzofuran	2	26	mg/kg dry wt	0.15 U	0.17 U		0.19 U	0.17 U			
Fluoranthene	0.42	2.23	mg/kg dry wt	1.9	3.6	1.6	2.6	2.4	1.1	0.5	Out - RR<=1
Fluorene	0.077	0.536	mg/kg dry wt	0.15	0.27		0.22	0.18			
Indeno(1,2,3-cd)pyrene	0.2	2.6	mg/kg dry wt	0.73	1.4		1.5	1.2			
Naphthalene	0.18	0.561	mg/kg dry wt	0.27	0.36		0.27	0.35			

Table A-2 - Pond A Toxicity Data Evaluation

Data from BERA Table 7-9c

				Pond							
				Site			Background		March 2012 Evaluation		
			Sample Name:	T05PA-001	T05PA-003		T05BL-003	T05BL-004	Note that Highest HQ for site data is max conc divided by Effect Criteria.		
			Sample Depth (Feet):	0 - 0.5	0 - 0.5		0 - 0.5	0 - 0.5	Lowest HQ for Bkgd data is min conc divided by Effect Criteria.		
			Date Collected:	6/21/2005	6/21/2005		6/23/2005	6/23/2005			
			Location ID:	T05PA-001	T05PA-003		T05BL-003	T05BL-004	RR is Site HQ minus Bkgd HQ		
Species	Test	Lab control Result	Units			TOXICITY					
Chironomus dilutus	Survival	83.75	%	76.25	71.25		86.25	93.75			
Chironomus dilutus	Growth	1.79	mg/larvae	1.68	1.47		1.39	1.56			
Hyalella azteca	Survival	91.25	%	8.75	1.25		51.25	88.75			
Hyalella azteca	Growth	0.597	mg/amphipod	0.3	0.08		0.237	0.29			
Constituent	No Effect Criteria	Effect Criteria	Units			SEDIMENT CHEMISTRY Highest Site HQ			Lowest Bkgd HQ	RR	Comment
Phenanthrene	0.2	1.17	mg/kg dry wt	0.96 J	1.8	1.5	0.97	0.84			
Phenol	-	-	mg/kg dry wt	0.082	0.14		0.18	0.16			
Pyrene	0.2	1.52	mg/kg dry wt	1.8	3.5	2.3	2.2	2.2	1.4	0.9	Out - RR<=1
Total PAHs (1)	1.6	22.8	mg/kg dry wt	13.3 J	25.2	1.1	20.2	18	0.8	0.3	Out - RR<=1
Pesticides											
4,4'-DDD	0.00488	0.028	mg/kg dry wt	0.013	0.015		0.018	0.017			
4,4'-DDE	0.00316	0.0313	mg/kg dry wt	0.0097 J	0.019 J		R	0.016 J			
alpha-Chlordane	0.0032	0.0176	mg/kg dry wt	0.0041 J	0.0041		0.0055	0.0034			
Delta-BHC	0.12	0.01	mg/kg dry wt	0.00059 U	0.00097 J		0.00076 U	0.00068 U			
Dieldrin	0.0019	0.0618	mg/kg dry wt	0.004 J	0.0042		0.00076 U	0.0052 J			
Endosulfan Sulfate	-	-	mg/kg dry wt	0.00059 UJ	0.00067 U		0.00076 U	0.013 J			
Endrin Ketone	-	-	mg/kg dry wt	0.00059 U	0.00067 U		0.00076 U	0.00068 U			
Gamma-Chlordane	-	-	mg/kg dry wt	0.0031	0.0042		0.0065	0.0036			
PCBs											
Aroclor-1254	0.0598	0.676	mg/kg dry wt	0.21 EB	0.42 EB		1.4 JEB	1.1 JEB	1.6	-2	Out - RR<=1
Aroclor-1260	0.0598	0.676	mg/kg dry wt	0.42 J	0.55		0.57 J	0.46			
Total PCBs	0.0598	0.676	mg/kg dry wt	0.63 J	0.97	1.4	1.97 J	1.56 J	2.3	-0.9	Out - RR<=1
Metals and Cyanide											
Aluminum	-	-	mg/kg dry wt	8,900	12,000		12,000	12,000			
Antimony	12	60	mg/kg dry wt	0.27 J	0.73 J		0.52 J	0.47 J			
Arsenic	9.79	33	mg/kg dry wt	12	18		10	8.1			
Barium	-	-	mg/kg dry wt	80	150		82	79			
Beryllium	-	-	mg/kg dry wt	0.63	0.91		0.88	0.73			
Cadmium	1	4.98	mg/kg dry wt	12	25	5.0	9.9	9.8	2.0	3	Potential COC - RR>1
Calcium	-	-	mg/kg dry wt	1,400 J	2,000 J		3,300 J	3,100 J			
Chromium	43.4	111	mg/kg dry wt	98	210	1.9	110	120	1.0	0.9	Out - RR<=1
Cobalt	-	-	mg/kg dry wt	9.1	14		12	11			
Copper	31.6	149	mg/kg dry wt	130	260	1.7	170	160	1.1	0.7	Out - RR<=1
Iron	20,000	40,000	mg/kg dry wt	17,000	24,000		25,000	17,000			
Lead	36	128	mg/kg dry wt	120	240	1.9	450	300	2.3	-0.5	Out - RR<=1
Magnesium	-	-	mg/kg dry wt	2,900	3,600		4,100	2,900			

Table A-2 - Pond A Toxicity Data Evaluation

Data from BERA Table 7-9c

				Site		Pond	Background		March 2012 Evaluation		
			Sample Name:	T05PA-001	T05PA-003		T05BL-003	T05BL-004	Note that Highest HQ for site data is max conc divided by Effect Criteria.		
			Sample Depth (Feet):	0 - 0.5	0 - 0.5		0 - 0.5	0 - 0.5	Lowest HQ for Bkgd data is min conc divided by Effect Criteria.		
			Date Collected:	6/21/2005	6/21/2005		6/23/2005	6/23/2005			
			Location ID:	T05PA-001	T05PA-003		T05BL-003	T05BL-004	RR is Site HQ minus Bkgd HQ		
Species	Test	Lab control Result	Units			TOXICITY					
Chironomus dilutus	Survival	83.75	%	76.25	71.25		86.25	93.75			
Chironomus dilutus	Growth	1.79	mg/larvae	1.68	1.47		1.39	1.56			
Hyalella azteca	Survival	91.25	%	8.75	1.25		51.25	88.75			
Hyalella azteca	Growth	0.597	mg/amphipod	0.3	0.08		0.237	0.29			
Constituent	No Effect Criteria	Effect Criteria	Units			SEDIMENT CHEMISTRY Highest Site HQ			Lowest Bkgd HQ	RR	Comment
Manganese	460	5,500	mg/kg dry wt	280 J	450 J		200 J	160 J			
Mercury	0.18	1.06	mg/kg dry wt	0.31	0.67		0.54	0.47			
Nickel	23	48.6	mg/kg dry wt	33	54	1.1	52	46	0.9	0.2	Out - RR<=1
Potassium	-	-	mg/kg dry wt	1,200	1,300		1,500	1,100			
Selenium	-	-	mg/kg dry wt	0.54	1		1.5	1.3			
Silver	2	10	mg/kg dry wt	1.4	3		1.7	2.1			
Sodium	-	-	mg/kg dry wt	130	130		2,500	2,100			
Thallium	-	-	mg/kg dry wt	0.15	0.25		0.4	0.26			
Vanadium	-	-	mg/kg dry wt	21	27		31	24			
Zinc	120	459	mg/kg dry wt	400 J	950 J	2.1	680 J	490 J	1.1	1	Out - RR<=1

(1) No effect/Effect criteria (TEC/PEC) were not in the original BERA

Table A-3 - Pond D Chemistry Data Evaluation

Data from BERA Table 7-6f

COPECs (mg/kg dry wt)	FOD	RME	CTE	No Effect Sediment Benchmark	Effect Sediment Benchmark	No Effect HQ RME	No Effect HQ CTE	Effect HQ RME	Effect HQ CTE	No Effect RR RME	No Effect RR CTE	Effect RR RME	Effect RR CTE	March 2012 Evaluation Scenario	March 2012 Evaluation Comment
VOCs															
1,1,1-Trichloroethane	0/4	1.30E-02	7.63E-03	0.17	2.2	0.1	0.04	0.01	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
1,1,2,2-Tetrachloroethane	0/4	1.30E-02	7.63E-03	0.94	12.2	0.01	0.008	0.001	0.0006	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
1,1-Dichloroethene	0/4	1.30E-02	7.63E-03	0.031	0.4	0.4	0.2	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Butanone	4/4	6.90E-02	4.96E-02	0.27	3.5	0.3	0.2	0.02	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Hexanone	0/4	1.30E-02	7.63E-03	0.022	0.29	0.6	0.3	0.05	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4-Methyl-2-pentanone	0/4	1.30E-02	7.63E-03	0.033	0.43	0.4	0.2	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acetone	4/4	2.00E-01	1.34E-01	0.0087	0.11	23	15	2	1	12	9	<1	<1	3	Out - Scenario 1, 2, or 3
Carbon disulfide	3/4	7.00E-03	3.93E-03	0.00085	0.011	8	5	0.6	0.4	2	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Chloromethane	0/4	1.30E-02	7.63E-03	--	--	--	--	--	--	--	--	--	--	NA	
cis-1,2-Dichloroethene	0/4	1.30E-02	7.63E-03	--	--	--	--	--	--	--	--	--	--	NA	
cis-1,3-Dichloropropene	0/4	1.30E-02	7.63E-03	--	--	--	--	--	--	--	--	--	--	NA	
Isopropylbenzene	0/4	1.30E-02	7.63E-03	--	--	--	--	--	--	--	--	--	--	NA	
Methyl acetate	0/4	1.30E-02	7.63E-03	--	--	--	--	--	--	--	--	--	--	NA	
Methylene chloride	0/4	1.30E-02	8.38E-03	0.37	4.8	0.04	0.02	0.003	0.002	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Styrene	0/4	1.30E-02	7.63E-03	--	--	--	--	--	--	--	--	--	--	NA	
Tetrachloroethene	0/4	1.30E-02	7.63E-03	0.41	5.3	0.03	0.02	0.002	0.001	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
trans-1,3-Dichloropropene	0/4	1.30E-02	7.63E-03	--	--	--	--	--	--	--	--	--	--	NA	
Trichlorofluoromethane	0/4	1.30E-02	7.63E-03	--	--	--	--	--	--	--	--	--	--	NA	
Xylene (total)	1/4	1.30E-02	7.79E-03	0.025	0.33	0.5	0.3	0.04	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
SVOCs															
1,1'-Biphenyl	1/4	2.65E-01	1.89E-01	--	--	--	--	--	--	--	--	--	--	NA	
2-Methylnaphthalene	3/4	2.65E-01	1.44E-01	0.33	4.3	0.8	0.4	0.06	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Methylphenol	1/4	2.65E-01	1.73E-01	0.012	0.16	22	14	2	1	3	5	<1	<1	3	Out - Scenario 1, 2, or 3
4-Bromophenyl-phenylether	0/4	2.65E-01	1.84E-01	1.3	16.9	0.2	0.1	0.02	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4-Chloroaniline	0/4	2.65E-01	1.84E-01	--	--	--	--	--	--	--	--	--	--	NA	
4-Methylphenol	0/4	2.65E-01	1.84E-01	--	--	--	--	--	--	--	--	--	--	NA	
4-Nitroaniline	0/4	6.50E-01	4.38E-01	--	--	--	--	--	--	--	--	--	--	NA	
Acenaphthene	3/4	2.65E-01	1.29E-01	0.62	8.1	0.4	0.2	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acenaphthylene	4/4	2.50E-01	1.81E-01	0.33	4.3	0.8	0.5	0.06	0.04	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acetophenone	0/4	2.65E-01	1.84E-01	--	--	--	--	--	--	--	--	--	--	NA	
Anthracene	4/4	2.90E+00	7.10E-01	0.057	0.85	51	12	3	0.8	43	7	3	<1	5	Potential COC
Benzaldehyde	3/4	2.40E-01	1.28E-01	--	--	--	--	--	--	--	--	--	--	NA	
Benzo(a)pyrene	4/4	6.70E+00	2.04E+00	0.15	1.5	45	14	5	1	36	7	4	<1	5	Potential COC
Benzo(b)fluoranthene	4/4	3.20E+00	1.98E+00	--	--	--	--	--	--	--	--	--	--	NA	
Benzo(g,h,i)perylene	4/4	9.10E-01	6.43E-01	0.17	0.32	5	4	3	2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Benzo(k)fluoranthene	4/4	3.60E+00	1.11E+00	--	--	--	--	--	--	--	--	--	--	NA	
bis(2-Ethylhexyl)phthalate	3/4	2.20E+00	8.48E-01	890	11570	0.002	0.001	0.0002	0.0001	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Carbazole	4/4	1.80E-01	1.08E-01	--	--	--	--	--	--	--	--	--	--	NA	
Chrysene	4/4	6.90E+00	2.18E+00	0.17	1.3	42	13	5	2	33	7	4	<1	5	Potential COC
Cyclohexane	0/4	1.30E-02	7.63E-03	--	--	--	--	--	--	--	--	--	--	NA	
Dibenzofuran	3/4	2.65E-01	1.11E-01	2	26	0.1	0.06	0.01	0.004	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Fluoranthene	4/4	1.00E+01	3.18E+00	0.42	2.2	24	8	4	1	18	4	3	<1	5	Potential COC
Fluorene	4/4	3.60E-01	1.25E-01	0.077	0.54	5	2	0.7	0.2	3	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Hexachlorobenzene	0/4	2.65E-01	1.72E-01	0.02	0.26	13	9	1	0.7	2	3	<1	<1	3	Out - Scenario 1, 2, or 3
Hexachlorobutadiene	0/4	2.65E-01	1.84E-01	--	--	--	--	--	--	--	--	--	--	NA	
Indeno(1,2,3-cd)pyrene	4/4	8.00E-01	6.41E-01	0.2	2.6	4	3	0.3	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Isophorone	0/4	2.65E-01	1.84E-01	--	--	--	--	--	--	--	--	--	--	NA	
Naphthalene	3/4	2.65E-01	1.64E-01	0.18	0.56	2	0.9	0.5	0.3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
N-Nitrosodiphenylamine	0/4	2.65E-01	1.84E-01	--	--	--	--	--	--	--	--	--	--	NA	

Table A-3 - Pond D Chemistry Data Evaluation

Data from BERA Table 7-6f

COPECs (mg/kg dry wt)	FOD	RME	CTE	No Effect Sediment Benchmark	Effect Sediment Benchmark	No Effect HQ RME	No Effect HQ CTE	Effect HQ RME	Effect HQ CTE	No Effect RR RME	No Effect RR CTE	Effect RR RME	Effect RR CTE	March 2012 Evaluation Scenario	March 2012 Evaluation Comment
Pentachlorophenol	0/4	6.50E-01	4.38E-01	--	--	--	--	--	--	--	--	--	--	NA	
Phenanthrene	4/4	4.80E+00	1.49E+00	0.2	1.2	24	7	4	1	17	3	3	<1	5	Potential COC
Phenol	0/4	2.65E-01	1.84E-01	--	--	--	--	--	--	--	--	--	--	NA	
Pyrene	4/4	1.30E+01	3.76E+00	0.2	1.52	67	19	9	2	55	11	7	1	5	Potential COC
Pesticides/PCBs															
4,4'-DDD	3/3	7.30E-03	4.70E-03	0.0049	0.028	1	1	0.3	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4,4'-DDE	3/3	5.10E-03	4.72E-03	0.0032	0.031	2	1	0.2	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4,4'-DDT	0/3	5.50E-04	4.42E-04	0.0042	0.063	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
alpha-Chlordane	3/3	1.50E-03	1.08E-03	0.0032	0.018	0.5	0.3	0.1	0.1	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1016	0/4	5.50E-03	4.55E-03	0.06	0.7	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1221	0/4	1.10E-02	8.16E-03	0.06	0.7	0.2	0.1	0.02	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1232	0/4	5.50E-03	4.54E-03	0.06	0.7	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1242	0/4	5.50E-03	4.54E-03	0.06	0.7	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1248	0/4	5.50E-03	4.54E-03	0.06	0.7	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1254	0/4	5.50E-03	4.54E-03	0.06	0.7	0.1	0.1	0.01	0	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1260	4/4	2.50E-01	1.43E-01	0.06	0.7	4	2	0.4	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Dieldrin	1/3	2.20E-03	9.70E-04	0.0019	0.062	1	0.5	0.04	0	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endosulfan I	0/4	4.20E-04	2.81E-04	0.0029	0.073	0.1	0.1	0.006	0.004	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endosulfan II	0/4	5.50E-04	4.54E-04	0.0055	0.14	0.1	0.1	0.004	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endosulfan Sulfate	1/4	8.00E-03	2.33E-03	--	--	--	--	--	--	--	--	--	--	NA	
Endrin	0/4	5.50E-04	4.54E-04	0.002	0.21	0.2	0.2	0.003	0.002	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endrin Aldehyde	1/2	2.10E-03	1.89E-03	--	--	--	--	--	--	--	--	--	--	NA	
Endrin Ketone	1/1	9.10E-03	8.65E-03	--	--	--	--	--	--	--	--	--	--	NA	
Gamma-Chlordane	1/2	5.60E-03	3.63E-03	--	--	--	--	--	--	--	--	--	--	NA	
Heptachlor Epoxide	0/4	4.20E-04	2.81E-04	0.0025	0.016	0.2	0.1	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Methoxychlor	0/4	2.75E-03	1.88E-03	0.019	0.48	0.1	0.1	0.01	0.004	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Total PCBs	4/4	2.50E-01	1.43E-01	0.06	0.68	4	2	0.4	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Toxaphene	0/4	5.00E-02	3.03E-02	0.028	0.7	2	1	0.07	0.04	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Metals															
Aluminum	4/4	8.67E+03	6.40E+03	--	--	--	--	--	--	--	--	--	--	NA	
Antimony	4/4	2.00E+00	1.19E+00	12	60	0.2	0.1	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Arsenic	4/4	1.23E+01	7.66E+00	9.8	33	1	0.8	0.4	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Barium	4/4	1.19E+02	8.11E+01	--	--	--	--	--	--	--	--	--	--	NA	
Beryllium	1/2	6.50E-01	5.16E-01	--	--	--	--	--	--	--	--	--	--	NA	
Cadmium	4/4	1.56E+01	9.23E+00	1	5	16	9	3	2	8	6	2	1	5	Potential COC - Site-related
Chromium	4/4	1.41E+02	9.93E+01	43	111	3	2	1	0.9	2	1	<1	<1	3	Out - Scenario 1, 2, or 3
Cobalt	1/4	7.00E+00	5.90E+00	--	--	--	--	--	--	--	--	--	--	NA	
Copper	4/4	1.79E+02	1.19E+02	32	149	6	4	1	0.8	2	2	<1	<1	3	Out - Scenario 1, 2, or 3
Cyanide	1/3	7.20E-01	4.28E-01	--	--	--	--	--	--	--	--	--	--	NA	
Iron	4/4	1.35E+04	1.04E+04	20,000	40,000	0.7	0.5	0.3	0.3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Lead	4/4	1.96E+02	1.30E+02	36	128	5	4	2	1	<1	1	<1	<1	1	Out - Scenario 1, 2, or 3
Manganese	4/4	2.97E+02	2.11E+02	460	5500	0.6	0.5	0.05	0.04	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Mercury	4/4	6.00E-01	3.94E-01	0.18	1.06	3	2	0.6	0.4	2	1	<1	<1	2	Out - Scenario 1, 2, or 3
Nickel	4/4	4.67E+01	2.90E+01	23	48.6	2	1	1	0.6	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Selenium	3/4	2.00E+00	1.16E+00	--	--	--	--	--	--	--	--	--	--	NA	
Silver	4/4	8.60E+00	4.22E+00	2	10	4	2	0.9	0.4	3	1	<1	<1	2	Out - Scenario 1, 2, or 3
Thallium	1/4	2.80E-01	2.13E-01	--	--	--	--	--	--	--	--	--	--	NA	
Vanadium	3/4	2.12E+01	1.45E+01	--	--	--	--	--	--	--	--	--	--	NA	
Zinc	4/4	5.90E+02	3.89E+02	120	459	5	3	1.3	0.8	2	2	<1	<1	3	Out - Scenario 1, 2, or 3

Table A-4 - Pond D Toxicity Data Evaluation

Data from BERA Table 7-9c

				Pond						March 2012 Evaluation		
				Site			Background			Note that Highest HQ for site data is max conc divided by Effect Criteria.		
			Sample Name:	T05PD-002	BD062105		T05BL-003	T05BL-004		Lowest HQ for Bkgd data is min conc divided by Effect Criteria.		
			Sample Depth (Feet):	0 - 0.5	0 - 0.5		0 - 0.5	0 - 0.5		RR is Site HQ minus Bkgd HQ		
			Date Collected:	6/21/2005	6/21/2005		6/23/2005	6/23/2005				
			Location ID:	T05PD-002	T05PD-002		T05BL-003	T05BL-004				
Species	Test	Lab control Result	Units									
Chironomus dilutus	Survival	83.75	%	77.5			86.25	93.75				
Chironomus dilutus	Growth	1.79	mg/larvae	1.81			1.39	1.56				
Hyalella azteca	Survival	91.25	%	16.25			51.25	88.75				
Hyalella azteca	Growth	0.597	mg/amphipod	0.528			0.237	0.29				
Constituent	No Effect Criteria	Effect Criteria	Units			Highest Site HQ				Lowest Bkgd HQ	RR	Comment
VOC												
2-Butanone	0.27	3.51	mg/kg dry wt	0.023 J	0.02		0.038 J	0.029 J				
Acetone	0.0087	0.1131	mg/kg dry wt	0.058 JEB	0.074 J		0.13 JEB	0.15 JEB				
Carbon disulfide	0.00085	0.01105	mg/kg dry wt	0.0016 J	0.0018 J		0.013 J	0.0057 J				
Ethylbenzene	3.6	46.8	mg/kg dry wt	0.00069 J	0.00054 J		0.0053 J	0.0062 UJ				
Methyl tert butyl ether	-	-	mg/kg dry wt	0.002 U	0.0021 U		0.0041 J	0.0062 UJ				
Styrene	-	-	mg/kg dry wt	0.002 UJ	0.0021 U		0.002 J	0.0062 UJ				
Toluene	0.67	8.71	mg/kg dry wt	0.001 J	0.00088 J		0.0068 UJ	0.0062 UJ				
Xylene (Total)	0.025	0.325	mg/kg dry wt	0.0021 J	0.0012 J		0.02 UJ	0.019 UJ				
SVOC												
1,1'-Biphenyl	-	-	mg/kg dry wt	0.11 UJ	0.088 J		0.19 U	0.17 U				
2-Methylnaphthalene	0.33	4.29	mg/kg dry wt	0.077 J	0.25 J		0.36	0.43				
2-Methylphenol	0.012	0.156	mg/kg dry wt	0.016 JEB	0.0021 UJ		0.046 U	0.043 U				
Acenaphthene	0.62	8.06	mg/kg dry wt	0.052 J	0.13 J		0.097	0.084				
Acenaphthylene	0.33	4.29	mg/kg dry wt	0.16 J	0.087 J		0.31	0.47				
Anthracene	0.0572	0.845	mg/kg dry wt	0.48 J	2.9 J	3.4	0.44	0.46		0.5	3	Potential COC
Benzaldehyde	-	-	mg/kg dry wt	0.082 J	0.078 J		0.41 J	0.17 UJ				
Benzo(a)pyrene	0.15	1.45	mg/kg dry wt	1.2 J	6.7 J	4.6	1.7	1.5		1.0	4	Potential COC
Benzo(b)fluoranthene	-	-	mg/kg dry wt	0.84 J	3.2 J		2.3	1.8				
Benzo(g,h,i)perylene	0.17	0.32	mg/kg dry wt	0.81 J	0.91 J	2.8	1.8	1.3		4.1	-1	Out - RR<=1
Benzo(k)fluoranthene	-	-	mg/kg dry wt	0.89 J	3.6 J		1.8	1.6				
Benzo[a]anthracene	0.11	1.05	mg/kg dry wt	0.97 J	7.1 J	6.8	1.3	1.3		1.2	6	Potential COC
bis(2-Ethylhexyl)phthalate	890	11,570	mg/kg dry wt	0.21 J	0.26 J		5.9	1.9				
Carbazole	-	-	mg/kg dry wt	0.11 UJ	0.093 J		0.22	0.17 U				
Chrysene	0.17	1.29	mg/kg dry wt	1.1 J	6.9 J	5.3	1.8	1.5		1.2	4	Potential COC
Dibenz[a,h]anthracene	0.033	0.429	mg/kg dry wt	0.24 J	0.92 J	2.1	0.5	0.4		0.9	1	Out - RR<=1
Dibenzofuran	2	26	mg/kg dry wt	0.11 UJ	0.09 J		0.19 U	0.17 U				
Fluoranthene	0.42	2.23	mg/kg dry wt	1.4 J	10 J	4.5	2.6	2.4		1.1	3	Potential COC
Fluorene	0.077	0.536	mg/kg dry wt	0.089 J	0.36 J		0.22	0.18				
Indeno(1,2,3-cd)pyrene	0.2	2.6	mg/kg dry wt	0.71 J	0.8 J		1.5	1.2				
Naphthalene	0.18	0.561	mg/kg dry wt	0.13 J	0.25 J		0.27	0.35				

Table A-4 - Pond D Toxicity Data Evaluation

Data from BERA Table 7-9c

				Pond					March 2012 Evaluation		
				Site			Background		Note that Highest HQ for site data is max conc divided by Effect Criteria.		
			Sample Name:	T05PD-002	BD062105		T05BL-003	T05BL-004			
			Sample Depth (Feet):	0 - 0.5	0 - 0.5		0 - 0.5	0 - 0.5	Lowest HQ for Bkgd data is min conc divided by Effect Criteria.		
			Date Collected:	6/21/2005	6/21/2005		6/23/2005	6/23/2005			
			Location ID:	T05PD-002	T05PD-002		T05BL-003	T05BL-004	RR is Site HQ minus Bkgd HQ		
Species	Test	Lab control Result	Units								
Chironomus dilutus	Survival	83.75	%	77.5			86.25	93.75			
Chironomus dilutus	Growth	1.79	mg/larvae	1.81			1.39	1.56			
Hyalella azteca	Survival	91.25	%	16.25			51.25	88.75			
Hyalella azteca	Growth	0.597	mg/amphipod	0.528			0.237	0.29			
Constituent	No Effect Criteria	Effect Criteria	Units			Highest Site HQ			Lowest Bkgd HQ	RR	Comment
Phenanthrene	0.2	1.17	mg/kg dry wt	0.75 J	4.8 J	4.1	0.97	0.84	0.7	3	Potential COC
Phenol	-	-	mg/kg dry wt	0.11 U	0.1 U		0.18	0.16			
Pyrene	0.2	1.52	mg/kg dry wt	1.7 J	13 J	8.6	2.2	2.2	1.4	7	Potential COC
Total PAHs (1)	1.6	22.8	mg/kg dry wt	11.6 J	61.9 J	2.7	20.2	18	0.8	2	Potential COC
Pesticides											
4,4'-DDD	0.00488	0.028	mg/kg dry wt	0.0073	0.0061		0.018	0.017			
4,4'-DDE	0.00316	0.0313	mg/kg dry wt	0.0048	0.0051 J		R	0.016 J			
alpha-Chlordane	0.0032	0.0176	mg/kg dry wt	0.0015	0.0015		0.0055	0.0034			
Delta-BHC	0.12	0.01	mg/kg dry wt	0.00082 U	0.00084 U		0.00076 U	0.00068 U			
Dieldrin	0.0019	0.0618	mg/kg dry wt	0.0018	0.0022		0.00076 U	0.0052 J			
Endosulfan Sulfate	-	-	mg/kg dry wt	0.00082 U	0.00084 U		0.00076 U	0.013 J			
Endrin Ketone	-	-	mg/kg dry wt	0.0082 J	0.0091 J		0.00076 U	0.00068 U			
Gamma-Chlordane	-	-	mg/kg dry wt	0.0013	0.002 J		0.0065	0.0036			
PCBs											
Aroclor-1254	0.0598	0.676	mg/kg dry wt	0.0082 U	0.0084 U		1.4 JEB	1.1 JEB			
Aroclor-1260	0.0598	0.676	mg/kg dry wt	0.13 J	0.12 J		0.57 J	0.46			
Total PCBs	0.0598	0.676	mg/kg dry wt	0.13 J	0.12 J		1.97 J	1.56 J			
Metals and Cyanide											
Aluminum	-	-	mg/kg dry wt	5,200	4,700		12,000	12,000			
Antimony	12	60	mg/kg dry wt	0.47 J	0.46 J		0.52 J	0.47 J			
Arsenic	9.79	33	mg/kg dry wt	5.8	5.5		10	8.1			
Barium	-	-	mg/kg dry wt	51	44		82	79			
Beryllium	-	-	mg/kg dry wt	0.35	0.3		0.88	0.73			
Cadmium	1	4.98	mg/kg dry wt	4.6	4		9.9	9.8			
Calcium	-	-	mg/kg dry wt	1,100	950		3,300 J	3,100 J			
Chromium	43.4	111	mg/kg dry wt	86	70		110	120			
Cobalt	-	-	mg/kg dry wt	4.8	4.4		12	11			
Copper	31.6	149	mg/kg dry wt	72	69		170	160			
Iron	20,000	40,000	mg/kg dry wt	8,200	7,300		25,000	17,000			
Lead	36	128	mg/kg dry wt	96	94		450	300			
Magnesium	-	-	mg/kg dry wt	1,600	1,500		4,100	2,900			

Table A-4 - Pond D Toxicity Data Evaluation

Data from BERA Table 7-9c

				Site		Pond	Background		March 2012 Evaluation
			Sample Name:	T05PD-002	BD062105		T05BL-003	T05BL-004	Note that Highest HQ for site data is max conc divided by Effect Criteria.
			Sample Depth (Feet):	0 - 0.5	0 - 0.5		0 - 0.5	0 - 0.5	Lowest HQ for Bkgd data is min conc divided by Effect Criteria.
			Date Collected:	6/21/2005	6/21/2005		6/23/2005	6/23/2005	
			Location ID:	T05PD-002	T05PD-002		T05BL-003	T05BL-004	RR is Site HQ minus Bkgd HQ
Species	Test	Lab control Result	Units						
Chironomus dilutus	Survival	83.75	%	77.5			86.25	93.75	
Chironomus dilutus	Growth	1.79	mg/larvae	1.81			1.39	1.56	
Hyalella azteca	Survival	91.25	%	16.25			51.25	88.75	
Hyalella azteca	Growth	0.597	mg/amphipod	0.528			0.237	0.29	
Constituent	No Effect Criteria	Effect Criteria	Units			Highest Site HQ			Lowest Bkgd HQ / RR / Comment
Manganese	460	5,500	mg/kg dry wt	140	120		200 J	160 J	
Mercury	0.18	1.06	mg/kg dry wt	0.26 J	0.29 J		0.54	0.47	
Nickel	23	48.6	mg/kg dry wt	19	18		52	46	
Potassium	-	-	mg/kg dry wt	480	420		1,500	1,100	
Selenium	-	-	mg/kg dry wt	0.29	0.26		1.5	1.3	
Silver	2	10	mg/kg dry wt	0.44	0.49		1.7	2.1	
Sodium	-	-	mg/kg dry wt	99	86		2,500	2,100	
Thallium	-	-	mg/kg dry wt	0.1	0.087		0.4	0.26	
Vanadium	-	-	mg/kg dry wt	12	9.9		31	24	
Zinc	120	459	mg/kg dry wt	220	200		680 J	490 J	

(1) No effect/Effect criteria (TEC/PEC) were not in the original BERA

Table A-5 - Pond E Chemistry Data Evaluation

Data from BERA Table 7-6g

COPECs (mg/kg dry wt)	FOD	RME	CTE	No Effect Sediment Benchmark	Effect Sediment Benchmark	No Effect HQ RME	No Effect HQ CTE	Effect HQ RME	Effect HQ CTE	No Effect RR RME	No Effect RR CTE	Effect RR RME	Effect RR CTE	March 2012 Evaluation Scenario	March 2012 Evaluation Comment
VOCs															
1,1,1-Trichloroethane	0/2	1.35E-02	1.25E-02	0.17	2.2	0.1	0.07	0.01	0.006	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
1,1,2,2-Tetrachloroethane	0/2	1.35E-02	1.25E-02	0.94	12.2	0.01	0.01	0.001	0.001	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
1,1-Dichloroethene	0/2	1.35E-02	1.25E-02	0.031	0.4	0.4	0.4	0.03	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Butanone	1/2	7.50E-01	3.82E-01	0.27	3.5	3	1	0.2	0.1	3	1	<1	<1	2	Out - Scenario 1, 2, or 3
2-Hexanone	0/2	1.35E-02	1.25E-02	0.022	0.29	0.6	0.6	0.05	0.04	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4-Methyl-2-pentanone	1/2	1.30E-01	7.18E-02	0.033	0.43	4	2	0.3	0.2	4	2	<1	<1	3	Out - Scenario 1, 2, or 3
Acetone	1/2	2.30E+00	1.16E+00	0.0087	0.11	264	133	20	10	254	127	20	10	6	Out - associated with preservation/lab analysis
Carbon disulfide	1/2	4.40E-02	2.88E-02	0.00085	0.011	52	34	4	3	46	29	4	2	6	Out - Low Toxicity for VOCs; not site-related
Chloromethane	0/2	1.35E-02	1.25E-02	--	--	--	--	--	--	--	--	--	--	NA	
cis-1,2-Dichloroethene	0/2	1.35E-02	1.25E-02	--	--	--	--	--	--	--	--	--	--	NA	
cis-1,3-Dichloropropene	0/2	1.35E-02	1.25E-02	--	--	--	--	--	--	--	--	--	--	NA	
Isopropylbenzene	0/2	1.35E-02	1.25E-02	--	--	--	--	--	--	--	--	--	--	NA	
Methyl acetate	0/2	1.35E-02	1.25E-02	--	--	--	--	--	--	--	--	--	--	NA	
Methylene chloride	0/2	4.35E-02	2.85E-02	0.37	4.8	0.1	0.08	0.009	0.006	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Styrene	0/2	1.35E-02	1.25E-02	--	--	--	--	--	--	--	--	--	--	NA	
Tetrachloroethene	0/2	1.35E-02	1.25E-02	0.41	5.3	0.03	0.03	0.003	0.002	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
trans-1,3-Dichloropropene	0/2	1.35E-02	1.25E-02	--	--	--	--	--	--	--	--	--	--	NA	
Trichlorofluoromethane	0/2	1.35E-02	1.25E-02	--	--	--	--	--	--	--	--	--	--	NA	
Xylene (total)	1/2	1.35E-02	8.75E-03	0.025	0.33	0.5	0.4	0.04	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
SVOCs															
1,1'-Biphenyl	0/2	2.35E-01	2.08E-01	--	--	--	--	--	--	--	--	--	--	NA	
2-Methylnaphthalene	2/2	6.10E-02	6.05E-02	0.33	4.3	0.2	0.2	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Methylphenol	0/2	2.35E-01	2.08E-01	0.012	0.16	20	17	2	1	<1	8	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
4-Bromophenyl-phenylether	0/2	2.35E-01	2.08E-01	1.3	16.9	0.2	0.2	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4-Chloroaniline	0/2	2.35E-01	2.08E-01	--	--	--	--	--	--	--	--	--	--	NA	
4-Methylphenol	0/2	2.35E-01	2.08E-01	--	--	--	--	--	--	--	--	--	--	NA	
4-Nitroaniline	0/2	6.00E-01	5.28E-01	--	--	--	--	--	--	--	--	--	--	NA	
Acenaphthene	2/2	9.10E-02	8.20E-02	0.62	8.1	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acenaphthylene	2/2	1.80E-01	1.70E-01	0.33	4.3	0.5	0.5	0.04	0.04	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acetophenone	1/2	2.35E-01	1.40E-01	--	--	--	--	--	--	--	--	--	--	NA	
Anthracene	2/2	4.80E-01	3.95E-01	0.057	0.85	8	7	1	0.5	<1	1	<1	<1	1	Out - Scenario 1, 2, or 3
Benzaldehyde	1/2	3.50E-01	2.93E-01	--	--	--	--	--	--	--	--	--	--	NA	
Benzo(a)pyrene	2/2	2.20E+00	1.85E+00	0.15	1.5	15	12	2	1	6	6	<1	<1	3	Out - Scenario 1, 2, or 3
Benzo(b)fluoranthene	1/1	2.20E+00	2.20E+00	--	--	--	--	--	--	--	--	--	--	NA	
Benzo(g,h,i)perylene	2/2	1.10E+00	8.20E-01	0.17	0.32	6	5	3	3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Benzo(k)fluoranthene	2/2	1.40E+00	1.14E+00	--	--	--	--	--	--	--	--	--	--	NA	
bis(2-Ethylhexyl)phthalate	2/2	2.00E+01	1.55E+01	890	11570	0.02	0.02	0.002	0.001	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Carbazole	2/2	1.60E-01	1.55E-01	--	--	--	--	--	--	--	--	--	--	NA	
Chrysene	2/2	1.90E+00	1.80E+00	0.17	1.3	11	11	1	1	3	5	<1	<1	3	Out - Scenario 1, 2, or 3
Cyclohexane	1/2	1.35E-02	9.75E-03	--	--	--	--	--	--	--	--	--	--	NA	
Dibenzofuran	1/2	2.35E-01	1.62E-01	2	26	0.1	0.08	0.009	0.006	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Fluoranthene	2/2	2.90E+00	2.55E+00	0.42	2.2	7	6	1	1	1	2	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
Fluorene	2/2	1.30E-01	1.00E-01	0.077	0.54	2	1	0.2	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Hexachlorobenzene	0/2	2.35E-01	2.08E-01	0.02	0.26	12	10	0.9	0.8	<1	5	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
Hexachlorobutadiene	0/2	2.35E-01	2.08E-01	--	--	--	--	--	--	--	--	--	--	NA	
Indeno(1,2,3-cd)pyrene	2/2	1.40E+00	1.02E+00	0.2	2.6	7	5	0.5	0.4	<1	2	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
Isophorone	0/2	2.35E-01	2.08E-01	--	--	--	--	--	--	--	--	--	--	NA	
Naphthalene	2/2	9.00E-02	8.55E-02	0.18	0.56	1	0.5	0.2	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
N-Nitrosodiphenylamine	1/2	1.40E+00	8.18E-01	--	--	--	--	--	--	--	--	--	--	NA	

Table A-5 - Pond E Chemistry Data Evaluation

Data from BERA Table 7-6g

COPECs (mg/kg dry wt)	FOD	RME	CTE	No Effect Sediment Benchmark	Effect Sediment Benchmark	No Effect HQ RME	No Effect HQ CTE	Effect HQ RME	Effect HQ CTE	No Effect RR RME	No Effect RR CTE	Effect RR RME	Effect RR CTE	March 2012 Evaluation Scenario	March 2012 Evaluation Comment
Pentachlorophenol	0/2	6.00E-01	5.28E-01	--	--	--	--	--	--	--	--	--	--	NA	
Phenanthrene	2/2	1.80E+00	1.50E+00	0.2	1.2	9	7	2	1	2	3	<1	<1	3	Out - Scenario 1, 2, or 3
Phenol	1/2	2.35E-01	1.38E-01	--	--	--	--	--	--	--	--	--	--	NA	
Pyrene	2/2	3.10E+00	2.65E+00	0.2	1.52	16	14	2	2	5	5	<1	<1	3	Out - Scenario 1, 2, or 3
Pesticides/PCBs															
4,4'-DDD	2/2	1.00E-02	9.60E-03	0.0049	0.028	2	2	0.4	0.3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4,4'-DDE	1/1	9.60E-03	9.60E-03	0.0032	0.031	3	3	0.3	0.3	<1	2	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
4,4'-DDT	0/1	4.65E-03	4.65E-03	0.0042	0.063	1	1	0.1	0.07	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
alpha-Chlordane	1/2	4.30E-03	2.24E-03	0.0032	0.018	1.3	0.7	0.2	0.1	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1016	0/2	4.65E-03	4.15E-03	0.06	0.7	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1221	0/2	9.50E-03	8.50E-03	0.06	0.7	0.2	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1232	0/2	4.65E-03	4.15E-03	0.06	0.7	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1242	0/2	4.65E-03	4.15E-03	0.06	0.7	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1248	0/2	4.65E-03	4.15E-03	0.06	0.7	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1254	1/2	2.30E-01	1.17E-01	0.06	0.7	4	2	0.3	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1260	1/2	1.20E-01	6.23E-02	0.06	0.7	2	1	0.2	0.1	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Dieldrin	1/2	1.90E-02	9.68E-03	0.0019	0.062	10	5	0.3	0.2	7	3	<1	<1	3	Out - Scenario 1, 2, or 3
Endosulfan I	0/2	2.40E-04	2.13E-04	0.0029	0.073	0.1	0.1	0.003	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endosulfan II	0/2	4.65E-04	4.15E-04	0.0055	0.14	0.1	0.1	0.003	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endosulfan Sulfate	1/2	4.80E-03	4.73E-03	--	--	--	--	--	--	--	--	--	--	NA	
Endrin	0/2	4.65E-04	4.15E-04	0.002	0.21	0.2	0.2	0.002	0.002	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endrin Aldehyde	2/2	7.60E-03	6.05E-03	--	--	--	--	--	--	--	--	--	--	NA	
Endrin Ketone	0/1	4.65E-03	4.65E-03	--	--	--	--	--	--	--	--	--	--	NA	
Gamma-Chlordane	1/1	5.60E-03	5.60E-03	--	--	--	--	--	--	--	--	--	--	NA	
Heptachlor Epoxide	0/2	2.40E-04	2.13E-04	0.0025	0.016	0.1	0.1	0.02	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Methoxychlor	1/2	8.10E-03	5.25E-03	0.019	0.48	0.4	0.3	0.02	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Total PCBs	2/2	2.30E-01	1.75E-01	0.06	0.68	4	3	0.3	0.3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Toxaphene	0/2	2.40E-02	2.13E-02	0.028	0.7	1	1	0.03	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Metals															
Aluminum	2/2	1.09E+04	9.47E+03	--	--	--	--	--	--	--	--	--	--	NA	
Antimony	2/2	1.89E+01	1.23E+01	12	60	2	1	0.3	0.2	2	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Arsenic	2/2	2.11E+01	1.82E+01	9.8	33	2	2	0.6	0.6	1	1	<1	<1	1	Out - Scenario 1, 2, or 3
Barium	2/2	6.17E+02	5.34E+02	--	--	--	--	--	--	--	--	--	--	NA	
Beryllium	1/2	7.20E-01	6.00E-01	--	--	--	--	--	--	--	--	--	--	NA	
Cadmium	2/2	1.59E+01	1.46E+01	1	5	16	15	3	3	9	11	2	2	6	Potential COC
Chromium	2/2	3.54E+02	2.79E+02	43	111	8	6	3	3	7	5	3	2	6	Potential COC
Cobalt	0/2	6.50E+00	5.65E+00	--	--	--	--	--	--	--	--	--	--	NA	
Copper	2/2	6.53E+02	5.46E+02	32	149	21	17	4	4	17	15	4	3	6	Potential COC
Cyanide	2/2	5.00E-01	4.00E-01	--	--	--	--	--	--	--	--	--	--	NA	
Iron	2/2	4.96E+04	3.54E+04	20,000	40,000	2	2	1	0.9	2	1	<1	<1	2	Out - Scenario 1, 2, or 3
Lead	2/2	1.76E+03	1.53E+03	36	128	49	43	14	12	43	40	12	11	6	Potential COC
Manganese	2/2	3.26E+02	2.90E+02	460	5500	0.7	0.6	0.06	0.05	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Mercury	2/2	7.80E-01	6.60E-01	0.18	1.06	4	4	0.7	0.6	3	3	<1	<1	3	Out - Scenario 1, 2, or 3
Nickel	2/2	6.17E+01	6.13E+01	23	48.6	3	3	1	1	2	2	<1	<1	3	Out - Scenario 1, 2, or 3
Selenium	2/2	3.20E+00	2.85E+00	--	--	--	--	--	--	--	--	--	--	NA	
Silver	2/2	1.17E+01	1.16E+01	2	10	6	6	1	1	5	5	<1	<1	3	Out - Scenario 1, 2, or 3
Thallium	1/2	9.60E-01	5.75E-01	--	--	--	--	--	--	--	--	--	--	NA	
Vanadium	2/2	3.43E+01	3.27E+01	--	--	--	--	--	--	--	--	--	--	NA	
Zinc	2/2	1.46E+03	1.44E+03	120	459	12	12	3	3	10	10	3	3	6	Potential COC

Table A-6 - Pond I Chemistry Data Evaluation

Data from BERA Table 7-6i

COPECs (mg/kg dry wt)	FOD	RME	CTE	No Effect Sediment Benchmark	Effect Sediment Benchmark	No Effect HQ RME	No Effect HQ CTE	Effect HQ RME	Effect HQ CTE	No Effect RR RME	No Effect RR CTE	Effect RR RME	Effect RR CTE	March 2012 Evaluation Scenario	March 2012 Evaluation Comment
VOCs															
1,1,1-Trichloroethane	0/3	1.45E-02	8.18E-03	0.17	2.2	0.1	0.05	0.01	0.004	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
1,1,2,2-Tetrachloroethane	0/3	1.45E-02	8.18E-03	0.94	12.2	0.02	0.01	0.001	0.0007	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
1,1-Dichloroethene	0/3	1.45E-02	8.18E-03	0.031	0.4	0.5	0.3	0.04	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Butanone	3/3	3.80E-01	1.43E-01	0.27	3.5	1	0.5	0.1	0	1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Hexanone	0/3	1.45E-02	8.18E-03	0.022	0.29	0.7	0.4	0.05	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4-Methyl-2-pentanone	0/3	1.45E-02	8.18E-03	0.033	0.43	0.4	0.2	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acetone	3/3	1.10E+00	3.97E-01	0.0087	0.11	126	46	10	4	116	39	9	3	6	Out - associated with preservation/lab analysis
Carbon disulfide	2/3	1.20E-02	7.37E-03	0.00085	0.011	14	9	1	0.7	8	4	<1	<1	3	Out - Scenario 1, 2, or 3
Chloromethane	0/3	1.45E-02	8.18E-03	--	--	--	--	--	--	--	--	--	--	NA	
cis-1,2-Dichloroethene	0/3	1.45E-02	8.18E-03	--	--	--	--	--	--	--	--	--	--	NA	
cis-1,3-Dichloropropene	0/3	1.45E-02	8.18E-03	--	--	--	--	--	--	--	--	--	--	NA	
Isopropylbenzene	0/3	1.45E-02	8.18E-03	--	--	--	--	--	--	--	--	--	--	NA	
Methyl acetate	1/3	2.20E-02	1.04E-02	--	--	--	--	--	--	--	--	--	--	NA	
Methylene chloride	0/3	2.10E-02	1.06E-02	0.37	4.8	0.1	0.03	0.004	0.002	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Styrene	0/3	1.45E-02	8.18E-03	--	--	--	--	--	--	--	--	--	--	NA	
Tetrachloroethene	0/3	1.45E-02	8.18E-03	0.41	5.3	0.04	0.02	0.003	0.002	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
trans-1,3-Dichloropropene	0/3	1.45E-02	8.18E-03	--	--	--	--	--	--	--	--	--	--	NA	
Trichlorofluoromethane	0/3	1.45E-02	8.18E-03	--	--	--	--	--	--	--	--	--	--	NA	
Xylene (total)	0/3	1.45E-02	9.75E-03	0.025	0.33	0.6	0.4	0.04	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
SVOCs															
1,1'-Biphenyl	0/3	2.80E-01	1.81E-01	--	--	--	--	--	--	--	--	--	--	NA	
2-Methylnaphthalene	3/3	4.70E-01	2.18E-01	0.33	4.3	1	0.7	0.1	0.05	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Methylphenol	0/3	2.80E-01	1.58E-01	0.012	0.16	23	13	2	1	4	3	<1	<1	3	Out - Scenario 1, 2, or 3
4-Bromophenyl-phenylether	0/3	2.80E-01	1.81E-01	1.3	16.9	0.2	0.1	0.02	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4-Chloroaniline	0/3	2.80E-01	1.81E-01	--	--	--	--	--	--	--	--	--	--	NA	
4-Methylphenol	0/3	2.80E-01	1.81E-01	--	--	--	--	--	--	--	--	--	--	NA	
4-Nitroaniline	0/3	7.00E-01	4.07E-01	--	--	--	--	--	--	--	--	--	--	NA	
Acenaphthene	3/3	1.80E-01	1.55E-01	0.62	8.1	0.3	0.3	0.02	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acenaphthylene	3/3	5.60E-01	3.70E-01	0.33	4.3	2	1	0.1	0.09	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acetophenone	1/3	2.80E-01	1.65E-01	--	--	--	--	--	--	--	--	--	--	NA	
Anthracene	3/3	8.80E-01	5.95E-01	0.057	0.85	15	10	1	0.7	7	5	<1	<1	3	Out - Scenario 1, 2, or 3
Benzaldehyde	3/3	7.20E-01	3.98E-01	--	--	--	--	--	--	--	--	--	--	NA	
Benzo(a)pyrene	3/3	3.60E+00	2.30E+00	0.15	1.5	24	15	2	2	15	9	2	<1	4	Potential COC
Benzo(b)fluoranthene	3/3	3.80E+00	2.82E+00	--	--	--	--	--	--	--	--	--	--	NA	
Benzo(g,h,i)perylene	3/3	2.70E+00	1.59E+00	0.17	0.32	16	9	8	5	7	5	4	3	6	Potential COC
Benzo(k)fluoranthene	3/3	3.20E+00	1.62E+00	--	--	--	--	--	--	--	--	--	--	NA	
bis(2-Ethylhexyl)phthalate	3/3	4.70E+00	3.80E+00	890	11570	0.005	0.004	0.0004	0.0003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Carbazole	3/3	4.60E-01	3.05E-01	--	--	--	--	--	--	--	--	--	--	NA	
Chrysene	3/3	3.70E+00	2.55E+00	0.17	1.3	22	15	3	2	13	9	2	1	5	Potential COC
Cyclohexane	2/3	3.60E-02	1.40E-02	--	--	--	--	--	--	--	--	--	--	NA	
Dibenzofuran	2/3	9.00E-02	7.63E-02	2	26	0.05	0.04	0.003	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Fluoranthene	3/3	6.60E+00	4.42E+00	0.42	2.2	16	11	3	2	10	7	2	1	5	Potential COC
Fluorene	3/3	3.60E-01	2.38E-01	0.077	0.54	5	3	0.7	0.4	3	2	<1	<1	3	Out - Scenario 1, 2, or 3
Hexachlorobenzene	0/3	2.80E-01	1.52E-01	0.02	0.26	14	8	1	0.6	3	2	<1	<1	3	Out - Scenario 1, 2, or 3
Hexachlorobutadiene	0/3	2.80E-01	1.81E-01	--	--	--	--	--	--	--	--	--	--	NA	
Indeno(1,2,3-cd)pyrene	3/3	2.50E+00	1.48E+00	0.2	2.6	13	7	1	0.6	6	4	<1	<1	3	Out - Scenario 1, 2, or 3
Isophorone	0/3	2.80E-01	1.81E-01	--	--	--	--	--	--	--	--	--	--	NA	
Naphthalene	3/3	6.80E-01	3.10E-01	0.18	0.56	4	2	1	0.6	3	1	<1	<1	2	Out - Scenario 1, 2, or 3
N-Nitrosodiphenylamine	0/3	2.80E-01	1.81E-01	--	--	--	--	--	--	--	--	--	--	NA	

Table A-6 - Pond I Chemistry Data Evaluation

Data from BERA Table 7-6i

COPECs (mg/kg dry wt)	FOD	RME	CTE	No Effect Sediment Benchmark	Effect Sediment Benchmark	No Effect HQ RME	No Effect HQ CTE	Effect HQ RME	Effect HQ CTE	No Effect RR RME	No Effect RR CTE	Effect RR RME	Effect RR CTE	March 2012 Evaluation Scenario	March 2012 Evaluation Comment
Pentachlorophenol	0/2	7.00E-01	5.65E-01	--	--	--	--	--	--	--	--	--	--	NA	
Phenanthrene	3/3	2.80E+00	1.98E+00	0.2	1.2	14	10	2	2	7	5	1	<1	3	Out - Scenario 1, 2, or 3
Phenol	2/3	2.80E-01	1.62E-01	--	--	--	--	--	--	--	--	--	--	NA	
Pyrene	3/3	5.40E+00	3.42E+00	0.2	1.52	28	18	4	2	16	9	2	1	5	Potential COC
Pesticides/PCBs															
4,4'-DDD	2/2	1.90E-02	1.00E-02	0.0049	0.028	4	2	0.7	0.4	1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4,4'-DDE	2/2	1.50E-02	8.18E-03	0.0032	0.031	5	3	0.5	0.3	1	1	<1	<1	1	Out - Scenario 1, 2, or 3
4,4'-DDT	0/1	3.55E-04	3.55E-04	0.0042	0.063	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
alpha-Chlordane	3/3	1.10E-02	4.86E-03	0.0032	0.018	3	2	0.6	0.3	3	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Aroclor-1016	0/2	1.80E-02	1.18E-02	0.06	0.7	0.3	0.2	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1221	0/2	1.80E-02	1.45E-02	0.06	0.7	0.3	0.2	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1232	0/2	1.80E-02	1.18E-02	0.06	0.7	0.3	0.2	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1242	0/2	1.80E-02	1.18E-02	0.06	0.7	0.3	0.2	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1248	0/2	1.80E-02	1.18E-02	0.06	0.7	0.3	0.2	0.03	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1254	1/2	3.60E-01	1.83E-01	0.06	0.7	6	3	0.5	0.3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1260	3/3	7.60E-01	3.27E-01	0.06	0.7	13	5	1	0.5	5	2	<1	<1	3	Out - Scenario 1, 2, or 3
Dieldrin	2/2	9.40E-03	4.91E-03	0.0019	0.062	5	3	0.2	0.1	2	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Endosulfan I	0/2	3.55E-04	3.20E-04	0.0029	0.073	0.1	0.1	0.005	0.004	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endosulfan II	0/2	5.50E-04	4.53E-04	0.0055	0.14	0.1	0.1	0.004	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endosulfan Sulfate	1/2	6.60E-03	3.48E-03	--	--	--	--	--	--	--	--	--	--	NA	
Endrin	0/2	5.50E-04	4.53E-04	0.002	0.21	0.2	0.2	0.003	0.002	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endrin Aldehyde	0/1	3.55E-04	3.55E-04	--	--	--	--	--	--	--	--	--	--	NA	
Endrin Ketone	0/1	3.55E-04	3.55E-04	--	--	--	--	--	--	--	--	--	--	NA	
Gamma-Chlordane	2/2	7.40E-03	4.04E-03	--	--	--	--	--	--	--	--	--	--	NA	
Heptachlor Epoxide	0/2	3.55E-04	3.20E-04	0.0025	0.016	0.1	0.1	0.02	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Methoxychlor	0/2	2.85E-03	1.60E-03	0.019	0.48	0.2	0.1	0.01	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Total PCBs	3/3	1.12E+00	4.47E-01	0.06	0.68	19	7	2	0.7	3	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Toxaphene	0/2	4.45E-02	3.65E-02	0.028	0.7	2	1	0.06	0.05	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Metals															
Aluminum	3/3	1.24E+04	9.98E+03	--	--	--	--	--	--	--	--	--	--	NA	
Antimony	3/3	4.50E+00	1.62E+00	12	60	0.4	0.1	0.08	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Arsenic	3/3	1.30E+01	1.07E+01	9.8	33	1	1	0.4	0.3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Barium	3/3	2.19E+02	1.71E+02	--	--	--	--	--	--	--	--	--	--	NA	
Beryllium	3/3	1.20E+00	7.22E-01	--	--	--	--	--	--	--	--	--	--	NA	
Cadmium	3/3	3.02E+01	1.54E+01	1	5	30	15	6	3	23	12	5	2	6	Potential COC
Chromium	3/3	2.57E+02	1.47E+02	43	111	6	3	2	1	4	2	2	<1	5	Potential COC
Cobalt	3/3	8.60E+00	6.32E+00	--	--	--	--	--	--	--	--	--	--	NA	
Copper	3/3	3.55E+02	2.22E+02	32	149	11	7	2	1	8	5	2	1	5	Potential COC
Cyanide	2/2	2.00E+00	1.26E+00	--	--	--	--	--	--	--	--	--	--	NA	
Iron	3/3	3.10E+04	2.43E+04	20,000	40,000	2	1	0.8	0.6	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Lead	3/3	3.00E+02	1.91E+02	36	128	8	5	2	1	3	3	<1	<1	3	Out - Scenario 1, 2, or 3
Manganese	3/3	3.80E+02	3.08E+02	460	5500	0.8	0.7	0.07	0.06	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Mercury	3/3	6.60E-01	4.88E-01	0.18	1.06	4	3	0.6	0.5	2	2	<1	<1	3	Out - Scenario 1, 2, or 3
Nickel	3/3	7.06E+01	3.77E+01	23	48.6	3	2	1	0.8	2	<1	<1	<1	2	Out - Scenario 1, 2, or 3
Selenium	3/3	3.70E+00	2.25E+00	--	--	--	--	--	--	--	--	--	--	NA	
Silver	3/3	1.88E+01	7.90E+00	2	10	9	4	2	0.8	8	3	2	<1	5	Potential COC
Thallium	2/3	9.20E-01	4.12E-01	--	--	--	--	--	--	--	--	--	--	NA	
Vanadium	3/3	3.35E+01	2.34E+01	--	--	--	--	--	--	--	--	--	--	NA	
Zinc	3/3	6.66E+02	4.13E+02	120	459	6	3	1	0.9	3	2	<1	<1	3	Out - Scenario 1, 2, or 3

Table A-7 - Pond I Toxicity Data Evaluation

Data from BERA Table 7-9b and 9c

March 2012 Evaluation

Note that Highest HQ for site data is max conc divided by Effect Criteria.
Lowest HQ for Bkgd data is min conc divided by Effect Criteria.
RR is Site HQ minus Bkgd HQ

				Site		Background				
			Sample Name:	T05BR-005		T05BL-003	T05BL-004			
			Sample Depth (Feet):	0 - 0.5		0 - 0.5	0 - 0.5			
			Date Collected:	6/22/2005		6/23/2005	6/23/2005			
			Location ID:	T05BR-005		T05BL-003	T05BL-004			
Species	Test	Lab control Result	Units							
Chironomus dilutus	Survival	83.75	%	88.75		86.25	93.75			
Chironomus dilutus	Growth	1.79	mg/larvae	1.2		1.39	1.56			
Hyalella azteca	Survival	91.25	%	86.25		51.25	88.75			
Hyalella azteca	Growth	0.597	mg/amphipod	0.314		0.237	0.29			
Constituent	No Effect Criteria	Effect Criteria	Units		Highest Site HQ			Lowest Bkgd HQ	RR	Comment
VOC										
2-Butanone	0.27	3.51	mg/kg dry wt	0.077		0.038 J	0.029 J			
Acetone	0.0087	0.1131	mg/kg dry wt	0.2 J	1.8	0.13 JEB	0.15 JEB	1.15	1	Out - RR<=1
Carbon disulfide	0.00085	0.01105	mg/kg dry wt	0.0026 J		0.013 J	0.0057 J			
Chlorobenzene	0.82	10.66	mg/kg dry wt	0.0029 J		--	--			
Cyclohexane	-	-	mg/kg dry wt	0.003 J		--	--			
Ethylbenzene	3.6	46.8	mg/kg dry wt	0.0046 U		0.0053 J	0.0062 UJ			
Methyl tert butyl ether	-	-	mg/kg dry wt	0.0046 U		0.0041 J	0.0062 UJ			
Toluene	0.67	8.71	mg/kg dry wt	0.0046 U		0.002 J	0.0062 UJ			
SVOC										
1,1'-Biphenyl	-	-	mg/kg dry wt	0.18 U		0.19 U	0.17 U			
2-Methylnaphthalene	0.33	4.29	mg/kg dry wt	0.47		0.36	0.43			
2-Methylphenol	0.012	0.156	mg/kg dry wt	0.045 U		0.046 U	0.043 U			
Acenaphthene	0.62	8.06	mg/kg dry wt	0.18		0.097	0.084			
Acenaphthylene	0.33	4.29	mg/kg dry wt	0.56		0.31	0.47			
Anthracene	0.0572	0.845	mg/kg dry wt	0.88	1.0	0.44	0.46	0.52	0.5	Out - RR<=1
Benzaldehyde	-	-	mg/kg dry wt	0.34 J		0.41 J	0.17 UJ			
Benzo(a)pyrene	0.15	1.45	mg/kg dry wt	3.6	2.5	1.7	1.5	1.03	1	Out - RR<=1
Benzo(b)fluoranthene	-	-	mg/kg dry wt	3.8		2.3	1.8			
Benzo(g,h,i)perylene	0.17	0.32	mg/kg dry wt	2.7	8.4	1.8	1.3	4.06	4	Potential COC
Benzo(k)fluoranthene	-	-	mg/kg dry wt	3.2		1.8	1.6			
Benzo[a]anthracene	0.11	1.05	mg/kg dry wt	2.8	2.7	1.3	1.3	1.24	1	Out - RR<=1
bis(2-Ethylhexyl)phthalate	890	11,570	mg/kg dry wt	3.6		5.9	1.9			
Carbazole	-	-	mg/kg dry wt	0.46		0.22	0.17 U			
Chrysene	0.17	1.29	mg/kg dry wt	3.7	2.9	1.8	1.5	1.16	2	Potential COC
Dibenz[a,h]anthracene	0.033	0.429	mg/kg dry wt	0.87	2.0	0.5	0.4	0.93	1	Out - RR<=1
Dibenzofuran	2	26	mg/kg dry wt	0.18 U		0.19 U	0.17 U			
Fluoranthene	0.42	2.23	mg/kg dry wt	6.6	3.0	2.6	2.4	1.08	2	Potential COC
Fluorene	0.077	0.536	mg/kg dry wt	0.36		0.22	0.18			
Indeno(1,2,3-cd)pyrene	0.2	2.6	mg/kg dry wt	2.5		1.5	1.2			

Table A-7 - Pond I Toxicity Data Evaluation

Data from BERA Table 7-9b and 9c

March 2012 Evaluation

Note that Highest HQ for site data is max conc divided by Effect Criteria.
Lowest HQ for Bkgd data is min conc divided by Effect Criteria.
RR is Site HQ minus Bkgd HQ

				Site		Background				
			Sample Name:	T05BR-005		T05BL-003	T05BL-004			
			Sample Depth (Feet):	0 - 0.5		0 - 0.5	0 - 0.5			
			Date Collected:	6/22/2005		6/23/2005	6/23/2005			
			Location ID:	T05BR-005		T05BL-003	T05BL-004			
Species	Test	Lab control Result	Units							
Chironomus dilutus	Survival	83.75	%	88.75		86.25	93.75			
Chironomus dilutus	Growth	1.79	mg/larvae	1.2		1.39	1.56			
Hyalella azteca	Survival	91.25	%	86.25		51.25	88.75			
Hyalella azteca	Growth	0.597	mg/amphipod	0.314		0.237	0.29			
Constituent	No Effect Criteria	Effect Criteria	Units		Highest Site HQ			Lowest Bkgd HQ	RR	Comment
Naphthalene	0.18	0.561	mg/kg dry wt	0.68	1.2	0.27	0.35	0.48	1	Out - RR<=1
Phenanthrene	0.2	1.17	mg/kg dry wt	2.8	2.4	0.97	0.84	0.72	2	Potential COC
Phenol	-	-	mg/kg dry wt	0.16		0.18	0.16			
Pyrene	0.2	1.52	mg/kg dry wt	5.4	3.6	2.2	2.2	1.45	2	Potential COC
Total PAHs (1)	1.6	22.8	mg/kg dry wt	41.1	1.8	20.2	18	0.79	1	Potential COC - based on individual PAHs
Pesticides										
4,4'-DDD	0.00488	0.028	mg/kg dry wt	0.019		0.018	0.017			
4,4'-DDE	0.00316	0.0313	mg/kg dry wt	0.015 J		R	0.016 J			
alpha-Chlordane	0.0032	0.0176	mg/kg dry wt	0.011 J		0.0055	0.0034			
Delta-BHC	0.12	0.01	mg/kg dry wt	0.0016		0.00076 U	0.00068 U			
Dieldrin	0.0019	0.0618	mg/kg dry wt	0.0094		0.00076 U	0.0052 J			
Endrin Ketone	-	-	mg/kg dry wt	0.00071 U		0.00076 U	0.00068 U			
Gamma-Chlordane	-	-	mg/kg dry wt	0.0074		0.0065	0.0036			
PCBs										
Aroclor-1254	0.0598	0.676	mg/kg dry wt	0.36 JEB		1.4 JEB	1.1 JEB			
Aroclor-1260	0.0598	0.676	mg/kg dry wt	0.76	1.1	0.57 J	0.46	0.68	0.4	Out - RR<=1
Total PCBs	0.0598	0.676	mg/kg dry wt	1.12 J	1.7	1.97 J	1.56 J	2.31	-1	Out - RR<=1
Metals and Cyanide										
Aluminum	-	-	mg/kg dry wt	12,000		12,000	12,000			
Antimony	12	60	mg/kg dry wt	0.6 J		0.52 J	0.47 J			
Arsenic	9.79	33	mg/kg dry wt	13		10	8.1			
Barium	-	-	mg/kg dry wt	200		82	79			
Beryllium	-	-	mg/kg dry wt	0.9		0.88	0.73			
Cadmium	1	4.98	mg/kg dry wt	12	2.4	9.9	9.8	1.97	0.4	Potential COC - based on chemistry; site-related
Calcium	-	-	mg/kg dry wt	2,100 J		3,300 J	3,100 J			
Chromium	43.4	111	mg/kg dry wt	140	1.3	110	120	0.99	0.3	Potential COC - based on chemistry; site-related
Cobalt	-	-	mg/kg dry wt	7.1		12	11			
Copper	31.6	149	mg/kg dry wt	220	1.5	170	160	1.07	0.4	Potential COC - based on chemistry; site-related
Iron	20,000	40,000	mg/kg dry wt	31,000		25,000	17,000			
Lead	36	128	mg/kg dry wt	190	1.5	450	300	2.34	-1	Out - RR<=1

Table A-7 - Pond I Toxicity Data Evaluation

Data from BERA Table 7-9b and 9c

March 2012 Evaluation

Note that Highest HQ for site data is max conc divided by Effect Criteria.
Lowest HQ for Bkgd data is min conc divided by Effect Criteria.
RR is Site HQ minus Bkgd HQ

				Site		Background	
			Sample Name:	T05BR-005		T05BL-003	T05BL-004
			Sample Depth (Feet):	0 - 0.5		0 - 0.5	0 - 0.5
			Date Collected:	6/22/2005		6/23/2005	6/23/2005
			Location ID:	T05BR-005		T05BL-003	T05BL-004
Species	Test	Lab control Result	Units				
Chironomus dilutus	Survival	83.75	%	88.75		86.25	93.75
Chironomus dilutus	Growth	1.79	mg/larvae	1.2		1.39	1.56
Hyalella azteca	Survival	91.25	%	86.25		51.25	88.75
Hyalella azteca	Growth	0.597	mg/amphipod	0.314		0.237	0.29

Constituent	No Effect Criteria	Effect Criteria	Units		Highest Site HQ			Lowest Bkgd HQ	RR	Comment
Magnesium	-	-	mg/kg dry wt	3,400		4,100	2,900			
Manganese	460	5,500	mg/kg dry wt	380 J		200 J	160 J			
Mercury	0.18	1.06	mg/kg dry wt	0.6		0.54	0.47			
Nickel	23	48.6	mg/kg dry wt	31		52	46			
Potassium	-	-	mg/kg dry wt	1,300		1,500	1,100			
Selenium	-	-	mg/kg dry wt	1.2		1.5	1.3			
Silver	2	10	mg/kg dry wt	3.3		1.7	2.1			
Sodium	-	-	mg/kg dry wt	210		2,500	2,100			
Thallium	-	-	mg/kg dry wt	0.25		0.4	0.26			
Vanadium	-	-	mg/kg dry wt	23		31	24			
Zinc	120	459	mg/kg dry wt	390 J		680 J	490 J			

(1) No effect/Effect criteria (TEC/PEC) were not in the original BERA

Table A-8 - Pond N Chemistry Data Evaluation

Data from BERA Table 7-6j

COPECs (mg/kg dry wt)	FOD	RME	CTE	No Effect Sediment Benchmark	Effect Sediment Benchmark	No Effect HQ RME	No Effect HQ CTE	Effect HQ RME	Effect HQ CTE	No Effect RR RME	No Effect RR CTE	Effect RR RME	Effect RR CTE	March 2012 Evaluation Scenario	March 2012 Evaluation Comment
VOCs															
1,1,1-Trichloroethane	0/1	6.00E-03	6.00E-03	0.17	2.2	0.04	0.04	0.003	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
1,1,2,2-Tetrachloroethane	0/1	6.00E-03	6.00E-03	0.94	12.2	0.01	0.01	0	0.0005	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
1,1-Dichloroethene	0/1	6.00E-03	6.00E-03	0.031	0.4	0.2	0.2	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Butanone	1/1	1.00E-02	1.00E-02	0.27	3.5	0.04	0.04	0.003	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Hexanone	0/1	6.00E-03	6.00E-03	0.022	0.29	0.3	0.3	0.02	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4-Methyl-2-pentanone	0/1	6.00E-03	6.00E-03	0.033	0.43	0.2	0.2	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acetone	1/1	8.70E-02	8.70E-02	0.0087	0.11	10	10	0.8	0.8	<1	4	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
Carbon disulfide	0/1	6.00E-03	6.00E-03	0.00085	0.011	7	7	0.5	0.5	1	2	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
Chloromethane	0/1	6.00E-03	6.00E-03	--	--	--	--	--	--	--	--	--	--	NA	
cis-1,2-Dichloroethene	0/1	6.00E-03	6.00E-03	--	--	--	--	--	--	--	--	--	--	NA	
cis-1,3-Dichloropropene	0/1	6.00E-03	6.00E-03	--	--	--	--	--	--	--	--	--	--	NA	
Isopropylbenzene	0/1	6.00E-03	6.00E-03	--	--	--	--	--	--	--	--	--	--	NA	
Methyl acetate	0/1	6.00E-03	6.00E-03	--	--	--	--	--	--	--	--	--	--	NA	
Methylene chloride	0/1	6.00E-03	6.00E-03	0.37	4.8	0.02	0.02	0.001	0.001	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Styrene	0/1	6.00E-03	6.00E-03	--	--	--	--	--	--	--	--	--	--	NA	
Tetrachloroethene	0/1	6.00E-03	6.00E-03	0.41	5.3	0.01	0.01	0.001	0.001	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
trans-1,3-Dichloropropene	0/1	6.00E-03	6.00E-03	--	--	--	--	--	--	--	--	--	--	NA	
Trichlorofluoromethane	0/1	6.00E-03	6.00E-03	--	--	--	--	--	--	--	--	--	--	NA	
Xylene (total)	0/1	6.00E-03	6.00E-03	0.025	0.33	0.2	0.2	0.02	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
SVOCs															
1,1'-Biphenyl	1/1	4.20E-02	4.20E-02	--	--	--	--	--	--	--	--	--	--	NA	
2-Methylnaphthalene	1/1	6.90E-02	6.90E-02	0.33	4.3	0.2	0.2	0.02	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
2-Methylphenol	0/1	1.65E-01	1.65E-01	0.012	0.16	14	14	1	1	<1	4	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
4-Bromophenyl-phenylether	0/1	1.65E-01	1.65E-01	1.3	16.9	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
4-Chloroaniline	0/1	1.65E-01	1.65E-01	--	--	--	--	--	--	--	--	--	--	NA	
4-Methylphenol	0/1	1.65E-01	1.65E-01	--	--	--	--	--	--	--	--	--	--	NA	
4-Nitroaniline	0/1	4.15E-01	4.15E-01	--	--	--	--	--	--	--	--	--	--	NA	
Acenaphthene	1/1	9.20E-02	9.20E-02	0.62	8.1	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acenaphthylene	1/1	1.90E-01	1.90E-01	0.33	4.3	0.6	0.6	0.04	0.04	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Acetophenone	0/1	1.65E-01	1.65E-01	--	--	--	--	--	--	--	--	--	--	NA	
Anthracene	1/1	4.00E-01	4.00E-01	0.057	0.85	7	7	0.5	0.5	<1	1	<1	<1	1	Out - Scenario 1, 2, or 3
Benzaldehyde	1/1	1.30E-01	1.30E-01	--	--	--	--	--	--	--	--	--	--	NA	
Benzo(a)pyrene	1/1	9.80E-01	9.80E-01	0.15	1.5	7	7	1	1	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Benzo(b)fluoranthene	1/1	1.20E+00	1.20E+00	--	--	--	--	--	--	--	--	--	--	NA	
Benzo(g,h,i)perylene	1/1	3.50E-01	3.50E-01	0.17	0.32	2	2	1	1	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Benzo(k)fluoranthene	1/1	5.80E-01	5.80E-01	--	--	--	--	--	--	--	--	--	--	NA	
bis(2-Ethylhexyl)phthalate	1/1	1.30E+01	1.30E+01	890	11570	0.01	0.01	0.001	0.001	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Carbazole	1/1	1.30E-01	1.30E-01	--	--	--	--	--	--	--	--	--	--	NA	
Chrysene	1/1	1.10E+00	1.10E+00	0.17	1.3	7	7	0.9	0.9	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Cyclohexane	0/1	6.00E-03	6.00E-03	--	--	--	--	--	--	--	--	--	--	NA	
Dibenzofuran	1/1	7.20E-02	7.20E-02	2	26	0.04	0.04	0.003	0.003	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Fluoranthene	1/1	1.90E+00	1.90E+00	0.42	2.2	5	5	0.9	0.9	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Fluorene	1/1	1.30E-01	1.30E-01	0.077	0.54	2	2	0.2	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Hexachlorobenzene	0/1	1.65E-01	1.65E-01	0.02	0.26	8	8	0.6	0.6	<1	3	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
Hexachlorobutadiene	0/1	1.65E-01	1.65E-01	--	--	--	--	--	--	--	--	--	--	NA	
Indeno(1,2,3-cd)pyrene	1/1	4.10E-01	4.10E-01	0.2	2.6	2	2	0.2	0.2	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Isophorone	0/1	1.65E-01	1.65E-01	--	--	--	--	--	--	--	--	--	--	NA	
Naphthalene	1/1	7.80E-02	7.80E-02	0.18	0.56	0.4	0.4	0.1	0.1	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
N-Nitrosodiphenylamine	0/1	1.65E-01	1.65E-01	--	--	--	--	--	--	--	--	--	--	NA	

Table A-8 - Pond N Chemistry Data Evaluation

Data from BERA Table 7-6j

COPECs (mg/kg dry wt)	FOD	RME	CTE	No Effect Sediment Benchmark	Effect Sediment Benchmark	No Effect HQ RME	No Effect HQ CTE	Effect HQ RME	Effect HQ CTE	No Effect RR RME	No Effect RR CTE	Effect RR RME	Effect RR CTE	March 2012 Evaluation Scenario	March 2012 Evaluation Comment
Pentachlorophenol	0/1	4.15E-01	4.15E-01	--	--	--	--	--	--	--	--	--	--	NA	
Phenanthrene	1/1	1.10E+00	1.10E+00	0.2	1.2	5	5	0.9	0.9	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Phenol	0/1	1.65E-01	1.65E-01	--	--	--	--	--	--	--	--	--	--	NA	
Pyrene	1/1	1.50E+00	1.50E+00	0.2	1.52	8	8	1	1	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Pesticides/PCBs															
4,4'-DDD	1/1	3.50E-02	3.50E-02	0.0049	0.028	7	7	1	1	5	6	<1	1	3	Out - Scenario 1, 2, or 3
4,4'-DDE	1/1	2.10E-02	2.10E-02	0.0032	0.031	7	7	0.7	0.7	3	5	<1	<1	3	Out - Scenario 1, 2, or 3
4,4'-DDT	--	--	--	0.0042	0.063	--	--	--	--	--	--	--	--	NA	
alpha-Chlordane	1/1	6.60E-03	6.60E-03	0.0032	0.018	2	2	0.4	0.4	1	2	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
Aroclor-1016	0/1	3.30E-03	3.30E-03	0.06	0.7	0.1	0.1	0.005	0.005	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1221	0/1	6.50E-03	6.50E-03	0.06	0.7	0.1	0.1	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1232	0/1	3.30E-03	3.30E-03	0.06	0.7	0.1	0.1	0.005	0.005	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1242	0/1	3.30E-03	3.30E-03	0.06	0.7	0.1	0.1	0.005	0.005	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1248	0/1	3.30E-03	3.30E-03	0.06	0.7	0.1	0.1	0.005	0.005	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1254	0/1	3.30E-03	3.30E-03	0.06	0.7	0.1	0.1	0.005	0.005	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Aroclor-1260	1/1	5.50E-01	5.50E-01	0.06	0.7	9	9	1	0.8	2	6	<1	<1	3	Out - Scenario 1, 2, or 3
Dieldrin	1/1	7.40E-02	7.40E-02	0.0019	0.062	39	39	1	1	36	37	1	1	3	Out - Scenario 1, 2, or 3
Endosulfan I	--	--	--	0.0029	0.073	--	--	--	--	--	--	--	--	NA	
Endosulfan II	0/1	3.30E-04	3.30E-04	0.0055	0.14	0.1	0.1	0.002	0.002	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endosulfan Sulfate	--	--	--	--	--	--	--	--	--	--	--	--	--	NA	
Endrin	0/1	3.30E-04	3.30E-04	0.002	0.21	0.1	0.1	0.002	0.002	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Endrin Aldehyde	1/1	2.20E-03	2.20E-03	--	--	--	--	--	--	--	--	--	--	NA	
Endrin Ketone	0/1	3.30E-04	3.30E-04	--	--	--	--	--	--	--	--	--	--	NA	
Gamma-Chlordane	1/1	1.10E-02	1.10E-02	--	--	--	--	--	--	--	--	--	--	NA	
Heptachlor Epoxide	0/1	1.70E-04	1.70E-04	0.0025	0.016	0.07	0.07	0.01	0.01	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Methoxychlor	1/1	1.60E-02	1.60E-02	0.019	0.48	0.8	0.8	0.03	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Total PCBs	1/1	5.50E-01	5.50E-01	0.06	0.68	9	9	0.8	0.8	<1	2	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
Toxaphene	0/1	1.70E-02	1.70E-02	0.028	0.7	0.6	0.6	0.02	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Metals															
Aluminum	1/1	9.09E+03	9.09E+03	--	--	--	--	--	--	--	--	--	--	NA	
Antimony	0/1	1.05E+00	1.05E+00	12	60	0.1	0.1	0.02	0.02	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Arsenic	1/1	9.00E+00	9.00E+00	9.8	33	0.9	0.9	0.3	0.3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Barium	1/1	1.13E+02	1.13E+02	--	--	--	--	--	--	--	--	--	--	NA	
Beryllium	0/1	4.60E-01	4.60E-01	--	--	--	--	--	--	--	--	--	--	NA	
Cadmium	1/1	1.38E+01	1.38E+01	1	5	14	14	3	3	7	10	1	2	5 or 6	Potential COC
Chromium	1/1	1.63E+02	1.63E+02	43	111	4	4	1	1	2	3	<1	1	3	Out - Scenario 1, 2, or 3
Cobalt	0/1	4.60E+00	4.60E+00	--	--	--	--	--	--	--	--	--	--	NA	
Copper	1/1	2.10E+02	2.10E+02	32	149	7	7	1	1	3	5	<1	<1	3	Out - Scenario 1, 2, or 3
Cyanide	1/1	4.00E+00	4.00E+00	--	--	--	--	--	--	--	--	--	--	NA	
Iron	1/1	1.22E+04	1.22E+04	20,000	40,000	1	0.6	0.3	0.3	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Lead	1/1	1.85E+02	1.85E+02	36	128	5	5	1	1	<1	3	<1	<1	2 or 3	Out - Scenario 1, 2, or 3
Manganese	1/1	1.60E+02	1.60E+02	460	5500	0.3	0.3	0.03	0.03	<1	<1	<1	<1	1	Out - Scenario 1, 2, or 3
Mercury	1/1	4.30E-01	4.30E-01	0.18	1.06	2	2	0.4	0.4	<1	1	<1	<1	1	Out - Scenario 1, 2, or 3
Nickel	1/1	4.92E+01	4.92E+01	23	48.6	2	2	1	1	1	1	<1	<1	1	Out - Scenario 1, 2, or 3
Selenium	1/1	1.40E+00	1.40E+00	--	--	--	--	--	--	--	--	--	--	NA	
Silver	1/1	1.05E+01	1.05E+01	2	10	5	5	1	1	4	4	<1	<1	3	Out - Scenario 1, 2, or 3
Thallium	1/1	6.00E-01	6.00E-01	--	--	--	--	--	--	--	--	--	--	NA	
Vanadium	1/1	2.39E+01	2.39E+01	--	--	--	--	--	--	--	--	--	--	NA	
Zinc	1/1	4.78E+02	4.78E+02	120	459	4	4	1	1	1	2	<1	<1	2 or 3	Out - Scenario 1, 2, or 3

APPENDIX D.3

04/12/12 TERRESTRIAL REFINEMENT

DRAFT

Memorandum

From: Bart Hoskins, EPA Ecological Risk Assessor
To: David Newton, EPA Remedial Project Manager, Peterson Puritan Site
Cc: Peterson Puritan Site File
Date: April 12, 2012
RE: Additional Refinements to Terrestrial Ecological Risk Calculations, Peterson Puritan OU 2

Introduction

This memorandum presents refined terrestrial risk calculations performed by the U.S. EPA to help the Peterson Puritan PRP group identify areas to be addressed in the Feasibility Study (FS) for Operable Unit 2 of the site. These refined calculations do not indicate a need to alter the existing BERA. Rather, it is recommended to include this memorandum in the administrative record for the site as an additional step in the ecological risk assessment process, and cite it along with the BERA as the basis for setting Remedial Action Objectives (RAOs) for terrestrial portions of the site. Alternatively, it could be included as an appendix to the FS.

The Baseline Ecological Risk Assessment (BERA) for the Peterson Puritan Site, Operable Unit 2, was written by Arcadis BBL in June of 2007, and revised in November of 2007 and September of 2008 based on regulator comments. Following the September 2008 revision, the US EPA still had many concerns about the risk interpretation in the BERA. EPA substantially revised the BERA text and issued alternative text that was incorporated into an Agency Revision document in August 2009. The Agency Revision did not alter any food chain risk calculations or input values to those risk calculations. **Attachment 1** to this memorandum summarizes the changes that were implemented.

The Arcadis BBL BERA contained food chain models that estimated risk from contaminants in site soils to birds and mammals. Several contaminants, notably lead, zinc, and bis-2-exylhexyl phthalate (BEHP) had hazard quotients (HQs) substantially above 1.0 to wildlife receptors based on the food chain risk calculations in the Arcadis BBL BERA. **Table 1** summarizes the major risk-driving chemicals and exposure pathways, and their associated HQs. The Agency Revision BERA did not alter these calculations, but did conclude that there was potential terrestrial risk for birds and mammals based on the food chain models.

As the site moves into the FS phase, a BERA should provide some guidance on areas that may require action based on potential ecological risks. EPA found that for some contaminants, the risks presented in the BERA were so wide-spread that it was difficult to prioritize areas for remedial action. This was especially true for BEHP, which is rarely a risk-driving chemical in ecological risk assessments. Zinc and lead also had HQs above what would typically be seen in a BERA based on the concentrations found on site. These unusual findings, combined with the overall difficulty in setting Remedial Action Outcomes (RAOs) for terrestrial risk in an urbanized river setting (where site-related

contribution to risk may often be difficult to discern from "background" contributions), prompted EPA to re-examine the assumptions in the food chain models to see if further refinement would provide a clearer picture of risks for OU 2.

All versions of the BERA contained terrestrial food chain models in which wildlife receptors were assumed to feed on prey items associated with soil. All three of the risk-driving exposures pathways (small omnivorous bird, small omnivorous mammal, and large omnivorous bird) used earthworms as a representative soil-associated food item. The earthworm is used because a variety of reasonably well-validated approaches are available for estimating earthworm tissue residue levels based on soil concentrations. Also, field verification is possible on a site-specific basis by either collecting worms from the site, or exposing earthworms to site soils in a laboratory setting.

Terrestrial food chain models are inherently uncertain because they are simplistic and mechanistic. BERA food chain models typically contain some input factors that are based on scientific literature, and therefore don't necessarily reflect site-specific exposure parameters. Often, when food chain models indicate a potential risk, EPA will re-examine the exposure assumptions, and/or will collect site-specific data to refine the risk estimates (as described above for uptake of contaminants to earthworms). In this case, EPA examined two factors in detail for the risk-driving chemicals, namely the biota-to-soil accumulation factors (BSoilAFs) and the toxicity reference values (TRVs).

The BSoilAF is an estimate of how much of a site contaminant will move from soil to a lower trophic level in the food chain. For example, the BSoilAF estimates how much of a contaminant will move from soil to earthworms, which then become prey for birds. The BSoilAF is simply a ratio, expressed in decimal terms, of how much contaminant will be present in earthworms relative to the concentration in soil. So, a BSoilAF of 0.5 means that earthworm will contain half as much contaminant as the soil in which they live. The BSoilAF values used in the BERA (unchanged in all revisions) were literature-based, and not site-specific, as is typical of most BERAs.

A TRV is a daily dose which is considered "safe" to the wildlife receptor. It is expressed in milligrams of chemical per kilogram (body weight) of receptor per day of exposure. The food chain models calculate a dose that will result from site contamination, expressed in the same units as a TRV. The dose is divided by the TRV in order to calculate a hazard quotient (HQ). An HQ exceeds 1.0 when the estimated dose from the food chain model exceeds the TRV. TRVs are generally derived through review of multiple feeding studies using different species. So, a TRV for the American Robin might be derived from laboratory feeding studies using quails or pheasants, or other domesticated bird species which are readily available for laboratory testing. Most studies used to develop TRVs generate No Observed Adverse Effect Level (NOAEL) and Lowest Observed Adverse Effect Level (LOAEL) endpoints. In these studies, laboratory organisms are exposed to a range of chemical concentrations. The highest concentration that does *not* show an adverse effect is called the NOAEL. The lowest concentration that *does* show an adverse effect is called the LOAEL.

Together, the selection of the BSoilAFs and TRVs can substantially change the food chain model results. EPA had originally left these values unchanged in the Agency Revision of the BERA to minimize the changes to the original Arcadis BBL document. For the current effort, EPA re-evaluated these input values for lead, zinc, and BEHP to help identify and prioritize terrestrial areas at the site that may require remediation.

This effort showed that several input variables in the existing BERA could be refined, with the combined effect that the resulting food chain model estimates will help identify areas needing further attention, and will more closely adhere to current Agency-recommended input values. In all cases, the resulting risks estimated are lower than those found in the BERA. The following is a summary of major finding and risk outcomes.

Changes to BSoilAF Values

EPA found two noteworthy changes to the BSoilAFs for zinc and BEHP that substantially refined the risk estimates for these chemicals.

The new BSoilAF for zinc is not a single value, but rather a regression equation that uses the site-specific zinc concentrations in soil to estimate zinc residue levels in earthworms. This equation comes from a paper by Sample et al. (1999) as cited in the EPA document *Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)*, OSWER Directive 9285.7-73. EPA considers the Eco-SSL documents to be the best current guidance documents for evaluating terrestrial risk, therefore the use of this regression equation is entirely compatible with EPA risk guidance. **Tables 2 to 4** this document show the new BSoilAF values and the resulting HQs using the new input values for large omnivorous birds (LOB), small omnivorous mammals, and small omnivorous birds (SOB).

For BEHP, the Arcadis BBL BERA and subsequent revisions used a BSoilAF of 129, which means that a soil concentration of 1 ppm would result in an estimated concentration of 129 ppm in earthworms. EPA performed a literature search to determine whether this estimate is plausible, and found a highly relevant study on the bioavailability of phthalate congeners to earthworms by Xiao-yu Hu et al (2005). This paper suggested that a much lower value would be appropriate. The new BSoilAF value of 0.17 is three orders-of-magnitude lower than the value used in the BERA, and entirely defensible because it is based specifically on measured uptake of phthalate congeners (including BEHP) in earthworms. The changes in the risk calculations using the new BSoilAF for BEHP in the LOB and SOB models are reflected in **Tables 2 and 4**, respectively. The reference is provided as **Attachment 2**.

Further discussion of the zinc and BEHP BSoilAFs originally used in the BERA is presented in **Attachment 4**.

Changes to TRVs

New TRVs for lead and zinc were included in the calculations presented in **Tables 2 to 4**. The BERA used a particularly conservative NOAEL TRV for lead. A literature review provided the basis for changing these TRVs. Calculations were performed both as part of this effort (see **Table 9**) and by TechLaw, under the Environmental Services Assistance Team (ESAT) contract, to develop appropriate TRVs. The TechLaw effort was part of a 2008 project to enhance the usefulness of the EcoSSL documents by developing effect-based EcoSSL values using the same literature database used to derive the original EcoSSLs (see **Attachment 3**). In both cases, the calculations were based on EPA EcoSSL literature for lead and zinc (see **Table 9** for selected TRVs). These data sets were extensively reviewed for completeness and quality, and are therefore very defensible.

Further discussion of the lead and zinc TRVs originally utilized in the BERA is presented in **Attachment 4**.

Effect of Revised Values

Table 5 provides the HQs for large omnivorous birds, small omnivorous mammals, and small omnivorous birds resulting from the updated risk calculations. These values can be compared to those in **Table 1** to show the magnitude of the changes. The large omnivorous bird model (**Table 2**) assumed a site-wide exposure by combining all surface soil samples across the entire site. The other two models assumed exposures to specific areas within the site. The small omnivorous bird model is specific to the Unnamed Island (**Table 4a**) and J.M. Mills Landfill (**Table 4b**) and assumes that a small omnivorous bird feeds exclusively on earthworms only in these areas. Similarly, the small omnivorous mammal model (**Table 3**) was specific to a small mammal feeding exclusively on earthworms only at the J.M. Mills Landfill. As in the original BERA, risks for each receptor are calculated based on four scenarios. Reasonable Maximum Exposures (RMEs) and Central Tendency Exposures (CTEs) are used as the exposure point concentrations. NOAEL TRVs and LOAEL TRVs are used as the toxicity values. Taken together, these variables allow risk estimates to be arranged in increasing order of potential risk, and increasing order of confidence, as shown in **Table 5** and discussed in greater detail below.

Tables 1 and 5 show that many HQs, which were quite high in the BERA, dropped below 1.0 for some combinations of exposures and TRVs. The HQs in each of these tables are adjusted by subtracting background risk, resulting in "Residual Risk" values. Residual risk represents potential site-related risk over and above the existing background risk.

Risk Interpretation Matrix

Table 6 is the Risk Interpretation Matrix used in the updated BERA. This matrix sorts risk into ascending order and increasing confidence in the risk potential. All risk

estimates in this table are based on Residual Risk. The table divides the HQs into six categories. Risk scenario 1 occurs when the HQs are less than 1.0 for all combinations of NOAEL and LOAEL TRVs, and RME and CTE exposures. One can state with a high degree of confidence that risk under those conditions is unlikely. At the other end of the spectrum, risk scenario 6 occurs when the HQs exceed 1.0 in all combinations of NOAEL and LOAEL and RME and CTE exposures. One can state with more confidence that risk is likely under those conditions, with confidence increasing with higher HQs.

The four categories in between risk scenarios one and six represent varying degrees of confidence that risk may be present, with some indication of the magnitude of that risk. The bold line separating categories 3 and 4 indicates a point at which remedial action might start to be considered, provided the risk calculations are adequately supported. So, it is unlikely that remedial action would be indicated in categories 1 through 3. The likelihood increases that action may be needed in categories 4, 5, and 6. In certain cases, EPA may require either more study or remedial action when faced with risk categories 5 or 6. Risk category 4 may require more consideration in some cases, but this is highly dependent on confidence in the food chain models.

Keeping this matrix in mind, the results of the risk re-calculation can be seen in the context of potential need for remediation based on HQs. The revised risk calculations removed much of the risk for some areas of the site and some chemicals, as follows (see **Table 5**):

- Zinc falls below risk scenario 3 for all receptors and areas of the site.

- Lead remains as a potential risk-driver, but only for small omnivorous birds on the Unnamed Island (risk scenario 5).

- Both cadmium (although not included in the revised risk calculations) and BEHP for large omnivorous birds site-wide fall in risk scenario 4, indicating that adverse effects are possible, but only under maximum exposure (RME) conditions. However, the RR exceeds 1.0 for both of these COCs only when site-wide maximum (RME) concentrations are used in the models. Since it is a reasonable assumption that the mean (CTE) exposure for an animal with a large foraging area is adequately protective, the recommended risk conclusion is to require no remedial action for cadmium or BEHP with respect to a site-wide, large omnivorous bird exposure.

- BEHP for small omnivorous birds feeding on Unnamed Island falls in risk scenario 4, indicating that adverse effects are possible under maximum exposure (RME) conditions. As detections of BEHP on Unnamed Island appear to be related to waste disposal, it is recommended to require remedial action for BEHP at Unnamed Island.

- Cadmium (although not included in the revised risk calculations) remains as a potential risk-driver, but only for small omnivorous birds at the J.M. Mills Landfill (risk scenario 5).

- The risk to small mammals from exposure to aluminum is likely over-estimated. The Eco-SSL report for aluminum states that Al becomes bioavailable only in soils at pHs below 5.5. Acidic soils are not expected to be encountered at the site, such that it appears likely that the calculated risks to small mammals were over-estimated. Hence, no further action is recommended based on this risk conclusion.

Table 7 provides potential soil PRGs for small omnivorous birds feeding on Unnamed Island and at J.M. Mills Landfill based on the most conservative input variables. These PRGs were obtained by "back-calculating" the small omnivorous bird food chain model to an HQ value = 1.0 using NOAEL and LOAEL TRVs. The geometric mean of these two concentrations is considered the Maximum Acceptable Toxic Concentration (MATC) and typically selected as the recommended PRG. The reference concentration is selected as the potential PRG when the resulting MATC falls below the reference concentration. **NOTE that this table does not indicate a need for remedial action in any area except the Unnamed Island where risk to receptors is possible with a moderate degree of confidence and J.M. Mills Landfill due to potential risk from cadmium.** These PRGs are provided primarily to show the effects of the revised input variables on the most conservative scenario.

Conclusions for Terrestrial Risk

Using well-supported and standard EPA input values (considered most current and appropriate for this site), EPA re-calculated terrestrial food chain model risk for the main risk-driving COPCs. The resulting HQs and evaluation of risk above background levels suggest potential risk from lead and BEHP to small omnivorous birds feeding at the Unnamed Island, with low (BEHP) and moderate (lead) confidence in the risk estimate. The evaluation also suggests potential risk from cadmium to small omnivorous birds feeding at the J.M. Mills Landfill, with moderate confidence in the risk estimate. Lead, cadmium, and BEHP pose a low potential risk site-wide, but with lower confidence in the estimate than observed for the Unnamed Island and J.M. Mills Landfill. These revised risk estimates are suggested as the basis for site risk management decision-making based on surface soil risk to terrestrial wildlife receptors.

References

Sample, B. E., J. J. Beauchamp, R. Efroymson, and G. W. Suter, II. 1999. Literature-derived bioaccumulation models for earthworms: development and validation. Environ. Toxicol. Chem. 18: 2110-2120, as shown in Table 4a of Attachment 4-1, Guidance for developing ecological soil screening levels (Eco-SSLs), OSWER Directive 9285.7-55.

U.S. Environmental Protection Agency (USEPA). 2005. Ecological Soil Screening Levels for Lead. Interim Final. Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-70. March.

U.S. Environmental Protection Agency (USEPA). 2007. Ecological Soil Screening Levels for Zinc. Interim Final. Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-73. June.

Xiao-yu Hu, Bei Wen, Shuzhen Zhang, and Xiao-quan Shan. 2005. Bioavailability of phthalate congeners to earthworms (*Eisenia fetida*) in artificially contaminated soils. Ecotoxicol. Environ. Saf. 62:26-24.

Tables

TABLE 1. SUMMARY OF TERRESTRIAL RISK CALCULATED IN THE BERA FOR SELECTED COCS, HABITATS, AND WILDLIFE RECEPTORS
PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RI

Area	COC	HQs from BERA[1]				BERA Residual Risk[4]			
		No Effect HQ[2]		**Effect HQ[3]**		**No Effect RR**		**Effect RR**	
		RME	CTE	RME	CTE	RME	CTE	RME	CTE
Site-wide (large omnivorous birds) - includes J.M. Mills Landfill and Unnamed Island									
	Cadmium (Cd)	9.4	0.9	4.5	0	7	<1	3	<1
	Lead (Pb)	6040	629	604	63	2933	173	293	17
	Zinc (Zn)	352	47	39	5.2	282	32	31	4
	BEHP	4277	26	1340	8	4237	17	1328	5
J.M. Mills Landfill (small mammals) - in addition to site-wide risks noted above									
	Aluminum (Al)	637	168	64	17	196	62	20	6
	Zinc (Zn)	32	6	16	3.0	28	5	14	3
J.M. Mills Landfill (small omnivorous birds) - in addition to site-wide risks noted above									
	Cadmium (Cd)	17	3	8	1	14	2	7	1
	Lead (Pb)	5114	936	511	94	1600	409	160	41
	Zinc (Zn)	677	106	75	12.0	598	89	66	10
	BEHP	376	35	118	11	330	24	103	7
Unnamed Island (small omnivorous birds) - in addition to site-wide risks noted above									
	Lead (Pb)	29638	682	2964	68	26129	155	2613	15
	Zinc (Zn)	1641	44	181.6	5	1561	27.2	173	3
	BEHP	7487	54	2346	17	7441	43	2332	13

Notes

[1] Hazard quotients as calculated by BERA (USEPA, 2009, Revision of Arcadis, 2008).

[2] No Effect HQ = HQ based on NOAEL TRV

- For the CTE case the No Effect HQ = CTE/NOAEL, or the dose based on average (or central tendency exposure) exposure divided by the NOAEL TRV
- For the RME case the No Effect HQ = RME/NOAEL, or the dose based on maximum (or reasonable maximum exposure) exposure divided by the NOAEL TRV

[3] Effect HQ = HQ based on LOAEL TRV

[4] Residual Risk (RR) is the incremental risk above background calculated by subtracting the risk (HQ) calculated at the reference location from the HQ in the site exposure area.

COC - Contaminant of Concern
BEHP - bis(2-ethylhexyl)phthalate
BERA - Baseline Ecological Risk Assesment
CTE - Central Tendency Exposure (dose based on average values for soil concentrations)
RME - Reasonable Maximum Exposure (dose based on 95% UCL)
HQ - Hazard Quotient
LOAEL - Lowest Observed Adverse Effects Level
NOAEL - No Observed Adverse Effects Level
TRV - Toxicity Reference Value
RR - Residual Risk (Site HQ - Reference HQ)

TABLE 2. LARGE OMNIVOROUS BIRD DIETARY MODELING CALCULATIONS - SITE-WIDE
PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RI

						Dose (mg/kg BW/day)		TRVs		No Effect HQ		Effect HQ		Residual Risk			
	Soil (dw)		Food (ww)			TDI		(mg/kg BW/day)		RME/NOAEL	CTE/NOAEL	RME/LOAEL	CTE/LOAEL	**No Effect RR**		**Effect RR**	
COC	CTE [1]	RME [2]	BSoilAF (ww/dw)[3]	CTE	RME	CTE	RME	NOAEL [4]	LOAEL [4]	RME	CTE	RME	CTE	RME	CTE	RME	**CTE**
Site Lead	128	313	0.13	16.5	40.3	7.2	69	1.63	44.6	42.2	4.4	1.5	0.2	21	1	<1	<1
Ref Lead	92.8	161	0.13	11.9	20.7	5.2	35	1.63	44.6	21.7	3.2	0.79	0.12	N/A	N/A	N/A	N/A
Site Cadmium [5]	2.6	7.1	1.32	3.4	9.3	1.3	14	1.45	3.05	9.4	0.9	4.5	0.4	7	<1	3	<1
Ref Cadmium [5]	1.1	1.9	1.32	1.5	2.5	0.59	3.7	1.45	3.05	2.5	0.4	1.2	0.19	N/A	N/A	N/A	N/A
Site Zinc	129	132	regression	67	68	27	102	66.1	171	1.5	0.4	0.6	0.2	<1	<1	<1	<1
Ref Zinc	40	52	regression	46	50	18	73	66.1	171	1.1	0.3	0.4	0.1	N/A	N/A	N/A	N/A
Site BEHP	0.57	25.5	0.17	0.097	4.3	0.041	7.1	1.1	3.51	6.5	0.037	2	0.012	6	<1	2	<1
Ref BEHP	0.21	0.24	0.17	0.035	0.041	0.015	0.067	1.1	3.51	0.061	0.013	0.019	0.004	N/A	N/A	N/A	N/A

Notes:

The calculations follow those presented in the BERA (USEPA, 2009, Revision of Arcadis, 2008). The site-wide exposure area includes all on-site data.

The revisions, shown highlighted, utilize alternative TRVs and BSAFs.

COC = Contaminant of Concern

BEHP = bis(2-ethylhexyl)phthalate

BERA = Baseline Ecological Risk Assessment (USEPA, 2009, Revision of Arcadis, 2008)

N/A = Not Applicable or Not Available

RME = Reasonable Maximum Exposure

CTE = Central Tendency Exposure

HQ = Hazard Quotient

BSoilAF = Biota-Soil Accumulation Factor

NOAEL = No Observed Adverse Effects Level

LOAEL = Lowest Observed Adverse Effects Level

TRV = Toxicity Reference Value

BW = Body weight

ww = Wet Weight

dw = Dry weight

RR = Residual Risk

Ref = Reference Area from BERA Data upstream in the Blackstone River

TDI = Total Daily Intake (daily dose); TDI = P (FIR*Cf+SIR*Cs)

P = Proportion of diet [see Table 8]

FIR = Food intake Rate (kg food ww/kg bw/day) [see Table 8]

SIR = Soil intake rate normalized to body weight (kg soil dw/kg bw/day) [see Table 8]

C_f = Concentration in food (mg/kg food ww); C_s * BSoilAF; or regression [see note 3]

C_s = Concentration in soil (mg/kg soil dw)

TDI = Total daily intake (mg/kg BW/day)

Water intake assumed minimal; diet 100% earthworms

[1] CTE values are from BERA Appendix BB and correspond to the geometric mean for the Site-wide EPC Group (2).

[2] RME values are from BERA Appendix BB and correspond to the 95% UCL .

[3] Lead and cadmium values are from Table 7-3 of BERA.
BEHP value from Xiao-yu Hu, Bei Wen, Shuzhen Zhang, and Xiao-quan Shan. 2005. Bioavailability of phthalate congeners to earthworms (Eisenia fetida) in artificially contaminated soils. Ecotoxicol. Environ. Saf. 62:26-24.
Zinc value generated via regression:
ln(Cworm dw) = 0.328 * ln(Csoil dw) + 4.449, where Cworm dw is the concentration of zinc in the worm tissue on a dry weight basis, and Csoil dw is the concentration of zinc in the soil on a dry weight basis
Regression equation from Sample, B. E., J. J. Beauchamp, R. Efroymson, and G. W. Suter, II. 1999. Literature-derived bioaccumulation models for earthworms: development and validation. Environ. Toxicol. Chem. 18: 2110-2120, as shown in Table 4a of Attachment 4-1, Guidance for developing ecological soil screening levels (Eco-SSLs), OSWER Directive 9285.7-55.
Note: results were converted from dw to ww by assuming 84% moisture content in earthworms (multiplied dw result by 0.16).

[4] Revised TRVs for lead and zinc based on the Eco-SSL reports for lead (OSWER Directive 9285.7-70) and zinc (OSWER Directive 9285.7-73). The revised TRVs were calculated by TechLaw and reported to U.S. EPA in a technical memorandum dated 11/18/08 (TDF No. 1216). [See Attachment 3]

[5] While cadmium has been included in this table, calculations have not been revised from the BERA.

TABLE 3. SMALL OMNIVOROUS MAMMALS DIETARY MODELING CALCULATIONS - J.M. MILLS LANDFILL
PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RI

						Dose (mg/kg BW/day)		TRVs		No Effect HQ		Effect HQ		Residual Risk			
	Soil (dw)		Food (ww)			TDI		(mg/kg BW/day)		RME/NOAEL	CTE/NOAEL	RME/NOAEL	CTE/NOAEL	**No Effect RR**		**Effect RR**	
COC	CTE [1]	RME [2]	BSoilAF (ww/dw)[3]	CTE	RME	CTE	RME	NOAEL [4]	LOAEL [4]	RME	CTE	RME	CTE	RME	CTE	RME	**CTE**
Site Aluminum [5]	7360	9170	0.15	1133	1412	323	1230	1.9	19.3	637	168	64	17	196	62	20	6
Ref Aluminum [5]	4640	6350	0.15	715	978	204	852	1.9	19.3	441	106	44	11	N/A	N/A	N/A	N/A
Site Zinc	252	442	regression	84	101	24	87	75.4	297.6	1.2	0.3	0.3	0.1	<1	<1	<1	<1
Ref Zinc	40.4	51.7	regression	46	50	13	42	75.4	297.6	0.6	0.2	0.1	0.04	N/A	N/A	N/A	N/A

Notes:

The calculations follow those presented in the BERA (USEPA, 2009, Revision of Arcadis, 2008). The exposure area is for J.M. Landfill data only.
The revisions, shown highlighted, utilize alternative TRVs and BSAFs.

COC = Contaminant of Concern
BERA = Baseline Ecological Risk Assessment (USEPA, 2009, Revision of Arcadis, 2008)
N/A = Not Applicable or Not Available
RME = Reasonable Maximum Exposure
CTE = Central Tendency Exposure
HQ = Hazard Quotient
BSoilAF = Biota-Soil Accumulation Factor
NOAEL = No Observed Adverse Effects Level
LOAEL = Lowest Observed Adverse Effects Level
TRV = Toxicity Reference Value
BW = Body weight
ww = Wet Weight
dw = Dry weight
RR = Residual Risk
Ref = Reference Area from BERA Data upstream in the Blackstone River

TDI = Total Daily Intake (daily dose); TDI = P (FIR*Cf+SIR*Cs)
P = Proportion of diet [see Table 8]
FIR = Food intake Rate (kg food ww/kg bw/day) [see Table 8]
SIR = Soil intake rate normalized to body weight (kg soil dw/kg bw/day) [see Table 8]
C_f = Concentration in food (mg/kg food ww); C_s * BSoilAF; or regression [see note 3]
C_s = Concentration in soil (mg/kg soil dw)
TDI = Total daily intake (mg/kg BW/day)
Water intake assumed minimal; diet 100% earthworms

[1] CTE values are from Appendix BB of the BERA and correspond to the geometric mean .
[2] RME values are from Appendix BB of the BERA and correspond to the 95% UCL.
[3] Aluminum value is from Table 7-3 of BERA.
Zinc value generated via regression:
ln(Cworm dw) = 0.328 * ln(Csoil dw) + 4.449, where Cworm dw is the concentration of zinc in the worm tissue on a dry weight basis, and Csoil dw is the concentration of zinc in the soil on a dry weight basis
Regression equation from Sample, B. E., J. J. Beauchamp, R. Efroymson, and G. W. Suter, II. 1999. Literature-derived bioaccumulation models for earthworms: development and validation. Environ. Toxicol. Chem. 18: 2110-2120, as shown in Table 4a of Attachment 4-1, Guidance for developing ecological soil screening levels (Eco-SSLs), OSWER Directive 9285.7-55.
Note: results were converted from dw to ww by assuming 84% moisture content in earthworms (multiplied dw result by 0.16).
[4] Revised TRVs for zinc (NOAEL, LOAEL) from the Eco-SSL report for zinc (OSWER Directive 9285.7-73). [See Table 9]
[5] While aluminum has been included in this table, calculations have not been revised from the BERA.

TABLE 4a. SMALL OMNIVOROUS BIRD DIETARY MODELING CALCULATIONS - UNNAMED ISLAND
PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RI

						Dose (mg/kg BW/day)		TRVs (mg/kg BW/day)		No Effect HQ		Effect HQ		Residual Risk			
	Soil (dw)		Food (ww)			TDI				RME/NOAEL	CTE/NOAEL	RME/LOAEL	CTE/LOAEL	**No Effect RR**		**Effect RR**	
COC	CTE [1]	RME [2]	BSoilAF (ww/dw)[3]	CTE	RME	CTE	RME	NOAEL [4]	LOAEL [4]	RME	CTE	RME	CTE	RME	CTE	RME	**CTE**
UI Lead	120	1360	0.13	15	175	7.8	338	1.63	44.6	207	5	7.57	0.2	183	1	7	<1
Updated Lead [5]	147	1366	0.13	19	176	10	339	1.63	44.6	208	6	7.61	0.2	184	2	7	<1
Ref Lead	92.8	161	0.13	12	21	6.0	40	1.63	44.6	24.5	3.7	0.90	0.13	N/A	N/A	N/A	N/A
UI Zinc	105	1070	regression	63	135	29	261	66.1	171	4	0.4	1.5	0.2	3	<1	1	<1
Ref Zinc	40	52	regression	46	50	21	83	66.1	171	1	0.3	0.5	0.1	N/A	N/A	N/A	N/A
UI BEHP	1.0	39.4	0.17	0.18	6.7	0.086	12	1.1	3.5	11	0.078	3.5	0.024	11	<1	4	<1
Ref BEHP	0.2	0.2	0.17	0.035	0.041	0.017	0.076	1.1	3.5	0.069	0.015	0.0216	0.005	N/A	N/A	N/A	N/A

Notes:

The calculations follow those presented in the BERA (USEPA, 2009, Revision of Arcadis, 2008). The exposure area is for Unnamed Island data only.

The revisions, shown highlighted, utilize alternative TRVs and BSoilAFs.

COC = Contaminant of Concern

BERA = Baseline Ecological Risk Assessment (USEPA, 2009, Revision of Arcadis, 2008)

N/A = Not Applicable or Not Available

UI = Unnamed Island

RME = Reasonable Maximum Exposure

CTE = Central Tendency Exposure

HQ = Hazard Quotient

BSoilAF = Biota-Soil Accumulation Factor

NOAEL = No Observed Adverse Effects Level

LOAEL = Lowest Observed Adverse Effects Level

TRV = Toxicity Reference Value

BW = Body weight

ww = Wet weight

dw = Dry weight

RR = Residual Risk

Ref = Reference Area from BERA Data upstream in the Blackstone River

TDI = Total Daily Intake (daily dose); TDI = P (FIR*Cf+SIR*Cs)

P = Proportion of diet [see Table 8]

FIR = Food intake Rate (kg food ww/kg bw/day) [see Table 8]

SIR = Soil intake rate normalized to body weight (kg soil dw/kg bw/day) [see Table 8]

C_f = Concentration in food (mg/kg food ww); C_s * BSoilAF; or regression [see note 3]

C_s = Concentration in soil (mg/kg soil dw)

TDI = Total daily intake (mg/kg BW/day)

Water intake assumed minimal; diet 100% earthworms

[1] CTE values are from BERA Appendix BB and correspond to the geometric mean for the Unnamed Island.

[2] RME values are from Appendix BB of the BERA.

[3] Lead value is from Table 7-3 of BERA.
BEHP value from Xiao-yu Hu, Bei Wen, Shuzhen Zhang, and Xiao-quan Shan. 2005. Bioavailability of phthalate congeners to earthworms (Eisenia fetida) in artificially contaminated soils. Ecotoxicol. Environ. Saf. 62:26-24.
Zinc value generated via regression:
ln(Cworm dw) = 0.328 * ln(Csoil dw) + 4.449, where Cworm dw is the concentration of zinc in the worm tissue on a dry weight basis, and Csoil dw is the concentration of zinc in the soil on a dry weight basis
Regression equation from Sample, B. E., J. J. Beauchamp, R. Efroymson, and G. W. Suter, II. 1999. Literature-derived bioaccumulation models for earthworms: development and validation. Environ. Toxicol. Chem. 18: 2110-2120, as shown in Table 4a of Attachment 4-1, Guidance for developing ecological soil screening levels (Eco-SSLs), OSWER Directive 9285.7-55.
Note: results were converted from dw to ww by assuming 84% moisture content in earthworms (multiplied dw result by 0.16).

[4] Revised TRVs for lead and zinc based on the Eco-SSL reports for lead (OSWER Directive 9285.7-70) and zinc (OSWER Directive 9285.7-73). The revised TRVs were calculated by TechLaw and reported to U.S. EPA in a technical memorandum dated 11/18/08 (TDF No. 1216). [See Attachment 3]

[5] Includes additional data collected on Unnamed Island after completion of the BERA. RME and CTE values are from Supplemental Ecological Risk Assessment for Unnamed Island Soils (AECOM, 2010).

TABLE 4b. SMALL OMNIVOROUS BIRD DIETARY MODELING CALCULATIONS - J.M. MILLS LANDFILL
PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RI

						Dose (mg/kg BW/day)		TRVs (mg/kg BW/day)		No Effect HQ		Effect HQ		Residual Risk			
	Soil (dw)		Food (ww)			TDI				RME/NOAEL	CTE/NOAEL	RME/LOAEL	CTE/LOAEL	**No Effect RR**		**Effect RR**	
COC	CTE [1]	RME [2]	BSoilAF (ww/dw)[3]	CTE	RME	CTE	RME	NOAEL [4]	LOAEL [4]	RME	CTE	RME	CTE	RME	CTE	RME	**CTE**
Site Lead	165	234	0.13	21	30	11	58	1.63	44.6	36	7	1.30	0.2	11	3	<1	<1
Ref Lead	93	161	0.13	12	21	6.0	40	1.63	44.6	24.5	3.7	0.90	0.13	N/A	N/A	N/A	N/A
Site Cadmium [5]	6.8	12	1.32	9	15	4	25	1.45	3.05	17	3	8.2	1.3	14	2	7	1
Ref Cadmium [5]	1.1	1.9	1.32	2	3	0.7	4	1.45	3.05	2.9	0.5	1.36	0.22	N/A	N/A	N/A	N/A
Site Zinc	252	442	regression	84	101	39	181	66.1	171	3	0.6	1.1	0.2	1	<1	<1	<1
Ref Zinc	40	52	regression	46	50	21	83	66.1	171	1	0.3	0.5	0.1	N/A	N/A	N/A	N/A
Site BEHP	0.7	2.0	0.17	0.11	0.3	0.055	1	1.1	3.5	1	0.050	0.2	0.016	<1	<1	<1	<1
Ref BEHP	0.2	0.2	0.17	0.035	0.041	0.017	0.076	1.1	3.5	0.069	0.015	0.0216	0.005	N/A	N/A	N/A	N/A

Notes:

The calculations follow those presented in the BERA (USEPA, 2009, Revision of Arcadis, 2008). The exposure area is for J.M. Landfill data only.

The revisions, shown highlighted, utilize alternative TRVs and BSoilAFs.

COC = Contaminant of Concern

BERA = Baseline Ecological Risk Assessment (USEPA, 2009, Revision of Arcadis, 2008)

N/A = Not Applicable or Not Available

RME = Reasonable Maximum Exposure

CTE = Central Tendency Exposure

HQ = Hazard Quotient

BSoilAF = Biota-Soil Accumulation Factor

NOAEL = No Observed Adverse Effects Level

LOAEL = Lowest Observed Adverse Effects Level

TRV = Toxicity Reference Value

BW = Body weight

ww = Wet weight

dw = Dry weight

RR = Residual Risk

Ref = Reference Area from BERA Data upstream in the Blackstone River

TDI = Total Daily Intake (daily dose); TDI = P (FIR*Cf+SIR*Cs)

P = Proportion of diet [see Table 8]

FIR = Food intake Rate (kg food ww/kg bw/day) [see Table 8]

SIR = Soil intake rate normalized to body weight (kg soil dw/kg bw/day) [see Table 8]

C_f = Concentration in food (mg/kg food ww); C_s * BSoilAF; or regression [see note 3]

C_s = Concentration in soil (mg/kg soil dw)

TDI = Total daily intake (mg/kg BW/day)

Water intake assumed minimal; diet 100% earthworms

[1] CTE values are from BERA Appendix BB and correspond to the geometric mean for the Unnamed Island.

[2] RME values are from Appendix BB of the BERA.

[3] Lead and cadmium values are from Table 7-3 of BERA.
BEHP value from Xiao-yu Hu, Bei Wen, Shuzhen Zhang, and Xiao-quan Shan. 2005. Bioavailability of phthalate congeners to earthworms (Eisenia fetida) in artificially contaminated soils. Ecotoxicol. Environ. Saf. 62:26-24.
Zinc value generated via regression:
ln(Cworm dw) = 0.328 * ln(Csoil dw) + 4.449, where Cworm dw is the concentration of zinc in the worm tissue on a dry weight basis, and Csoil dw is the concentration of zinc in the soil on a dry weight basis
Regression equation from Sample, B. E., J. J. Beauchamp, R. Efroymson, and G. W. Suter, II. 1999. Literature-derived bioaccumulation models for earthworms: development and validation. Environ. Toxicol. Chem. 18: 2110-2120, as shown in Table 4a of Attachment 4-1, Guidance for developing ecological soil screening levels (Eco-SSLs), OSWER Directive 9285.7-55.
Note: results were converted from dw to ww by assuming 84% moisture content in earthworms (multiplied dw result by 0.16).

[4] Revised TRVs for lead and zinc based on the Eco-SSL reports for lead (OSWER Directive 9285.7-70) and zinc (OSWER Directive 9285.7-73). The revised TRVs were calculated by TechLaw and reported to U.S. EPA in a technical memorandum dated 11/18/08 (TDF No. 1216). [See Attachment 3]

[5] While cadmium has been included in this table, calculations have not been revised from the BERA.

TABLE 5. SUMMARY OF REVISED TERRESTRIAL RISK ESTIMATES FOR SELECTED COCS, HABITATS, AND WILDLIFE RECEPTORS
PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RI

Area	COC	Revised HQs[1]				Revised Residual Risk[4]				Revised Risk Scenario[5]	Recommended Risk Conclusion	Basis of Risk Conclusion
		No Effect HQ[2]		Effect HQ[3]		No Effect RR		Effect RR				
		RME	CTE	RME	CTE	RME	CTE	RME	CTE			
Site-wide (large omnivorous birds) - includes J.M. Mills Landfill and Unnamed Island												
	Cadmium (Cd)	9.4	0.9	4	0.4	7	<1	3	<1	4	No Action	RR > 1 only in RME case[6]
	Lead (Pb)	42	4	2	0.2	21	1	<1	<1	2	No Action	RR > 1 only in RME/NOAEL case
	Zinc (Zn)	2	0.4	0.6	0.2	<1	<1	<1	<1	1	No Action	All RR < 1
	BEHP	6	0.04	2	0.01	6	<1	2	<1	4	No Action	RR > 1 only in RME case[6]
J.M. Mills Landfill (small mammals) - in addition to site-wide risks noted above												
	Aluminum (Al)	637	168	64	17	196	62	20	6	N/A	No Action	pH dependent[7]
	Zinc (Zn)	1.2	0.3	0.3	0.1	<1	<1	<1	<1	1	No Action	All RR < 1
J.M. Mills Landfill (small omnivorous birds) - in addition to site-wide risks noted above												
	Cadmium (Cd)	17.3	2.8	8	1.3	14	2	7	1	5	Possible Action - J.M. Mills Landfill	RR >1 at all but CTE/LOAEL case
	Lead (Pb)	36	7	1	0.2	11	3	<1	<1	3	No Action	RR > 1 only in NOAEL cases
	Zinc (Zn)	3	0.6	1.1	0.2	1	<1	<1	<1	2	No Action	RR > 1 only in RME/NOAEL case
	BEHP	1	0.05	0	0.02	<1	<1	<1	<1	1	No Action	All RR < 1
Unnamed Island (small omnivorous birds) - in addition to site-wide risks noted above												
	Lead (Pb)	208	6	8	0.2	184	2	7	<1	5	Possible Action - Unnamed Is.	RR >1 at all but CTE/LOAEL case
	Zinc (Zn)	4	0.4	2	0.2	3	<1	1	<1	2	No Action	RR > 1 only in RME/NOAEL case
	BEHP	11	0.1	4	0.02	11	<1	4	<1	4	Possible Action - Unnamed Is.	RR for receptor with small foraging area in both RME/NOAELand RME/LOAEL cases

Notes

[1] Hazard quotients as calculated using models from the BERA and revised with updated TRVs and BSoilAFs, July 2011.

[2] No Effect HQ = HQ based on NOAEL TRV
- For the CTE case the No Effect HQ = CTE/NOAEL, or the dose based on average (or central tendency exposure) exposure divided by the NOAEL TRV
- For the RME case the No Effect HQ = RME/NOAEL, or the dose based on maximum (or reasonable maximum exposure) exposure divided by the NOAEL TRV

[3] Effect HQ = HQ based on LOAEL TRV

[4] Residual Risk (RR) is the incremental risk above background calculated by subracting the risk (HQ) calculated at the reference location from the HQ calculated in the site exposure area

[5] Risk Scenarios, as presented in the BERA, are described in detail in Table 6. Values < 3 indicate adverse effects to the receptor are unlikely; > 3 adverse effects are possible.

[6] RR excceds background for Cd and BEHP only when calculated based on the maximum (RME) soil concentrations. Since large omnivorous birds feed site-wide, an average, or CTE, scenario is more appropriate to represent the dose to large birds. Using the CTE exposure, both NOAEL and LOAEL RR are < 1, and no action is recommended.

[7] Risk to mammals from exposure to aluminum in soils is pH dependent. Since pH of soil was not considered in these calculations, risk to mammals is likely over estimated.

COC - Contaminant of Concern
BEHP - bis(2-ethylhexyl)phthalate
BERA - Baseline Ecological Risk Assesment
CTE - Central Tendency Exposure (dose based on average values for soil concentrations)
RME - Reasonable Maximum Exposure (dose based on 95% UCL)
HQ - Hazard Quotient
LOAEL - Lowest Observed Adverse Effects Level
NOAEL - No Observed Adverse Effects Level
TRV - Toxicity Reference Value
RR - Residual Risk (Site HQ - Reference HQ)

TABLE 6. INTERPRETIVE RISK MATRIX FOR CHARACTERIZATION OF RISK IN THE BASELINE ECOLOGICAL RISK ASSESSMENT

[a]Interpretive Risk Matrix for sediment benchmarks, fish CBRs, and wildlife TRVs						
Risk Scenario	No effect (NOAEL)		Effect (LOAEL)		Potential for Adverse Population-level Effects	Confidence Level
	RME	CTE	RME	CTE		
1	RR ≤ 1	RR ≤ 1	RR ≤ 1	RR ≤ 1	Adverse effects are unlikely	High
2	RR > 1	RR ≤ 1	RR ≤ 1	RR ≤ 1	Adverse effects are unlikely	Moderate
3	RR > 1	RR > 1	RR ≤ 1	RR ≤ 1	Adverse effects are unlikely	Low
4	RR > 1	RR ≤ 1	RR > 1	RR ≤ 1	Adverse effects are possible	Low
5	RR > 1	RR > 1	RR > 1	RR ≤ 1	Adverse effects are possible	Moderate
6	RR > 1	RR > 1	RR > 1	RR > 1	Adverse effects are possible	High (increase with higher HQ)

[a]Interpretive Risk Matrix for surface water				
Risk Scenario	Chronic Toxicity		Potential for Adverse Population-level Effects	Confidence Level
	RME	CTE		
1,2 & 3	RR ≤ 1	RR ≤ 1	Adverse effects are unlikely	High
4 & 5	RR > 1	RR ≤ 1	Adverse effects are possible	Moderate
6	RR > 1	RR > 1	Adverse effects are possible	High (increase with higher HQs)

[a] Residual risks (RR) were calculated by subtracting reference Hazard Quotients (HQs) from site HQs for each COPEC. This matrix was used to characterize the relative risk represented by each RR value for the various risk scenarios.
CTE = central tendency exposure
CBR = critical body residue
COPEC = Contaminant of potential ecological concern
HQ = Hazard Quotient
LOAEL = lowest observed adverse effect level
NOAEL = no observed adverse effect level
RME = reasonable maximum exposure
RR = residual risk
TRV = toxicity reference value

TABLE 7. POTENTIAL ECOLOGICAL SOIL PRGS FOR UNNAMED ISLAND BASED ON REVISED MODELS
PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RI

			HQ		Potential PRGs (mg/kg)				
Area	COC	RME EPC (mg/kg) [1]	NOAEL [1]	LOAEL [1]	PRG based on NOAEL [2]	PRG based on LOAEL [2]	MATC [3]	Ref. EPC [1]	Recommended PRG [4]
J.M. Mills Landfill (small omnivorous birds)									
	Cadmium (Cd)	12	17	8.2	0.67	1.4	1.0	1.9	1.9
Unnamed Island (small omnivorous birds)									
	Lead (Pb)	1366	208	7.6	6.6	180	34	161	161
	BEHP	39.4	11	3.5	3.5	11	6.2	0.24	6.2

Notes
COC - Contaminant of Concern
RME - Reasonable Maximum Exposure (dose based on 95% UCL)
EPC - Exposure Point Concentration
HQ - Hazard Quotient
LOAEL - Lowest Observed Adverse Effects Level
NOAEL - No Observed Adverse Effects Level
PRG - Preliminary Remediation Goal
BEHP - bis(2-ethylhexyl)phthalate
MATC - Maximum Acceptable Toxic Concentration

[1] EPCs and HQs based on RME concentrations (see Table 4)
[2] Potential PRG = EPC / HQ
[3] MATC set as the geometric mean between the NOAEL and LOAEL values
[4] Recommended PRG is the maximum of the MATC and Reference RME EPC.

TABLE 8. EXPOSURE PARAMETERS FOR WILDLIFE MODELS USED IN THE BERA

Input values from Table 7-2a of BERA
Small Omnivorous Birds

P_f CTE	P_f RME	FIR CTE	FIR RME	P_S CTE	P_S RME	SIR CTE	SIR RME	C_f CTE	C_f RME
0.5	1	0.89	1.62	0.0166	0.0249	0.015	0.04	BSoilAF*Cs	BSoilAF*Cs

P_f = Proportion of contaminated food (unitless)
FIR = Food intake Rate (kg food ww/kg bw/day)
$P_{S=}$ Proportion of ingested food that is soil (wet weight basis, unitless)
SIR = Soil intake rate normalized to body weight (kg soil dw/kg bw-day)
C_f = Concentration in food (mg/kg food dw)
BsoilAF = Biota-Soil Accumulation Factor from Table 7-17 of BERA unless otherwise noted
C_s = Concentration in soil (mg/kg soil dw)

Input values from Table 7-2a of BERA
Large Omnivorous Birds

P_f CTE	P_f RME	FIR CTE	FIR RME	P_S CTE	P_S RME	SIR CTE	SIR RME	C_f CTE	C_f RME
0.5	1	0.77	1.43	0.0166	0.025	0.013	0.036	BSoilAF*Cs	BSoilAF*Cs

P_f = Proportion of contaminated food (unitless)
FIR = Food intake Rate (kg food ww/kg bw/day)
$P_{S=}$ Proportion of ingested food that is soil (wet weight basis, unitless)
SIR = Soil intake rate normalized to body weight (kg soil dw/kg bw-day)
C_f = Concentration in food (mg/kg food dw)
BsoilAF = Biota-Soil Accumulation Factor from Table 7-17 of BERA unless otherwise noted
C_s = Concentration in soil (mg/kg soil dw)

Input values from Table 7-2c of BERA
Small Omnivorous Mammals

P_f CTE	P_f RME	FIR CTE	FIR RME	P_S CTE	P_S RME	SIR CTE	SIR RME	C_f CTE	C_f RME
0.5	1	0.555	0.84	0.00384	0.00576	0.0024	0.0048	BSoilAF*Cs	BSoilAF*Cs

P_f = Proportion of contaminated food (unitless)
FIR = Food intake Rate (kg food ww/kg bw/day)
$P_{S=}$ Proportion of ingested food that is soil (wet weight basis, unitless)
SIR = Soil intake rate normalized to body weight (kg soil dw/kg bw-day)
C_f = Concentration in food (mg/kg food dw)
BsoilAF = Biota-Soil Accumulation Factor from Table 7-17 of BERA unless otherwise noted
C_s = Concentration in soil (mg/kg soil dw)

TABLE 9. TOXICITY REFERENCE VALUES CALCULATED FROM EPA ECO-SSL DATA

	BERA NOAEL	BERA LOAEL	Alternate NOAEL (1)	Alternate LOAEL (1)	Alternate Source Basis
Avian					
Cadmium	1.45	3.05			
Lead	0.0114	0.114	1.63	44.6	EPA 2005 (Eco SSL)
Zinc	14.5	131	66.1	171	EPA 2005 (Eco SSL)
BEHP	1.1	3.51			
Mammalian					
Aluminum	1.93	19.3			
Zinc	160	320	75.4	297.6	EPA 2005 (Eco SSL)

Notes

(1) See supporting calculations for mammalian values.
For avian values, see TechLaw memorandum (11/18/08) in Attachment 3.

BERA - Baseline Ecological Risk Assesment
LOAEL - Lowest Observed Adverse Effects Level
NOAEL - No Observed Adverse Effects Level
BEHP - bis(2-ethylhexyl)phthalate

Calculations

Mammalian Zn Eco-SSL			
NOAEL	type	LOAEL	type
75.4	Geomean	82.3	rep
	Rep & Gro	75.9	rep
		452	rep
		2514	rep
		4927	rep
		4878	rep
		12.2	rep
		81.1	rep
		232	rep
		326	rep
		326	rep
		353	rep
		424	rep
		103	growth
		87.1	growth
		2514	growth
		4927	growth
		4878	growth
		2838	growth
		8.71	growth
		16.1	growth
		28.2	growth
		75.7	growth
		81.1	growth
		89.1	growth
		424	growth
		667	growth
		956	growth
		968	growth
geomean		297.6	

Attachment 1

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Task Order No. 26
Task No. 01

Subject: Outline of the Major Changes Made to the Final Revised Baseline Ecological Risk Assessment for the Peterson Puritan Superfund Site – Operable Unit 2, Cumberland and Lincoln, Rhode Island.

Dear Mr. Hoskins:

The Environmental Services and Assistance Team (ESAT) was tasked under Technical Direction Form (TDF) No. 1301C to prepare a final revised Baseline Ecological Risk Assessment (BERA) for the Peterson Puritan Superfund Site – Operable Unit 2, Cumberland and Lincoln, Rhode Island. The work under that TDF consisted of finalizing the draft BERA (revised September 2008) originally prepared by the consulting firm Arcadis BBL. The final revised BERA prepared by ESAT was provided to Bart Hoskins, the Task Order Project Officer (TOPO), on May 15, 2009.

The revisions made by ESAT to some of the text and tables of the September 2008 draft BERA resulted in extensive changes in the final revised BERA. Some revisions corrected inconsistencies in the original document. Many other changes, however, were made to streamline and standardize the text across the various sections of the BERA. It was more efficient to write new text versus adapting the existing text to a new format.

The TOPO requested that ESAT prepare a memorandum outlining the major changes made to the draft BERA provided by Arcadis BBL. Those changes are discussed below. **Attachment 1** provides further details, whereas **Attachment 2** summarizes the changes made to the revised September 2008 draft BERA tables.

- **Executive summary risk tables**

The revised September 2008 draft BERA did not provide risk summary tables in the executive summary. ESAT prepared detailed "stand-alone" tables organized by Exposure Unit (EU). The information in the tables consisted of the target receptor groups, the measurement endpoints, the Weight of Evidence (WOE) for each measurement endpoint, the Residual Risk (RR) conclusion for each measurement endpoint, the major uncertainties for each measurement endpoint, general comments, and an overall risk conclusion for each assessment endpoint. The interpretive risk matrix used for deriving the RR conclusions was also included at the bottom of each table for easy reference. Those tables were repeated in the summary and conclusion section at the end of the final revised BERA.

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- **Weight-of-Evidence**

The revised September 2008 draft BERA discussed a WOE approach only in the last table of the report (Table 7-27). As part of the final revision, the WOE approach was presented in the problem formulation and used in the "WOE integration" tables prepared for each assessment endpoint, and the "risk summary tables" presented both in the executive summary and in the last section of the final revised BERA.

- **Problem formulation**

The endpoint selection process presented in the revised September 2008 draft BERA problem formulation was greatly expanded. Tables were included in the text to show how the measurement endpoints were linked to the EUs associated with each receptor group.

- **Risk Characterization**

ESAT rewrote the risk characterization because the interpretive risk matrix provided in the revised September 2008 draft BERA contained inconsistencies. Two updated interpretive risk matrices were prepared for use in the final revised BERA. The first one addressed risks derived from no effect and effect benchmarks (i.e., sediment benchmarks, fish critical body residues, and wildlife toxic reference values). The second one addressed risk derived from surface water benchmarks (specifically, chronic benchmarks).

It was deemed inappropriate to refer to chronic (or screening) surface water benchmarks as no effect values and acute surface water benchmarks as effect values. The reason was that both sets of values result in toxicity, if exceeded. The difference between the acute and chronic surface water benchmarks is in the exposure duration, not the presence or absence of a response. Hence, the focus of the surface water interpretative risk matrix was on the (more conservative) chronic benchmarks. Hazard Quotients (HQs) and RRs for the acute benchmarks were included in all of the surface water risk tables, but only to provide context.

The RR calculations were also changed, from dividing the site HQs by the reference HQs (which only shows how many times the site HQs exceed the reference HQs), to subtracting the reference HQs from the site HQs. As a result of this change, a RR > 1.0 now shows how much a background-adjusted site exposure by a Contaminant of Potential Ecological Concern (COPEC) exceeds that COPEC's benchmark. The latter provides a much richer context for use in risk management decision making.

The supporting text in the risk characterization section was greatly expanded to explain all of these changes

- **Calculating exposure concentrations for sediment samples**

The revised September 2008 draft BERA assessed risk to benthic invertebrates by comparing the COPEC levels in each sediment sample to no effect and effect sediment benchmarks. This approach did not match the interpretive risk matrix or the rest of the final revised BERA.

ESAT used data provided in Appendix BB of the revised September 2008 draft BERA to obtain EU-specific Central Tendency Exposure (CTE) and Reasonable Maximum Exposure (RME) values and used them to assess risk to benthic invertebrates. This approach was the same one used on surface water, fish tissue residues, and wildlife exposure modeling. The original text was re-written to reflect the new approach.

- **Assessing risk to fish and amphibians exposed to surface water**

The revised September 2008 draft BERA assessed risk to fish and amphibians exposed to surface water by comparing RME and CTE COPEC concentrations to no effect (i.e., chronic) and effect

(i.e., acute) surface water benchmarks, respectively.

As explained earlier, both the acute and chronic surface water benchmarks are effect benchmarks since exceedance of either one is assumed to result in toxicity. The difference is the exposure duration, not the response. Extensive changes were made to the text and the associated tables to re-interpret the risk based on exceedance of chronic surface water benchmarks.

- **Assessing risk to birds and mammals**

All the food chain modeling results in the revised September 2008 draft BERA were used without any changes in the final revised BERA prepared by ESAT. However, the text in the wildlife sections and their associated risk tables were modified to reflect the structure used elsewhere in the final revised BERA report.

The task was authorized under technical direction form No. 1437. The final completion date for the task is May 14, 2009.

Do not hesitate to contact Stan Pauwels at (617) 918-8669 or (207) 883-4780 should you have any questions or comments.

Sincerely,

Stan Pauwels
Senior Staff Scientist
TechLaw, Inc.

Attachment 1: Summary of major changes made by ESAT to the final revised BERA for the Peterson Puritan Superfund site

BERA Section	Arcadis/BBL (September 2008 version)	ESAT (May 2009 version)
Table of content	Table of content	The previous table of content was adjusted to reflect the changes in the BERA described below.
Executive summary	Executive summary.	The executive summary was re-written to reflect all of the changes made to the May 2009 BERA revision. This section also highlights the major uncertainties associated with each assessment endpoint evaluated in the BERA. The executive summary was made into a stand-alone decision tool.
Executive summary risk tables	Summary risk tables were not provided in the executive summary.	Executive summary risk tables were prepared and included in the final revised BERA. See Tables ES-1a to ES-1J for aquatic habitats, and Tables ES-2a to ES-2f for terrestrial habitats in the final revised BERA.
General introduction	Section 7.1	Section 7.1: ESAT made minor editorial changes to this subsection.
Site description	Section 7.1.1	Section 7.2: ESAT made minor editorial changes to this subsection.
Problem formulation	Section 7.2	Section 7.3: ESAT made minor editorial changes to this subsection, up to and including Section 7.3.1 (conceptual site model).
Assessment endpoints, risk questions, measurement endpoints, and weight of evidence	Section 7.2.2 (Selection of assessment and measurement endpoints)	Section 7.3.2: This section was re-written to provide standardized endpoints for use throughout the text and in the risk summary tables. Exhibits were included in the text to link measurement endpoints with specific habitats. A WOE table was also developed for use in the risk characterization and the risk summary tables.
Exposure assessment	Section 7.2.3	Section 7.3.3: ESAT made minor editorial changes to this subsection. No changes were made to any of the exposure calculations (except for sediment, see below) or the food chain model assumptions.
Effects assessment	Section 7.2.4	Section 7.3.4: ESAT made minor editorial changes to this subsection. No changes were made to any of the toxicity benchmarks.
Section 7.3.5 (Risk characterization)	Section 7.2.5	Section 7.3.5: This section was re-written to clarify the risk characterization process. The original risk matrix was corrected, expanded, and split into two tables, one for the sediment benchmarks, fish CBRs, and wildlife TRVs, and the other for surface water. The RR calculations were also changed, from dividing the site HQs by the reference HQs to subtracting the reference HQs from the site HQs
Assessment of risks to benthic macro-invertebrates	Section 7.3.1 (Introduction)	Section 7.4.1 (Introduction): ESAT made editorial changes to this subsection

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Sediment chemistry	Section 7.3.1 (Measurement endpoint #1): the evaluation compared individual samples to benchmarks.	Section 7.4.2 (Measurement endpoint 1.A): This section was rewritten. The COPEC-specific sediment CTE and RME concentrations from each aquatic habitat were compared to benchmarks to calculate COPEC-specific HQs and RRs.
Sediment toxicity testing	Section 7.3.2 (Measurement endpoint #2)	Section 7.4.3 (Measurement endpoint 1.B): This section was heavily edited to remove the comparison of the site toxicity test results to the laboratory control, and instead focus the discussion strictly on comparing the site toxicity test results to the field reference samples.
Benthic community assessment	Section 7.3.3 (Measurement endpoint #3)	Section 7.4.4 (Measurement endpoint 1.C): ESAT made minor editorial changes to this subsection
Sediment quality triad analysis	Section 7.3.4	Section 7.4.5: ESAT made minor editorial changes to the results discussion of the triad study. The conclusions were streamlined to be compatible with the rest of the revised text.
Fish community data	Section 7.4.1 (Measurement endpoint #1)	Section 7.5.1 (Measurement endpoint 2.A): ESAT made minor editorial changes to this subsection, except for the risk conclusion which now states that the fish community data were not used in the risk characterization.
Compare surface water data to benchmarks	Section 7.4.2 (Measurement endpoint #2)	Section 7.5.2 (Measurement endpoint 2.B): This section was re-written to focus the HQs and RRs on chronic toxicity, instead of acute toxicity.
Fish critical body residues	Section 7.4.3 (Measurement endpoint #3)	Section 7.5.3 (Measurement endpoint 2.C): This section was rewritten to be fully compatible with the HQ and RR approach used in other sections.
Compare surface water data to benchmarks for amphibians	Section 7.5.1 (Measurement endpoint #1)	Section 7.6.1 (Measurement endpoint 3.A): This section was drastically shortened because it provides data identical to that presented in Section 7.5.2 for fish.
Assessment of risk to birds	Section 7.6	Section 7.7: This section was rewritten to be fully compatible with the HQ and RR approach used in other sections.
Assessment of risk to mammals	Section 7.7	Section 7.8: This section was rewritten to be fully compatible with the HQ and RR approach used in other sections.
Uncertainty analysis	Section 7.8	Section 7.9: This section was substantially maintained, but with the addition of several paragraphs to address issues associated with (a) AVS & SEM, (b) using the arithmetic means as CTEs for sediment, (c) using unfiltered surface water samples, and (d) vernal pools.
Summary and conclusions	Section 7.9	Section 7.10: This section was re-written to be compatible with the new executive summary.

Attachment 2: Summary of changes made by ESAT to the tables in the final revised BERA for Peterson Puritan Superfund site

Original Number	New Number	Original Title	Status	Comments
--	ES-1a	Summary of Ecological Risk in Aquatic Habitats - Blackstone River (Near-Site)	New	--
--	ES-1b	Summary of Ecological Risk in Aquatic Habitats - Pond A	New	--
--	ES-1c	Summary of Ecological Risk in Aquatic Habitats - Pond B	New	--
--	ES-1d	Summary of Ecological Risk in Aquatic Habitats - Pond C	New	--
--	ES-1e	Summary of Ecological Risk in Aquatic Habitats - Pond D	New	--
--	ES-1f	Summary of Ecological Risk in Aquatic Habitats - Pond E	New	--
--	ES-1g	Summary of Ecological Risk in Aquatic H	New	--
--	ES-1h	Summary of Ecological Risk in Aquatic Habitats - Pond I	New	--
--	ES-1i	Summary of Ecological Risk in Aquatic Habitats - Pond N	New	--
--	ES-1j	Summary of Ecological Risk in Aquatic Habitats - Pond P	New	--
--	ES-1k	Summary of Ecological Risk in Aquatic Habitats - Wetlands A Through D	New	--
--	ES-2a	Summary of Ecological Risk in Terrestrial Habitats - J.M. Mills Landfill	New	--
--	ES-2b	Summary of Ecological Risk in Terrestrial Habitats - Unnamed Island	New	--
--	ES-2c	of Ecological Risk in Terrestrial Habitats - Nunes Parcel	New	--
--	ES-2d	Summary of Ecological Risk in Terrestrial Habitats - Quinnville Well Field	New	--
--	ES-2e	Summary of Ecological Risk in Terrestrial Habitats - Wetlands A Through D	New	--
--	ES-2f	Summary of Ecological Risk in Terrestrial Habitats - Pratt Dam	New	--
7-1a	--	Summary of COPECs Forwarded to the BERA – Aquatic Areas	No Change	--
7-1b	--	Summary of COPECs Forwarded to the BERA – Terrestrial Areas	No Change	--
--	7-1c	Weight-of-Evidence Documentation	New	--
7-2a	--	Exposure Parameters for Omnivorous Birds	No Change	--
7-2b	--	Exposure Parameters for Piscivorous Birds	No Change	--
7-2c	--	Exposure Parameters for Omnivorous Mammals	No Change	--
7-2d	--	Exposure Parameters for Piscivorous Mammals	No Change	--
7-3	--	Biota-Soil Accumulation Factors	No Change	--
7-4a	--	Avian Toxicity Benchmarks	No Change	--
7-4b	--	Mammalian Toxicity Benchmarks	No Change	--

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Original Number	New Number	Original Title	Status	Comments
7-5a	--	Selection of Screening Criteria for Volatile Organic Compounds in Sediment	No Change	--
7-5b	--	Selection of Screening Criteria for Semivolatile Organic Compounds in Sediment	No Change	--
7-5c	--	Selection of Screening Criteria for Pesticides and PCBs in Sediment	No Change	--
7-5d	--	Selection of Screening Criteria for Metals in Sediment	No Change	--
7-5e	--	Selection of Screening Criteria for Volatile Organic Compounds in Surface Water	No Change	--
7-5f	--	Selection of Screening Criteria for Semivolatile Organic Compounds in Surface Water	No Change	--
7-5g	--	Selection of Screening Criteria for Pesticides and PCBs in Surface Water	No Change	--
7-5h	--	Selection of Screening Criteria for Metals in Surface Water	No Change	--
7-6a.1	7-6a	Calculated Hazard Quotients for Benthic Invertebrates – Blackstone River (Upstream)	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6a.2		Sediment Effect HQs – Blackstone River (Upstream)		
7-6b.1	7-6b	Sediment No-Effect HQs – Blackstone River (Near-Site)	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6b.2		Sediment Effect HQs – Blackstone River (Near-Site)		
7-6c.1	7-6c	Sediment No-Effect HQs – Pond A	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6c.2		Sediment Effect HQs – Pond A		
7-6d.1	7-6d	Sediment No-Effect HQs – Pond B	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6d.2		Sediment Effect HQs – Pond B		
7-6e.1	7-6e	Sediment No-Effect HQs – Pond C	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6e.2		Sediment Effect HQs – Pond C		
7-6f.1	7-6f	Sediment No-Effect HQs – Pond D	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6f.2		Sediment Effect HQs – Pond D		
7-6g.1	7-6g	Sediment No-Effect HQs – Pond E	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6g.2		Sediment Effect HQs – Pond E		

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7-6h.1	7-6h	Sediment No-Effect HQs – Pond F	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6h.2		Sediment Effect HQs – Pond F		
7-6i.1	7-6i	Sediment No-Effect HQs – Pond I	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6i.2		Sediment Effect HQs – Pond I		
7-6j.1	7-6j	Sediment No-Effect HQs – Pond N	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6j.2		Sediment Effect HQs – Pond N		
7-6k.1	7-6k	Sediment No-Effect HQs – Pond P	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6k.2		Sediment Effect HQs – Pond P		
7-6l.1	--	Sediment No-Effect HQs – Unnamed Island	Deleted	--
7-6l.2	--	Sediment Effect HQs – Unnamed Island		
7-6m.1	7-6l	Sediment No-Effect HQs – Wetlands	Deleted & Replaced	Sample-by-sample analysis changed to comparison of EU based RMEs & CTEs to sediment benchmarks
7-6m.2		Sediment Effect HQs – Wetlands		
--	7-6m	Weight-of-Evidence Integration for Benthic Invertebrates	New	--
--	7-7	LMW PAHs, HMW PAHs, and Total PAHs in Sediment Collected From Aquatic Habitats	New	--
7-7a	--	Summary of Sediment No-Effect HQs	Deleted	--
7-7b	--	Summary of Sediment Effect HQs	Deleted	--
7-7c	--	Sediment Risk Summary Matrix	Deleted	--
7-7d	--	Sediment Residual Risk Summary Matrix	Deleted	--
7-8a	--	Summary of Sediment AVS/SEM Results – Blackstone River	Modified	Added SEM_AVS row
7-8b	--	Summary of Sediment AVS/SEM Results – Pond Areas	Modified	Added SEM_AVS row
7-9a	--	Sediment Toxicity Test Results	No Change	--
7-9b	--	Triad Sediment Chemistry and Toxicity Results - River	No Change	--
7-9c	--	Triad Sediment Chemistry and Toxicity Results – Pond	No Change	--
7-10a	--	Sediment Triad Study – Water Quality Measurements	No Change	--
7-10b	--	Sediment Triad Study – Grain Size and TOC Results	No Change	--
7-10c	--	Sediment Triad Study – Benthic Organism Counts	No Change	--
7-10d	--	Sediment Triad Study – Benthic Percent Higher Order Abundance	No Change	--
7-10e	--	Sediment Triad Study – Benthic Community Metric Results	No Change	--

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Original Number	New Number	Original Title	Status	Comments
7-10f	--	Sediment Triad Study – Weight-of-Evidence Table	Modified	Corrected wording in "Conclusion" column
7-11	--	Fish Community Organism Counts	No Change	--
7-12	--	Fish Community Metric Results	No Change	--
7-13a	--	Calculated Hazard Quotients for Fish and Amphibians – Blackstone River (Near-Site)	Modified	(a) Relabeled "LOAEL" as "Acute" and "NOAEL" as "Chronic", (b) RR calculated by division instead of subtraction, (c) Reordered columns.
7-13b	--	Calculated Hazard Quotients for Fish and Amphibians – Blackstone River (Upstream)	Modified	(a) Relabeled "LOAEL" as "Acute" and "NOAEL" as "Chronic", (b) RR calculated by division instead of subtraction, (c) Reordered columns.
7-13c	--	Calculated Hazard Quotients for Fish and Amphibians – Wetlands A through D	Modified	(a) Relabeled "LOAEL" as "Acute" and "NOAEL" as "Chronic", (b) RR calculated by division instead of subtraction, (c) Reordered columns.
7-13d	--	Calculated Hazard Quotients for Fish and Amphibians – Pond A	Modified	(a) Relabeled "LOAEL" as "Acute" and "NOAEL" as "Chronic", (b) RR calculated by division instead of subtraction, (c) Reordered columns.
7-13e	--	Calculated Hazard Quotients for Fish and Amphibians – Pond C	Modified	(a) Relabeled "LOAEL" as "Acute" and "NOAEL" as "Chronic", (b) RR calculated by division instead of subtraction, (c) Reordered columns.
7-13f	--	Calculated Hazard Quotients for Fish and Amphibians – Pond D	Modified	(a) Relabeled "LOAEL" as "Acute" and "NOAEL" as "Chronic", (b) RR calculated by division instead of subtraction, (c) Reordered columns.
7-13g	--	Calculated Hazard Quotients for Fish and Amphibians – Pond E	Modified	(a) Relabeled "LOAEL" as "Acute" and "NOAEL" as "Chronic", (b) RR calculated by division instead of subtraction, (c) Reordered columns.

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Original Number	New Number	Original Title	Status	Comments
7-13h	--	Calculated Hazard Quotients for Fish and Amphibians – Pond F	Modified	(a) Relabeled "LOAEL" as "Acute" and "NOAEL" as "Chronic", (b) RR calculated by division instead of subtraction, (c) Reordered columns.
7-13i	--	Calculated Hazard Quotients for Fish and Amphibians – Pond I	Modified	(a) Relabeled "LOAEL" as "Acute" and "NOAEL" as "Chronic", (b) RR calculated by division instead of subtraction, (c) Reordered columns.
7-13j	--	Calculated Hazard Quotients for Fish and Amphibians – Pond N	Modified	(a) Relabeled "LOAEL" as "Acute" and "NOAEL" as "Chronic", (b) RR calculated by division instead of subtraction, (c) Reordered columns.
7-13k	--	Calculated Hazard Quotients for Fish and Amphibians – Pond P	Modified	(a) Relabeled "LOAEL" as "Acute" and "NOAEL" as "Chronic", (b) RR calculated by division instead of subtraction, (c) Reordered columns.
7-13l	--	Summary of Effect HQs Matrix for Fish and Amphibians	Deleted	--
7-13m	--	Summary of No-Effect HQs for Fish and Amphibians	Deleted	--
7-13n	--	Risk Summary Matrix for Fish and Amphibians	Deleted	--
7-14	--	Critical Body Residues for Fish	No Change	--
7-15a	--	Comparison of Fish Tissue Data to CBRs – Effect and No-Effect HQs – Blackstone River (Upstream)	Modified	Reordered columns for consistency
7-15b	--	Comparison of Fish Tissue Data to CBRs – Effect and No-Effect HQs –Blackstone River (Near-Site)	Modified	Reordered columns for consistency
7-15c	--	Comparison of Fish Tissue Data to CBRs – Effect and No-Effect HQs –Pond A	Modified	Reordered columns for consistency
7-15d	--	Comparison of Fish Tissue Data to CBRs – Effect and No-Effect HQs –Pond F	Modified	Reordered columns for consistency
7-15e	--	Comparison of Fish Tissue Data to CBRs – Effect and No-Effect HQs –Reference Pond	Modified	Reordered columns for consistency
7-16	--	Fish Tissue Risk Matrix	Deleted	--
--	7-16a	Summary of Residual Risks for Fish Collected From the Blackstone River (Near-Site)	New	--
--	7-16b	Summary of Residual Risks for Fish Collected From Pond A	New	--
--	7-16c	Summary of Residual Risks for Fish Collected From Pond F	New	--

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Original Number	New Number	Original Title	Status	Comments
--	7-16d	Weight-of-Evidence Integration for Fish	New	--
--	7-16e	Weight-of-Evidence Integration for Amphibians	New	--
7-17a	--	Calculated Hazard Quotients for Large Omnivorous Birds – All Areas	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-17b	--	Calculated Hazard Quotients for Large Omnivorous Birds – Blackstone River (Upstream)	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
--	7-17c	Weight-of-Evidence Integration for Large Omnivorous Birds	New	--
7-18a	--	Calculated Hazard Quotients for Small Omnivorous Birds – Blackstone River (Upstream)	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-18b	--	Calculated Hazard Quotients for Small Omnivorous Birds – J.M. Mills Landfill	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-18c	--	Calculated Hazard Quotients for Small Omnivorous Birds – Unnamed Island	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-18d	--	Calculated Hazard Quotients for Small Omnivorous Birds – Nunes Parcel	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-18e	--	Calculated Hazard Quotients for Small Omnivorous Birds – Quinnville Well Field	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-18f	--	Calculated Hazard Quotients for Small Omnivorous Birds – Wetlands A through D	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-18g	--	Calculated Hazard Quotients for Small Omnivorous Birds – Pratt Dam	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
--	7-18h	Weight-of-Evidence Integration for Small Omnivorous Birds	New	--
7-19a	--	Calculated Hazard Quotients for Large Piscivorous Birds – Blackstone River (Upstream and Pond P-6)	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.

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Original Number	New Number	Original Title	Status	Comments
7-19b	--	Calculated Hazard Quotients for Large Piscivorous Birds – Blackstone River and Ponds A and F	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
--	7-19c	Weight-of-Evidence Integration for Large Piscivorous Birds	New	--
7-20a	--	Calculated Hazard Quotients for Small Piscivorous Birds – Blackstone River (Upstream)	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-20b	--	Calculated Hazard Quotients for Small Piscivorous Birds – Pond P-6	Deleted	--
7-20c	7-20b	Calculated Hazard Quotients for Small Piscivorous Birds – Blackstone River (Near-Site)	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-20d	7-20c	Calculated Hazard Quotients for Small Piscivorous Birds – Pond A	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-20e	7-20d	Calculated Hazard Quotients for Small Piscivorous Birds – Pond F	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
--	7-20e	Weight-of-Evidence Integration for Small Piscivorous Birds	New	--
7-21a	--	Summary of Omnivorous Bird Risk Rankings	Deleted	--
7-21b	--	Summary of Piscivorous Bird Risk Rankings	Deleted	--
7-22a	--	Calculated Hazard Quotients for Large Omnivorous Mammals – Blackstone River (Upstream)	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-22b	--	Calculated Hazard Quotients for Large Omnivorous Mammals – All Locations	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
--	7-22c	Weight-of-Evidence Integration for Large Omnivorous Mammals	New	--
7-23a	--	Calculated Hazard Quotients for Small Omnivorous Mammals – Blackstone River (Upstream)	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-23b	--	Calculated Hazard Quotients for Small Omnivorous Mammals – J.M. Mills Landfill	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.

Attachment 2: Summary of changes made by ESAT to the tables in the final revised BERA for Peterson Puritan Superfund site

Original Number	New Number	Original Title	Status	Comments
7-23c	--	Calculated Hazard Quotients for Small Omnivorous Mammals – Unnamed Island	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-23d	--	Calculated Hazard Quotients for Small Omnivorous Mammals – Nunes Parcel	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-23e	--	Calculated Hazard Quotients for Small Omnivorous Mammals – Quinnville Well Field	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-23f	--	Calculated Hazard Quotients for Small Omnivorous Mammals – Wetlands A through D	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-23g	--	Calculated Hazard Quotients for Small Omnivorous Mammals – Pratt Dam	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
--	7-23h	Weight-of-Evidence Integration for Small Omnivorous Mammals	New	--
7-24a	--	Calculated Hazard Quotients for Large Piscivorous Mammals – Blackstone River (Upstream and Pond P-6)	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-24b	--	Calculated Hazard Quotients for Large Piscivorous Mammals – Ponds A and F	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
--	7-24c	Weight-of-Evidence Integration for Large Piscivorous Mammals	New	--
7-25a	--	Calculated Hazard Quotients for Small Piscivorous Mammals – Blackstone River (Upstream)	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-25b	--	Calculated Hazard Quotients for Small Piscivorous Mammals – Pond P-6	Deleted	--
7-25c	7-25b	Calculated Hazard Quotients for Small Piscivorous Mammals – Blackstone River (Near-Site)	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
7-25d	7-25c	Calculated Hazard Quotients for Small Piscivorous Mammals – Pond A	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.

Attachment 2: Summary of changes made by ESAT to the tables in the final revised BERA for Peterson Puritan Superfund site

Original Number	New Number	Original Title	Status	Comments
7-25e	7-25d	Calculated Hazard Quotients for Small Piscivorous Mammals – Pond F	Modified	(a) RR calculated by division instead of subtraction, (b) Reordered columns.
--	7-25e	Weight-of-Evidence for Small Piscivorous Mammals	New	--
7-26a	--	Summary of Omnivorous Mammal Risk Rankings	Deleted	--
7-26b	--	Summary of Piscivorous Mammal Risk Rankings	Deleted	--
--	7-26a	Summary of Ecological Risk in Aquatic Habitats - Blackstone River (Near-Site)	New	--
--	7-26b	Summary of Ecological Risk in Aquatic Habitats - Pond A	New	--
--	7-26c	Summary of Ecological Risk in Aquatic Habitats - Pond B	New	--
--	7-26d	Summary of Ecological Risk in Aquatic Habitats - Pond C	New	--
--	7-26e	Summary of Ecological Risk in Aquatic Habitats - Pond D	New	--
--	7-26f	Summary of Ecological Risk in Aquatic Habitats - Pond E	New	--
--	7-26g	Summary of Ecological Risk in Aquatic Habitats - Pond F	New	--
--	7-26h	Summary of Ecological Risk in Aquatic Habitats - Pond I	New	--
--	7-26i	Summary of Ecological Risk in Aquatic Habitats - Pond N	New	--
--	7-26j	Summary of Ecological Risk in Aquatic Habitats - Pond P	New	--
--	7-26k	Summary of Ecological Risk in Aquatic Habitats - Wetlands A Through D	New	--
7-27	--	Weight of Evidence Summary for Ecological Risks	Deleted	--
--	7-27a	Summary of Ecological Risk in Terrestrial Habitats - J.M. Mills Landfill	New	--
--	7-27b	Summary of Ecological Risk in Terrestrial Habitats - Unnamed Island	New	--
--	7-27c	Summary of Ecological Risk in Terrestrial Habitats - Nunes Parcel	New	--
--	7-27d	Summary of Ecological Risk in Terrestrial Habitats - Quinnville Well Field	New	--
--	7-27e	Summary of Ecological Risk in Terrestrial Habitats - Wetlands A Through D	New	--
--	7-27f	Summary of Ecological Risk in Terrestrial Habitats - Pratt Dam	New	--

Attachment 2

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Rapid communication

Bioavailability of phthalate congeners to earthworms (*Eisenia fetida*) in artificially contaminated soils

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Abstract

Bioavailability of phthalate congeners, dimethyl phthalate, diethyl phthalate, di-*n*-butyl phthalate (DBP), di-(2-ethylhexyl) phthalate (DEHP), and dioctyl phthalate, to earthworms (*Eisenia fetida*) were studied when earthworms were exposed to two artificially contaminated agricultural and forest soils. Only DBP and DEHP were detected in earthworms. The uptake kinetics of DBP and DEHP in earthworms was fast within the initial 10 days followed by a nearly steady state for the subsequent 20 days. An equilibrium partitioning model could be used to describe the uptake kinetics of DBP and DEHP by earthworm in two types of soils ($r = 0.709-0.864$). The average biota-to-soil accumulation factors (BSAFs) of DBP and DEHP at $5\,mg\,kg^{-1}$ in soil were 0.27 ± 0.07 and 0.17 ± 0.03, respectively, in agricultural soil, while the BSAFs were 0.21 ± 0.06 and 0.07 ± 0.02, respectively, in forest soil. The concentrations of phthalates in earthworms increased with increasing concentrations of phthalates in soil. There was a significant correlation between $\log C_{soil}$ and $\log C_{worm}$, with $r = 0.999-0.993$, demonstrating a single linear partitioning of phthalates between soil and earthworms. The bioavailability of DBP and DEHP was assessed by Soxhlet, methanol, and methanol–water (1:1) extraction methods. Our results indicated that the extractable amounts of freshly added DBP and DEHP in soils by these extraction methods were significantly correlated with those in earthworms. It was observed that the extractable DBP and DEHP by the methanol and methanol–water (1:1) extraction methods decreased with their increasing residence time in soil. In contrast, the amount extracted by the Soxhlet extraction method did not show a similar decline. Therefore, Soxhlet extraction was a poor indicator of the bioavailability of DBP and DEHP to earthworms in soil, which could lead to overestimation of the risk of soil-associated DBP and DEHP. The extractable DBP and DEHP by methanol and methanol–water (1:1) significantly decreased over 440 days. Compared with the methanol–water (1:1) extraction method, the methanol extraction method was preferred for its ability to predict the bioavailability of DBP and DEHP in aged soils.
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Keywords: Bioavailability; Phthalates; Earthworms; Soil; Equilibrium partitioning model

1. Introduction

Earthworms comprise the largest part of the soil fauna biomass and are able to accumulate various organic contaminants, including chlorinated hydrocarbons (Morrison et al., 2000), polychlorinated biphenyls (Krauss et al., 2000), and polycyclic aromatic hydrocarbons (Kelsey and Alexander, 1997), etc. Accumulation of organic contaminants implies a risk not only to earthworm populations but also to many vertebrate species feeding on earthworms. Therefore, earthworms are considered standard soil toxicity test organisms and are suitable for assessing the bioavailability of many chemicals in the soil environment (Lanno et al., 2004).

Bioavailability is a measure of a chemical for entry into a biological receptor. It is specific to the receptor, the route of entry, the time of exposure, and the matrix containing the contaminant (Anderson et al., 1999). Therefore, when assessing the bioavailability of soil

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contaminants, it is crucial to study the uptake kinetics of these chemicals in organisms. To describe the uptake kinetics of organic compounds in soils or sediments, the equilibrium partitioning theory, initially proposed by Shea (1989) and further developed by DiToro et al. (1991), has frequently been applied (Connell and Markwell, 1990). It presumes that the uptake kinetics of organic chemicals in soil- and sediment-dwelling organisms is usually described as a simple hydrophobic partitioning process between pore water and lipids of the organisms. The theory has been validated for a number of soil- or sediment-dwelling organisms (Belfroid et al., 1996).

There is considerable evidence that the exposure of various organisms to organic compounds in soil is overestimated by the use of vigorous extraction methods (Kelsey and Alexander, 1997). The reason for this is that not all of the compounds removed from soil by these extraction procedures are available to soil organisms. The bioavailability of this soil pool depends on soil chemical and physical properties (Nam et al., 1998). The bioavailability decreases with increasing residence time (''aging effect'') of the compounds in soil or sediment, and such decreases differ among various organic contaminants (Kelsey and Alexander, 1997). Considering that bioassays of bioavailability are time consuming and expensive, it is essential to develop a simple method, a mild chemical extraction procedure, as a surrogate of bioassays to assess bioavailable pools (Kelsey et al., 1997; Tang et al., 1999).

Phthalate pollution is of global concern due to their widespread occurrence and endocrine-disrupting properties (Wezel et al., 2000; Hu et al., 2003). The continuous release of large quantities of phthalates into the environment remains a substantial threat to ecosystems and human health. However, there is little information on the bioavailability of phthalates to earthworms (Staples et al., 1997). Since bioavailability constitutes an ecological risk and is an indispensable part of a complete risk assessment of chemicals, it is worth investigating the bioavailability of soil-associated phthalates to earthworms.

In the present study, five phthalate congeners, dimethyl phthalate (DMP), diethyl phthalate (DEP), di-*n*-butyl phthalate (DBP), di-(2-ethylhexyl) phthalate (DEHP), and dioctyl phthalate (DNOP), all recognized as priority pollutants by the US Environmental Protection Agency (Environmental Protection Agency (EPA), 2002), were chosen as representatives of phthalate congeners to evaluate the effect of the physicochemical properties of test compounds on their bioavailability in soils. The earthworms studied were *Eisenia fetida*, a standard organism recommended by the Organization for Economic Cooperation and Development (OECD, 1984) for tests of acute and subacute toxicity of soil-associated pollutants. The objectives of the present study were to evaluate whether the equilibrium partitioning model could describe the uptake kinetics of phthalates in artificially contaminated soil by earthworms, to assess the relationship between different concentrations of phthalates in different soils and those in earthworms, to investigate the aging effect on the extractability and bioavailability of phthalates in soil, and to test the feasibility of a mild chemical extraction for estimating bioavailability of phthalates in soil.

2. Materials and methods

2.1. Soils

Two Chinese agricultural and forest soils (S1 and S2) collected from Beijing were used in the trial. The soils were air-dried, ground, and screened through a 1-mm nylon fiber sieve to remove stones, plant roots, and other large particles. Soil pH was measured in deionized water using a soil/solution ratio of 1:1 (w:v). Organic matter content was determined by the Walkley–Black procedure (Nelson and Sommers, 1982). Cation exchange capacity was determined by the method described by Rhoades (1982). Different amounts of phthalates were added dropwise to the soils as a dichloromethane solution and mixed thoroughly using a high-speed mixer (Waring blender). Autoclaved distilled water was added to give a moisture content of 40% water holding capacity (WHC). The spiked soils were then transferred to solvent-rinsed microcosms (3-kg Kilner jar). To each microcosm, 1.5 kg of the spiked soil was added, sealed, and then immediately sterilized with 2.5 Mrad of gamma irradiation from ^{60}Co. After sterilization, the microcosms were incubated at 20 °C for different time intervals. Over the course of this study, the jars were sealed and stored in the dark to prevent phthalates loss through volatilization and/or photodegradation over the period of incubation. The accuracy and homogeneity of the spiking and the concentrations of phthalate congeners after aging were evaluated by analyzing six subsamples as described below.

2.2. Uptake of phthalates

Earthworms (*E. fetida*), purchased from the Agricultural University of China (Beijing, China), were maintained in moistened uncontaminated soil S1 (40% WHC) using organic-free reagent water. Before Experiment 1, the phthalate contents in earthworms were determined.

Experiment 1. The uptake kinetics of soil-associated phthalates by earthworms. Phthalates were added to soils S1 and S2 to give final concentrations of 5 mg kg^{-1}. Three hundred earthworms (total weight 74,000 ± 300 mg) were exposed to the two artificially

contaminated soils separately from 5 to 30 days. At the 5th, 10th, 15th, 20th, and 30th day, worms were sampled to study the uptake kinetics. To minimize stress and disturbance to the worm collection, 10 worms were kept as a group in 1000-ml glass beakers. Each beaker contained 1 kg contaminated and moistened S1 or S2. The beakers were covered with wet filter paper and kept in the dark at $22\pm2\,^{\circ}C$. The earthworms were not fed during the experiments. After a given time interval the earthworms were removed, rinsed with water, and placed in wet filter paper for 24 h to allow the gut to empty. A 24-h period of depuration was chosen because this was sufficiently long for all soils to be eliminated from the worms (Belfroid et al., 1994). Then the earthworms were rinsed with water again and stored at $-20\,^{\circ}C$ for analysis.

Experiment 2. The effect of phthalates concentrations in soil on their bioavailability and the feasibility of mild chemical extraction for assessing bioavailability of phthalates in soil. Based on the results of Experiment 1, an exposure time of 15 days was selected to assess the near equilibrium relationship between the concentrations of phthalates in soils and those in earthworms. Phthalates were added to give final concentrations of 5.0, 10.0, 20.0, 40.0 and 50.0 mg kg^{-1} in dry soil. For each concentration in soil, 10 earthworms were used to determine the concentration in earthworms. Four replicates were carried out for each concentration point. The culture conditions of earthworms were the same as those in Experiment 1.

In our study we tested whether the methanol and methanol–water (1:1) extraction methods, which were often selected by others (Kelsey et al., 1997b), were feasible for assessing the bioavailability of phthalates in soils. After the spiked soils were incubated in the dark at $22\pm2\,^{\circ}C$ for 15 days, 3 g soil at each concentration level was transferred to a 50-ml glass centrifuge tube to which 30 ml of methanol or methanol–water (1:1) was added. The mixture was shaken on a reciprocating shaker for 24 h and the resulting slurry was then passed through a 0.25-μm nylon filter. A portion of 20 ml filtered solvent was extracted three times by 30 ml hexane. The extract was reduced to 0.5 ml by rotary evaporation prior to gas chromatographic analysis.

Experiment 3. The effect of aging on the extractability and bioavailability of phthalates in soil. S1, spiked with 20 mg kg^{-1} of phthalates, was incubated in the dark at $22\pm2\,^{\circ}C$ for 100 and for 440 days. Then, the earthworms were incubated in the soil and kept for 15 days. The culture conditions of earthworms were the same as those in Experiment 1. In the meantime, subsamples of soil were extracted by Soxhlet, methanol, or methanol–water (1:1) extraction methods. The extraction conditions were the same as those described above.

2.3. Determination of phthalates

Standards of DNOP, DEHP, DEP, DBP, and DMP were purchased from AccuStandard Inc (New Haven, CT, USA). All reagents used were of pesticide grade.

The frozen earthworm (ca. 2.5 g) or 2 g of soil was ground with 10 g of anhydrous Na_2SO_4 in a mortar and pestle prior to Soxhlet extraction. The ground mixture was placed in a thimble filter and extracted with 100 ml mixture of hexane and dichloromethane (1:1) for 24 h at 5–6 min $cycle^{-1}$. The extract was carefully concentrated to 2 ml by rotary evaporator. The residue was transferred to a column (1 cm i.d. × 10 cm) packed with silica gel (60–80 mesh), covered by 2-cm layer of sodium sulfate, which was used to clean up the extracts. Then, the column was washed with 30 ml hexane and 30 ml dichloromethane. The eluate was reduced to an adequate volume by rotary evaporator for analysis. The concentrations of phthalates were analyzed using a gas chromatograph equipped with an electron capture detector (Hewlett–Packard 6890, USA) and a HP-5 fused silica capillary column (film 0.32 μm, i.d. 0.25 mm, length 30 m) (J&W, USA). The details of the analytical method were reported in our previous work (Hu et al., 2003). The detection limits of DMP, DEP, DBP, DEHP, and DNOP are 12.51, 11.48, 10.29, 6.14, and 7.56 μg kg^{-1}, respectively.

2.4. Equilibrium partitioning model

The uptake kinetics of phthalates from spiked S1 and S2 by the earthworms (*E. fetida*) is described using the equilibrium partitioning model and both uptake and elimination are considered to follow a first order kinetics:

$$\frac{dC_{worm}}{dt} = k_u C_{soil} - k_e C_{worm}, \quad (1)$$

which can be expressed after integration as

$$C_{worm} = \frac{k_u}{k_e} C_{soil}(1 - e^{-k_e t}) + C_{worm,0} e^{-k_e t}, \quad (2)$$

where C_{worm} is the concentration of phthalates in earthworms on a wet-weight base and $C_{worm,0}$ is the initial phthalate concentration in earthworms kept in the "storing soil." C_{soil} is the concentration of phthalates in soil on a dry-weight base, which is considered constant, because the uptake of phthalates by earthworms results in only a negligible reduction of their concentrations in soil. k_u is the uptake rate constant (d^{-1}). k_e is the elimination rate constant (d^{-1}). Elimination includes desorption to the surrounding solution, losses due to excretion, and metabolic transformation.

At equilibrium $dC_{worm}/dt = 0$, Eq. (2) results in a simple partitioning of compounds between soil and

earthworms:

$$\frac{k_u}{k_e} = \frac{C_{worm}}{C_{soil}} = \text{BSAF}. \quad (3)$$

The ratio C_{worm}/C_{soil} is also defined as biota-to-soil accumulation factor (BSAF) at steady state conditions (Belfroid et al., 1996).

2.5. Data analysis

All statistical analyses were conducted with the software SPSS 11.5 for Windows (SPSS Inc., Chicago, IL, USA). One-sample t test was employed to compare the mean of a sample to a population mean, one-way ANOVA was used to assess the significance of the difference between groups, and linear regression analyses were conducted by the least-squares method. The curve of uptake kinetics was fitted to the equilibrium partitioning model using the nonlinear regression module of SPSS and the Levenberg–Marquardt method was used to determine the best estimates of parameters for the uptake kinetic curve. Statements of significant differences are based on $P \leqslant 0.05$.

3. Results and discussion

3.1. Soil properties and spiking of phthalates to soils

The properties of agricultural and forest soils (S1 and S2) are given in Table 1. The difference in organic matter (OM) contents in S1 and S2 was obvious. The OM content of S2 (4.53%) was higher than that of S1 (1.35%). Since phthalates are ubiquitous in the environment, it is difficult to find soil without any phthalates. The concentrations of phthalates in S1 were relatively lower than those in S2 (Table 1). Therefore, S1 was selected as the storage soil. When earthworms were exposed to S1 only DBP was detected in earthworms, and its concentration was $0.06 \pm 0.02\,\text{mg kg}^{-1}$. The concentrations of other phthalates in earthworms were lower than the detection limits.

In this study, different amounts of phthalates were spiked to S1 and S2. The maximum spiked amount was $50\,\text{mg kg}^{-1}$. Although this amount was higher than that in arable soils in China (Hu et al., 2003), it was equivalent to that in the polluted soils (Rugge and Ahlert, 1992). The phthalates in artificially contaminated soils (S1 and S2) were determined after spiking. The average recoveries ranged 95–102%, showing the accuracy and homogeneity of the spiking. After aging for different periods from 15 to 440 days, the recoveries of phthalates in spiked soils were found to be in the range 87–109%, indicating that microbial degradation and volatilization during the aging time were negligible. During the accumulation experiments (Experiments 1–3), no mortality was observed and the average weight of earthworms was constant.

3.2. Uptake of phthalates in soils to earthworms and the validity of the equilibrium partitioning model

In Experiment 1, earthworms were exposed to two artificially contaminated soils at $5\,\text{mg kg}^{-1}$ on dry-weight basis for 5, 10, 15, 20, and 30 days. Two of five test compounds, DBP and DEHP, were detected in earthworms exposed to the spiked S1 and S2. The concentrations of DBP and DEHP in earthworms increased rapidly from 0 to 10 days and then remained almost constant during the rest of the experimental

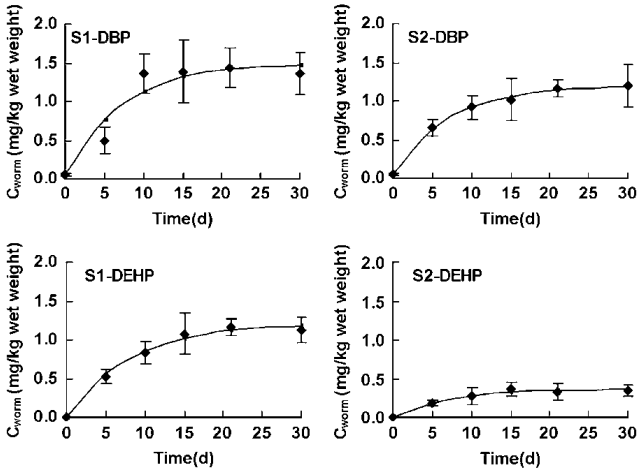


Fig. 1. Uptake curves of DBP and DEPH by earthworms exposed to the spiked S1 and S2 (mean ± SD). Data points: experimental values: Solid line: equilibrium partitioning model fitting.

Table 1
Physiochemical properties of soils

Soil	Sand	Silt	Clay	Organic matter	pH	CEC	Phthalates (mg kg^{-1})				
	(%)	(%)	(%)	(%)		(cmol kg^{-1})	DMP	DEP	DBP	DEHP	DNOP
S1	36.02	56.43	6.44	1.35	8.28	34.25	ND[a]	0.26 ± 0.04	0.27 ± 0.08	0.06 ± 0.01	ND
S2	31.91	60.55	6.84	4.53	7.58	36.57	0.14 ± 0.05	0.45 ± 0.13	0.44 ± 0.08	0.12 ± 0.03	ND

[a]ND, not detected.

period of 20 days (Fig. 1). To check the validity of the equilibrium partitioning model, we investigated whether the uptake curves of DBP and DEHP assimilated by earthworms exposed to spiked S1 and S2 could be described by Eq. (2). Good fits were obtained between the experimental data and Eq. (2) calculation for two soils. The correlation coefficients were in the range 0.709–0.864 (Table 2), indicating that the equilibrium partitioning model was valid. The fitted parameters k_u and k_e are shown in Table 2. The BSAFs calculated as the ratio of k_u to k_e, derived from the equilibrium partitioning model, are also listed in Table 2.

To deduce the exposure time necessary to reach approximate equilibrium concentrations of DBP and DEHP in earthworms, we calculated theoretical steady state concentrations using Eq. (3) and compared them to the concentrations at time steps 10, 15, and 20 days calculated from Eq. (2). After 10 days of exposure in spiked S1 the calculated concentrations of DBP and DEHP in earthworms were on the average of 75% of the theoretical steady state concentrations for DBP and 72% for DEHP. After 15 days of exposure, respective percentages were 94% (DBP) and 95% (DEHP); after 20 days the corresponding percentages were 96% (DBP) and 96% (DEHP), respectively. The calculated concentrations of DBP and DEHP in earthworms exposed to S2 for 15 days were 94% (DBP) and 93% (DEHP) of the theoretical steady state concentrations, respectively. Therefore, we supposed that the assumption of steady state conditions after 15 days of exposure was valid and we selected an exposure time of 15 days in the following experiments.

When the concentrations of DBP and DEHP in soils were 5 mg kg^{-1}, the mean steady state concentrations in earthworms were 1.39 ± 0.41 and 1.06 ± 0.27 mg kg^{-1} for DBP and DEHP, respectively, in spiked S1, while those in spiked S2 were 1.02 ± 0.32 and 0.36 ± 0.11 mg kg^{-1} for DBP and DEHP, respectively. The difference in steady state concentrations in DBP and DEHP in earthworms was significant ($P < 0.05$), although their concentrations in S1 and S2 were approximately the same. The steady state concentration of DBP in earthworms was higher than that of DEHP in both spiked S1 and S2. The steady state concentrations of DBP and DEHP in earthworms exposed to the spiked S1 were higher than those in the spiked S2.

The differences in bioavailability in the five phthalates could be explained by their behavior in soil and their uptake kinetics in earthworms. More hydrophobic compounds, such as DNOP, in soil were more slowly assimilated by earthworms because they had higher affinity for soil OM, which caused their desorption and diffusion to be too slow to replenish the soil solution (Landrum, 1989). With decreasing concentration of compounds in soil solution, the uptake of compounds by earthworms via dermis decreased and subsequently the concentration of compounds in earthworms decreased. However, more hydrophobic compounds were more easily taken via passive diffusion from the soil solution through the outer lipid membrane of earthworms (Krauss et al., 2000). Therefore, the bioavailability of soil-associated compounds to earthworms cannot be completely explained by their octanol–water partition coefficients (K_{ow}) and was simultaneously influenced by various factors such as the characteristics of the given compound, the soil, and the organism's toxicokinetics. Many people tried to assess the relationship between the bioavailability of organic pollutants in soils and their K_{ow}, although the BSAF is expected to be independent of K_{ow} according to its conception (Sijm et al., 2000; Krauss et al., 2000). For the phthalate congeners that we studied, the undetectable DMP and DEP in earthworms may be due to their higher metabolic degradation. In in vitro studies on metabolism of phthalate congeners it had been demonstrated that the lower the molecular weight of phthalate ester the faster the rate of metabolism (The Royal Society of Chemistry, 1981), although there was no information on the metabolic degradation of phthalates by earthworms. For undetectable DNOP, the most likely explanations were a strong sorption and a considerably slower desorption rate (Swann et al., 1983), which was not sufficient to replenish the solution phase depleted by the earthworm uptake. This effect was also observed for some pesticides (Curl et al., 1987; Lord et al., 1980). The difference in steady state concentrations of DBP and DEHP in earthworms exposed to spiked S1 and S2

Table 2
Toxicokinetic parameters of the equilibrium partitioning model for DBP and DEHP in soils

Soils	Phthalates	R	$k_u(d^{-1})$[a]	$k_e(d^{-1})$[a]	BSAF $= k_u/k_e$
S1	DBP	0.776	0.041(0.028–0.059)[a]	0.136(0.080–0.212)	0.307
	DEHP	0.861	0.030(0.225–0.036)	0.123(0.083–0.159)	0.244
S2	DBP	0.864	0.033(0.024–0.044)	0.138(0.089–0.191)	0.242
	DEHP	0.709	0.010(0.006–0.015)	0.130(0.072–0.233)	0.073

[a]95% confidence limits.

might be due to different soil properties of agricultural and forest soils. Higher organic matter in S2 led to less phthalates desorption and lower BSAF of DBP and DEHP in S2.

In our experiments, BSAFs were calculated by two methods; one was the ratio k_u/k_e, and the other was C_{worm}/C_{soil}. Because the BSAFs for each compound and soil calculated from k_u and k_e are single, we considered BSAF the population mean. There were six replicates of the BSAFs calculated from C_{worm}/C_{soil} for each compound and soil, and the six replicates were considered a sample. One-sample t test was employed to investigate whether there is statistical difference between the BSAFs calculated by the two methods, and it was found that there was no significant difference in BSAFs calculated by the two methods ($P>0.05$), which further manifested the validity of the equilibrium partitioning theory to describe uptake kinetics of soil-associated DBP and DEHP in earthworms.

Although the steady state conditions were reached after 15 days of exposure, slight decreases in the concentrations of DBP and DEHP in earthworms were found between residence times of 20 and 30 days in contaminated S1 and S2. Quite similar phenomena were observed by many other researchers for other organic chemicals (Krauss et al., 2000). Such differences were ascribed to the earthworms habits of living mainly in permanent burrows, and the surrounding soil solution may have been depleted of DBP and DEHP during the longer exposure time as a result of continuous uptake by the earthworms. The desorption and diffusion might be too slow to replenish the solution; therefore, the decreasing uptake amount resulted in decreasing concentrations in earthworm tissue at longer exposure times.

3.3. The effect of concentrations of phthalates in soil on their bioavailability and the feasibility of mild chemical extraction for predicting bioavailability of phthalates in soil

According to Eq. (3) there should be a simple linear partitioning relationship between C_{worm} and C_{soil} at steady state conditions.

To test this hypothesis, earthworms were exposed to soils receiving 5.0, 10.0, 20.0, 40.0, and 50.0 mg kg^{-1} test compounds for 15 days. Then the steady state concentrations of test compounds in earthworms were determined (Table 3). Subsequently, we conducted a linear regression analysis of $\log C_{worm}$ versus $\log C_{soil}$. The resulting regression equation was

$$\log C_{worm} = s \log C_{soil} + \log \mathrm{BSAF}. \quad (4)$$

If Eq. (4) was expanded with a nonlinearity parameter s (Krauss et al., 2000),

$$C_{worm} = \mathrm{BSAF}(C_{soil})^s. \quad (5)$$

Regression analyses showed significant relationship between $\log C_{soil}$ and $\log C_{worm}$ with $r = 0.993-0.999$. The parameters of s were 1.05 (DBP) and 0.77 (DEHP) in spiked S1 and 1.05 (DBP) and 0.94 (DEHP) in spiked S2. If s was about 1, the assumption of simple partitioning was met, i.e., a partitioning of DBP and DEHP between soils and lipid-rich earthworms.

The BSAFs of earthworms exposed to different concentrations of DBP and DEHP in soils are also

Table 3
Effect of DBP and DEHP concentrations in soils on their bioavailability to earthworms (mean ± SD)

Soils	C_{soil}	DBP		DEHP	
	(mg kg^{-1})	C_{worm} (mg kg^{-1})	BSAF	C_{worm} (mg kg^{-1})	BSAF
S1	5	1.39 ± 0.41[a]	0.28 ± 0.08	1.06 ± 0.27	0.21 ± 0.05
	10	2.26 ± 0.21	0.23 ± 0.02	2.02 ± 0.12	0.20 ± 0.04
	20	5.07 ± 1.67	0.25 ± 0.08	3.43 ± 0.61	0.17 ± 0.03
	40	11.21 ± 3.06	0.28 ± 0.08	5.61 ± 0.85	0.14 ± 0.02
	50	15.14 ± 5.52	0.30 ± 0.11	6.53 ± 1.53	0.13 ± 0.03
	r	0.995		0.999	
	s	1.05(0.84–1.27)[b]		0.77(0.68–0.88)	
S2	5	1.02 ± 0.32	0.20 ± 0.06	0.36 ± 0.11	0.07 ± 0.02
	10	1.81 ± 0.32	0.18 ± 0.03	0.84 ± 0.27	0.08 ± 0.03
	20	4.17 ± 1.52	0.21 ± 0.08	1.21 ± 0.23	0.06 ± 0.01
	40	8.31 ± 2.41	0.21 ± 0.06	2.75 ± 0.61	0.07 ± 0.02
	50	11.40 ± 4.42	0.23 ± 0.09	3.31 ± 0.54	0.07 ± 0.01
	r	0.998		0.993	
	s	1.05(0.92–1.18)		0.94(0.73–0.14)	

[a]The C_{worm} values were determined after 15-day incubation.
[b]95% confidence limits.

shown in Table 3. BSAFs of DBP and DEHP at five different soil concentrations were insignificantly different from each other ($P>0.05$), which demonstrated that the concentrations of DBP and DEHP in soils had no effect on their BSAFs.

The results of mild chemical extraction showed that there was different extractability of DBP and DEHP from soil by different solvents (Fig. 2). The average percentages extracted from S1 with methanol were 74.9% and 101.8% of total soil concentrations of DBP and DEHP, respectively. The average methanol extractable percentages were 44% (DBP) and 63% (DEHP) for S2. The extractable percentages by methanol increased linearly with increasing $\log K_{OW}$ for phthalates. However, methanol–water (1:1) could extract more than 80% of all test compounds in soil and the extractable percentages were independent of their $\log K_{OW}$. Correlation analysis was also made between the bioassay and the nonexhaustive chemical extraction, and the results are shown in Fig. 2. The methanol-extractable concentrations of DBP and DEHP were closely correlated with their concentrations in earthworms (DBP: $r=0.949$; DEHP: $r=0.938$). The correlation coefficients between methanol–water (1:1)-extractable concentrations of DBP and DEHP and their concentrations in earthworms were 0.946 and 0.890, respectively. The correlation coefficients did not differ from those between total soil concentrations and concentrations in earthworms (Table 3).

3.4. The effect of aging on the extractability and bioavailability of phthalates in soil

The aging effect often refers to the phenomenon that with increased residence time the extractability and bioavailability of organic compounds in soil decrease (Sijm et al., 2000; Alexander, 2000). Therefore, to properly understand the chemical behavior and bioavailability of organic compounds in soil, the aging effect must be considered.

The data in Table 4 represent the percentage recoveries of the amounts initially added. With increasing age of soil, the concentration of DBP in earthworms decreased to 82% of the steady state concentration in earthworms exposed to unaged soil after 100-day incubation and 68% after 440-day incubation, while for DEHP it decreased to 83% and 61% for 100 and 440-day incubation, respectively. However, the recoveries of DBP and DEHP by Soxhlet extraction appeared to decline only slightly with prolonged aging time, but the small decreases were statistically insignificant ($P>0.05$), which indicated that the Soxhlet extraction was not suitable for assessing the bioavailability of aged phthalates in soil. The percentage of phthalates

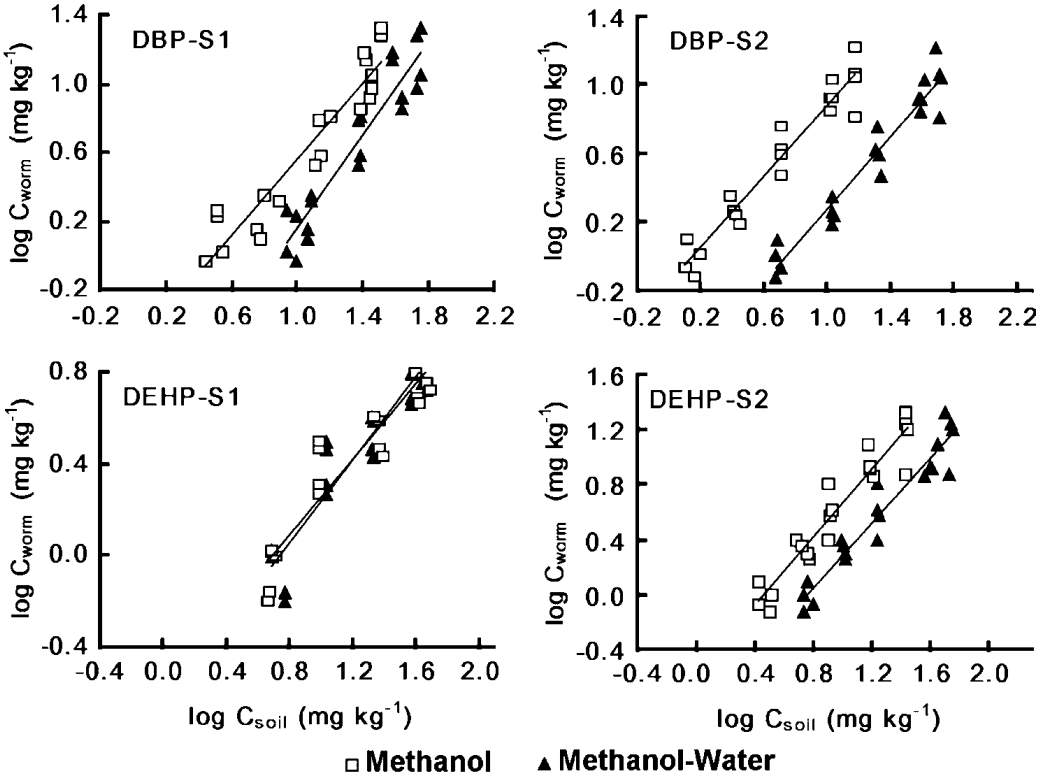


Fig. 2. Relationship between the concentrations of DBP and DEHP in earthworms exposed to the spike S1 and S2 and that extracted with mild chemical extractions.

Table 4
Influence of aging time of DBP and DEHP in S1 on their extractability and availability to earthworms

Compounds	Aging time (day)	Extracted by various methods (%)			Assimilated by worms (%)
		Soxhlet	Methanol–water	Methanol	
DBP	15	101.9A[a]	102.4A	61.1A	30.2 A
	100	99.0A	100.7A	50.2B	24.7B
	440	95.2A	94.7B	41.3C	20.4C
DEHP	15	102.0A	101.9A	95.2A	13.5A
	100	100.7A	98.8A	79.5B	11.3B
	440	100.9A	92.2B	57.9C	8.2C

[a]Values in the columns for the same compound followed by the same letter are not statistically different ($P>0.05$).

extracted by methanol–water (1:1) after 100-day incubation did not change significantly ($P>0.05$). However, after 440-day incubation, the extractability decreased obviously ($P<0.05$). Simultaneously, with increasing aging time, the extractable DBP by the methanol extraction method decreased to 82% and 68% after 100- and 440-day incubation, while the extractable DEHP decreased to 83% and 61%, respectively. These decline rates were consistent with those of earthworm assimilation. Our results revealed that the Soxhlet and methanol–water (1:1) extractions would lead to overestimation of the risk of aged DBP and DEHP in soils. Methanol extraction was the best predictor for approximating the bioavailability of phthalates to earthworms.

4. Conclusions

Among the five phthalates studied, only DBP and DEHP were detected in earthworms. DBP and DEHP had high BSAFs, which indicated that these compounds were more easily available to earthworms. Therefore, DBP and DEHP could be accumulated more readily through the food chain and pose greater threats to ecosystems and human health. Soil concentrations of DBP and DEHP had no significant effects on their corresponding BSAFs. Based on the statistical analysis, the uptake kinetics of phthalates in lab-contaminated soil by earthworms could be well described by the equilibrium partitioning model. With increased aging time, the extractability and bioavailability of phthalates decreased. Compared with the Soxhlet and the methanol–water (1:1) extraction methods, the methanol extraction method was preferred for its ability to predict the bioavailability of DBP and DEHP in soils. Nevertheless, the data represent merely the results of a feasibility study since there were only two soils, two compounds, and one species of test organism. More soils and organisms with different characteristics will be included in our future work.

Acknowledgments

This work was supported by the Chinese Academy of Sciences under Grant KZCX2-414 and the National Natural Science Foundation of China (Grants: 20377048 and 20237010).

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Attachment 3

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November 18, 2008

Office of Environmental Measurement and Evaluation
US EPA - Region I
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North Chelmsford, Massachusetts 01863

To: Mr. Bart Hoskins, EPA TOPO
Via: Mr. Louis Macri, ESAT Program Manager

TDF No. 1216
Task Order No. 26
Task No. 01

Subject: *Close-Out Letter for Calculating Effect-Based Ecological Soil Screening Levels for Fort Devens, Ayers, MA.*

Dear Mr. Hoskins:

Please find enclosed Excel tables providing effect-based Ecological Soil Screening Levels (EcoSSLs) for bird and mammal wildlife receptors. The EcoSSLs were calculated by a two-step process as described in the Technical Directive Form (TDF) and summarized below:

Step 1:

The first step started with downloading the latest version of the EcoSSLs from http://www.epa.gov/ecotox/ecossl, resulting in reports for 16 metals, three pesticides, and Polycyclic Aromatic Hydrocarbons (PAHs) (specifically, low molecular weight [LMW] PAHs and high molecular weight [HMW] PAHs).

No observed Adverse Effect Level (NOAEL) Toxicity Reference Values (TRVs) and Lowest Observed Adverse Effect Level (LOAEL) TRVs for reproduction, growth and survival were obtained from Table 5.1 (Avian Toxicity Data Extracted for Wildlife TRV) and Table 6.1 (Mammalian Toxicity Data Extracted for Wildlife TRV) from each report.

ESAT compiled the toxicity data following the example spreadsheet for zinc prepared by the Task Order Project Officer (TOPO). The zinc spreadsheet, and those developed by ESAT for the other target chemicals, provided separate sets of data columns for NOAEL TRVs and LOAEL TRVs which were either unbounded (i.e, derived from a study providing either a no effect or an effect value, but not both), or bounded (i.e., derived from a study providing both no effect and effect values), or a compilation of both unbounded and/or bounded values. The latter were referred to as "combined TRVs". The EcoSSL reports used only the combined values to derive the original EcoSSLs. Note, however, that the combined TRVs did not always represent a dataset of both unbounded and bounded values. Only unbounded TRVs were available for several combinations of receptors and chemicals. Following the example of the EcoSSL reports, ESAT presented the unbounded TRVs in the combined TRV column for those cases.

The reproduction and growth toxicity data were used to calculate a chemical-specific geometric mean TRV for the six data columns represented by the three sets of toxicity values (i.e., unbounded TRVs, bounded TRVs, and/or combined TRVs) and the two toxicity levels (i.e., NOAELs and/or LOAELs). **Appendix 1** summarizes the toxicity information for each chemical evaluated in this project. An internal quality control check was performed by comparing the geometric mean NOAEL TRVs for the combined toxicity data provided in the EcoSSL reports with the geometric mean NOAEL TRVs for the combined toxicity data calculated for this project (**Appendix 1**). No significant differences were found between these two data sets, indicating error-free data entry.

Step 2:

The second step used a simple Food Chain Model (FCM) to "back-calculate" chemical-specific NOAEL-based and LOAEL-based EcoSSLs for birds and mammals. The six wildlife receptors used by EPA to calculate the original EcoSSLs were retained for this project. The species consisted of two herbivores (the mourning dove and meadow vole), two soil invertivores (the American woodcock and the short-tailed shrew) and two higher trophic-level carnivores (the red-tailed hawk and the long-tailed weasel).

The FCM and the receptor-specific exposure parameters used to calculate the new NOAEL and LOAEL EcoSSLs were identical to those presented in the original EcoSSL reports, namely:

$$\text{Soil conc. (mg/kg)} = \frac{\text{TRV}}{(\text{FIR} * P_{soil}) + (\text{FIR} * P_{food} * \text{BAF}) * \text{AUF}}$$

where: TRV (mg/kg.d) = NOAEL or LOAEL toxicity reference values for birds or mammals
FIR (kg/kg.d) = food ingestion rate (receptor-specific)
P_{soil} (unitless) = fraction of the FIR consisting of soil (receptor-specific)
P_{food} (unitless) = fraction of the FIR consisting of food (receptor-specific)
BAF (unitless) = bioaccumulation factor (chemical-specific)
AUF (unitless) = area use factor (assumed equal to 1.0)

Note that the original EcoSSLs were derived using only NOAEL TRVs. The only difference with the work summarized in this close-out letter was that the new EcoSSLs were calculated using both the NOAEL TRVs and the LOAEL TRVs developed in Step 1. The outcome of the calculations was summarized in **Attachments 1 to 3** for the three bird receptors, and **Attachments 4 to 6** for the three mammal receptors.

Several observations follow:

- Bird toxicity data were not available for antimony, barium, beryllium, chromium VI, LMW PAHs, and HMW PAHs.
- With a few exceptions, the two soil invertivores had the lowest (= most-conservative) LOAEL EcoSSLs.
- The fraction of soil ingested during feeding was added to the full FIR, resulting in conservative NOAEL and LOAEL EcoSSLs.

Attachment 7 provides the species-specific LOAEL EcoSSLs (based on combined TRVs) calculated for this project. The lowest chemical-specific value for birds and mammals is bolded and was selected as the final "bird" and "mammal" LOAEL EcoSSL as shown in **Attachment 8**.

The precision of the FCM was double-checked by comparing the original NOAEL EcoSSLs (based on combined TRVs) developed by EPA against the re-calculated NOAEL EcoSSLs (also based on

combined TRVs) developed for this project. **Attachment 8** shows that the re-calculations performed by ESAT were accurate within rounding error.

A second internal quality control spot check was performed by dividing the LOAEL combined TRV by the NOAEL combined TRV for a chemical and multiplying the result by the original EcoSSL developed by EPA. This simple calculation produced the new LOAEL EcoSSLs. The reason behind this symmetry was that the FCM was identical for each combination of wildlife receptor and chemical, except for using a different TRV (i.e., a NOAEL TRV vs. a LOAEL TRV). This check also indicated that the LOAEL EcoSSLs presented in **Attachments 7 and 8** were accurate, within rounding error.

A discrepancy was found in the calculations for the LMW PAH NOAEL EcoSSL for the long-tailed weasel. The NOAEL EcoSSL calculated for this project equaled 11,735 mg/kg (see shaded value in **Attachment 6**), whereas the original NOAEL EcoSSL developed by EPA equaled 1,200 mg/kg. This difference was puzzling considering that the receptor-specific FCM developed by ESAT re-calculated the correct NOAEL Eco SSLs for all of the other chemicals. It is noted that the original EcoSSL is roughly one order of magnitude lower (within rounding error) of the re-calculated value and may therefore represent a typographical error (i.e., 1,200 instead of 12,000)

The task was requested by Mr. Hoskins, the TOPO, under TDF No. 1216. The completion date is November 18, 2008.

Do not hesitate to contact me at (617) 918-8669 at the EPA/OEME Biology Section, North Chelmsford, MA should you have any questions or comments.

Sincerely,

Stan Pauwels
Senior Staff Scientist
TechLaw, Inc.

ATTACHMENTS

Attachment 1: Mourning Dove (Avian herbivore)
NOAEL and LOAEL-Based ECO-SSLs

Chemicals	TRVs mg dw/kg bw-day						Dose Diet					Soil Concentration (mg/kg)					
	NOAEL			LOAEL			FIR					NOAEL-Based			LOAEL-Based		
	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined	kg dw/kg bw-day	P_{soil}	P_{seeds}	BAF	AUF	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined
Metals																	
Antimony	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	2.24	--	2.24	4.51	--	4.51	0.19	0.139	1	3.75E-02	1	67	--	67	134	--	134
Barium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Beryllium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cadmium	1.66	1.32	1.47	6.68	5.88	6.35	0.19	0.139	1	1.37E-01	1	32	25	28	127	112	121
Chromium III	2.38	4.63	2.66	16.9	14.5	15.6	0.19	0.139	1	4.10E-02	1	70	135	78	493	423	457
Chromium VI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cobalt	25.2	5.64	7.61	19.6	16.9	20.2	0.19	0.139	1	7.50E-03	1	905	203	273	704	607	724
Copper	17.5	19.6	4.05	33.5	35.5	34.9	0.19	0.139	1	1.41E-01	1	330	368	76	630	668	655
Lead	18.9	7.33	1.63	46.3	42.7	44.6	0.19	0.139	1	4.70E-02	1	535	207	46	1310	1208	1263
Manganese	170	257	179	--	377	377	0.19	0.139	1	7.90E-02	1	4105	6201	4322	--	9091	9091
Nickel	7.88	14.6	6.71	8.16	21.0	18.6	0.19	0.139	1	2.92E-02	1	247	456	210	255	658	581
Selenium	0.62	0.59	0.29	0.59	1.39	0.82	0.19	0.139	1	5.50E-01	1	4.7	4.5	2.2	4.5	11	6.3
Silver	--	--	2.02	60.5	--	60.5	0.19	0.139	1	1.40E-02	1	--	--	69	2080	--	2080
Vanadium	1.73	0.94	0.34	1.61	1.89	1.70	0.19	0.139	1	4.85E-03	1	63	35	13	59	69	62
Zinc	39.8	89.2	66.1	192	154	171	0.19	0.139	1	2.27E-01	1	572	1282	950	2766	2213	2464
Pesticides																	
DDT	7.07	1.37	0.23	2.14	5.32	2.70	0.19	0.139	1	5.06E-02	1	196	38	6.3	59	148	75
Dieldrin	1.21	0.51	0.07	0.45	1.51	0.80	0.19	0.139	1	4.10E-01	1	12	4.9	0.68	4.3	14	7.7
Pentachlorophenol	--	16.6	6.73	22.5	79.1	52.0	0.19	0.139	1	5.93E+00	1	--	14	5.8	20	69	45
PAHs																	
LMW-PAHs	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HMW-PAHs	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

-- - No information was available to calculate an Eco-SSL

mg dw/kg bw-day - milligrams (dry weight) per kilogram body weight per day

mg/kg - milligrams per kilograms

NOAEL - No Observed Adverse Effect Level

LOAEL - Lowest Observed Effect Level

TRVs - Toxicity Reference Values

FIR - Food Ingestion Rate

Px - Portion of Diet

BAF - Bioaccumulation Factor

AUF - Area Use Factor

Soil Concentration = $TRV/(((FIR*P_{soil})+(FIR*P_x*BAF))*AUF)$

Attachment 2: American Woodcock (Avian Soil Invertivore)
NOAEL and LOAEL-Based ECO-SSLs

Chemicals	TRVs mg dw/kg bw-day						Dose					Soil Concentration (mg/kg)					
	NOAEL			LOAEL			Diet					NOAEL-Based			LOAEL-Based		
	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined	FIR kg dw/kg bw-day	P_{soil}	P_{worms}	BAF	AUF	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined
Metals																	
Antimony	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	2.24	--	2.24	4.51	--	4.51	0.214	0.164	1	7.94E-02	1	43	--	43	94	--	94
Barium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Beryllium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cadmium	1.66	1.32	1.47	6.68	5.88	6.35	0.214	0.164	1	8.80E+00	1	0.87	0.69	0.77	4.52	3.98	4.29
Chromium III	2.38	4.63	2.66	16.9	14.5	15.6	0.214	0.164	1	3.06E-01	1	24	46	26	198	170	183
Chromium VI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cobalt	25.2	5.64	7.61	19.6	16.9	20.2	0.214	0.164	1	1.22E-01	1	412	92	124	356	306	366
Copper	17.5	19.6	4.05	33.5	35.5	34.9	0.214	0.164	1	5.15E-01	1	121	135	28	280	297	292
Lead	18.9	7.33	1.63	46.3	42.7	44.6	0.214	0.164	1	5.29E-01	1	128	49	11	380	351	366
Manganese	170	257	179	--	377	377	0.214	0.164	1	3.05E-02	1	4084	6170	4300	--	9390	9390
Nickel	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Selenium	0.62	0.59	0.29	0.59	1.39	0.82	0.214	0.164	1	9.65E-01	1	2.6	2.5	1.2	3.1	7.2	4.2
Silver	--	--	2.02	60.5	--	60.5	0.214	0.164	1	2.05E+00	1	--	--	4.3	163	--	163
Vanadium	1.73	0.94	0.34	1.61	1.89	1.70	0.214	0.164	1	4.20E-02	1	39	21	7.8	38	45	40
Zinc	39.8	89.2	66.1	192	154	171	0.214	0.164	1	6.55E+00	1	28	62	46	173	139	155
Pesticides																	
DDT	7.07	1.37	0.23	2.14	5.32	2.70	0.214	0.164	1	1.12E+01	1	2.9	0.56	0.09	1.1	2.8	1.4
Dieldrin	1.21	0.51	0.07	0.45	1.51	0.80	0.214	0.164	1	1.47E+01	1	0.38	0.16	0.02	0.18	0.62	0.33
Pentachlorophenol	--	16.6	6.73	22.5	79.1	52.0	0.209	0.03	1	1.46E+01	1	--	5.4	2.2	51	178	117
PAHs																	
LMW-PAHs	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HMW-PAHs	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

-- - No information was available to calculate an Eco-SSL

mg dw/kg bw-day - milligrams (dry weight) per kilogram body weight per day

mg/kg - milligrams per kilograms

NOAEL - No Observed Adverse Effect Level

LOAEL - Lowest Observed Effect Level

TRVs - Toxicity Reference Values

FIR - Food Ingestion Rate

Px - Portion of Diet

BAF - Bioaccumulation Factor

AUF - Area Use Factor

Soil Concentration = $TRV/(((FIR*P_{soil})+(FIR*P_x*BAF))*AUF)$

Attachment 3: Red-Tailed Hawk (Avian Carnivore)
NOAEL and LOAEL-Based ECO-SSLs

Chemicals	TRVs mg dw/kg bw-day						Dose					Soil Concentration (mg/kg)					
							Diet					NOAEL-Based			LOAEL-Based		
	NOAEL			LOAEL			FIR										
	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined	kg dw/kg bw-day	P_{soil}	$P_{mammals}$	BAF	AUF	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined
Metals																	
Antimony	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	2.24	--	2.24	4.51	--	4.51	0.0353	0.057	1	7.90E-04	1	1098	--	1089	2191	--	2191
Barium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Beryllium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cadmium	1.66	1.32	1.47	6.68	5.88	6.35	0.0353	0.057	1	9.10E-03	1	712	2639	630	2639	2324	2508
Chromium III	2.38	4.63	2.66	16.9	14.5	15.6	0.0353	0.057	1	3.96E-02	1	697	1085	780	3950	3391	3660
Chromium VI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cobalt	25.2	5.64	7.61	19.6	16.9	20.2	0.0353	0.057	1	1.09E-01	1	4300	686	1299	2382	2053	2451
Copper	17.5	19.6	4.05	33.5	35.5	34.9	0.0353	0.057	1	1.50E-02	1	6901	6826	1593	11691	12393	12162
Lead	18.9	7.33	1.63	46.3	42.7	44.6	0.0353	0.057	1	3.39E-02	1	5890	1858	508	11744	10825	11317
Manganese	170	257	179	--	377	377	0.0353	0.057	1	2.05E-02	1	62146	80758	65430	--	118393	118393
Nickel	7.88	14.6	6.71	8.16	21.0	18.6	0.0353	0.057	1	1.12E-02	1	3272	5498	2786	3077	7932	7002
Selenium	0.62	0.59	0.29	0.59	1.39	0.82	0.0353	0.057	1	4.23E-02	1	177	134	83	133	315	185
Silver	--	--	2.02	60.5	--	60.5	0.0353	0.057	1	4.00E-03	1	--	--	938	26994	--	26994
Vanadium	1.73	0.94	0.34	1.61	1.89	1.7	0.0353	0.057	1	1.23E-02	1	708	348	141	594	698	638
Zinc	39.8	89.2	66.1	192	154	171	0.0353	0.057	1	5.70E-03	1	17982	38172	29865	82351	65910	73359
Pesticides																	
DDT	7.07	1.37	0.23	2.14	5.32	2.70	0.0353	0.057	1	4.83E+00	1	41	4.9	0.12	7.7	19	10
Dieldrin	1.21	0.51	0.07	0.45	1.51	0.80	0.0353	0.057	1	1.20E+00	1	27	7.3	0.11	6.4	21	11
Pentachlorophenol	--	16.6	6.73	22.5	79.1	52.0	0.12	0.05	1	-1.26E-02	1	--	3090	1500	4190	14725	9685
PAHs																	
LMW-PAHs	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HMW-PAHs	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

-- - No information was available to calculate an Eco-SSL

mg dw/kg bw-day - milligrams (dry weight) per kilogram body weight per day

mg/kg - milligrams per kilograms

NOAEL - No Observed Adverse Effect Level

LOAEL - Lowest Observed Effect Level

TRVs - Toxicity Reference Values

FIR - Food Ingestion Rate

Px - Portion of Diet

BAF - Bioaccumulation Factor

AUF - Area Use Factor

Soil Concentration = $TRV/(((FIR*P_{soil})+(FIR*P_x*BAF))*AUF)$

Attachment 4: Meadow Vole (Mammalian Herbivore)
NOAEL and LOAEL-Based ECO-SSLs

Chemicals	TRVs mg dw/kg bw-day						Dose Diet					Soil Concentration mg/kg					
	NOAEL			LOAEL			FIR					NOAEL-Based			LOAEL-Based		
	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined	kg dw/kg bw-day	P_{soil}	P_{plants}	BAF	AUF	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined
Metals																	
Antimony	30.80	3.27	0.059	0.20	15.9	2.76	0.0875	0.032	1	3.50E-02	1	5254	558	10	34	2712	471
Arsenic	1.74	4.48	1.04	2.78	10.0	4.55	0.0875	0.032	1	3.75E-02	1	286	736	171	457	1646	748
Barium	21.8	123	51.8	0.74	269	82.7	0.0875	0.032	1	1.56E-01	1	1324	7483	3149	45	16334	5024
Beryllium	0.95	--	0.53	0.67	--	0.67	0.0875	0.032	1	2.58E-01	1	38	--	21	27	--	27
Cadmium	1.94	1.75	0.77	5.63	8.72	6.87	0.0875	0.032	1	8.85E-02	1	184	166	73	534	827	651
Chromium III	2.40	--	2.40	58.2	--	58.2	0.0875	0.032	1	4.10E-02	1	376	--	376	9107	--	9107
Chromium VI	2.64	28.8	9.24	28.7	55.4	38.4	0.0875	0.032	1	4.10E-02	1	414	4515	1447	4500	8677	6007
Cobalt	7.05	8.03	7.33	18.8	19.3	18.9	0.0875	0.032	1	7.50E-03	1	2040	2323	2121	5437	5585	5469
Copper	15.1	120	5.60	24.3	155	82.7	0.0875	0.032	1	2.62E-02	1	2974	23515	1100	4775	30424	16244
Lead	46.0	34.9	4.70	216	137	186	0.0875	0.032	1	1.28E-02	1	11744	8920	1200	55091	34908	47594
Manganese	44.9	76.3	51.4	68.5	212	146	0.0875	0.032	1	7.90E-02	1	4623	7858	5297	7056	21867	14999
Nickel	6.37	9.98	1.70	4.55	33.2	14.8	0.0875	0.032	1	2.51E-02	1	1275	1996	340	911	6637	2955
Selenium	0.48	0.40	0.14	0.55	0.84	0.66	0.0875	0.032	1	5.73E-01	1	9	8	2.7	10	16	12
Silver	--	--	6.02	119	--	119	0.0875	0.032	1	1.40E-02	1	--	--	1496	29471	--	29471
Vanadium	10.1	1.06	4.16	10.1	7.67	9.44	0.0875	0.032	1	4.85E-03	1	3144	329	1290	3135	2380	2926
Zinc	65.6	146	75.4	137	895	298	0.0875	0.032	1	9.47E-02	1	5914	13176	6798	12341	80673	26837
Pesticides																	
DDT	9.15	4.47	0.15	2.91	14.4	5.56	0.0875	0.032	1	3.80E-02	1	1494	730	24	475	2351	908
Dieldrin	1.42	0.67	0.02	0.99	1.74	1.27	0.0875	0.032	1	4.10E-01	1	37	17	0.39	25	45	33
Pentachlorophenol	13.5	5.45	8.43	23.7	22.0	22.7	0.0875	0.032	1	5.93E+00	1	26	10	16	45	42	43
PAHs																	
LMW-PAHs	184	153	65.6	248	435	356	0.0875	0.032	1	2.09E+00	1	989	824	353	1338	2341	1917
HMW-PAHs	32.6	13.8	0.62	33.7	40.7	38.4	0.0875	0.032	1	1.48E-01	1	2067	874	39	2140	2579	2435

-- - No information was available to calculate an Eco-SSL

mg dw/kg bw-day - milligrams (dry weight) per kilogram body weight per day

mg/kg - milligrams per kilograms

NOAEL - No Observed Adverse Effect Level

LOAEL - Lowest Observed Effect Level

TRVs - Toxicity Reference Values

FIR - Food Ingestion Rate

Px - Portion of Diet

BAF - Bioaccumulation Factor

AUF - Area Use Factor

Soil Concentration = $TRV/(((FIR*P_{soil})+(FIR*P_x*BAF))*AUF)$

Attachment 5: Short-Tailed Shrew (Mammalian Soil Invertivore)
NOAEL and LOAEL-Based ECO-SSLs

Chemicals	TRVs mg dw/kg bw-day						Dose Diet					Soil Concentration (mg/kg)					
	NOAEL			LOAEL			FIR					NOAEL-Based			LOAEL-Based		
	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined	kg dw/kg bw-day	P_{soil}	P_{worms}	BAF	AUF	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined
Metals																	
Antimony	30.80	3.27	0.059	0.20	15.9	2.76	0.209	0.030	1	1.00E+00	1	143	15	0.27	1	74	13
Arsenic	1.74	4.48	1.04	2.78	10.0	4.55	0.209	0.030	1	7.82E-02	1	77	198	46	123	443	201
Barium	21.8	123	51.8	0.74	269	82.7	0.209	0.030	1	9.10E-02	1	862	4867	2048	29	10625	3268
Beryllium	0.95	--	0.53	0.67	--	0.67	0.209	0.030	1	4.50E-02	1	61	--	34	43	--	43
Cadmium	1.94	1.75	0.77	5.63	8.72	6.87	0.209	0.030	1	1.02E+01	1	0.91	0.82	0.36	2.6	4.1	3.2
Chromium III	2.40	--	2.40	58.2	--	58.2	0.209	0.030	1	3.06E-01	1	34	--	34	828	--	828
Chromium VI	2.64	28.8	9.24	28.7	55.4	38.4	0.209	0.030	1	3.06E-01	1	38	411	132	409	789	546
Cobalt	7.05	8.03	7.33	18.8	19.3	18.9	0.209	0.030	1	1.22E-01	1	222	253	231	592	608	595
Copper	15.1	120	5.60	24.3	155	82.7	0.209	0.030	1	5.15E-01	1	133	1051	49	213	1360	726
Lead	46.0	34.9	4.70	216	137	186	0.209	0.030	1	3.72E-01	1	548	416	56	2571	1629	2221
Manganese	44.9	76.3	51.4	68.5	212	146	0.209	0.030	1	3.16E-02	1	3488	5928	3996	5323	16496	11315
Nickel	6.37	9.98	1.70	4.55	33.2	14.8	0.209	0.030	1	--	1	--	--	--	--	--	--
Selenium	0.48	0.40	0.14	0.55	0.84	0.66	0.209	0.030	1	1.06E+00	1	2.09	1.78	0.63	2.44	3.71	2.91
Silver	--	--	6.02	119	--	119	0.209	0.030	1	2.05E+00	1	--	--	14	274	--	274
Vanadium	10.1	1.06	4.16	10.1	7.67	9.44	0.209	0.030	1	4.20E-02	1	674	71	276	672	510	627
Zinc	65.6	146	75.4	137	895	298	0.209	0.030	1	4.54E+00	1	69	153	79	143	937	312
Pesticides																	
DDT	9.15	4.47	0.15	2.91	14.4	5.56	0.209	0.030	1	1.12E+01	1	3.9	1.9	0.06	1.2	6.1	2.4
Dieldrin	1.42	0.67	0.02	0.99	1.74	1.27	0.209	0.030	1	1.47E+01	1	0.46	0.22	0.0049	0.32	0.57	0.41
Pentachlorophenol	13.5	5.45	8.43	23.7	22.0	22.7	0.209	0.030	1	1.46E+01	1	4.4	1.8	2.8	7.7	7.2	7.4
PAHs																	
LMW-PAHs	184	153	65.6	248	435	356	0.209	0.030	1	3.04E+00	1	286	238	102	387	677	555
HMW-PAHs	32.6	13.8	0.62	33.7	40.7	38.4	0.209	0.030	1	2.60E+00	1	59	25	1.1	61	74	70

-- - No information was available to calculate an Eco-SSL

mg dw/kg bw-day - milligrams (dry weight) per kilogram body weight per day

mg/kg - milligrams per kilograms

NOAEL - No Observed Adverse Effect Level

LOAEL - Lowest Observed Effect Level

TRVs - Toxicity Reference Values

FIR - Food Ingestion Rate

Px - Portion of Diet

BAF - Bioaccumulation Factor

AUF - Area Use Factor

Soil Concentration = $TRV/(((FIR*P_{soil})+(FIR*P_x*BAF))*AUF)$

Attachment 6: Long-Tailed Weasel (Mammalian Carnivore)
NOAEL and LOAEL-Based ECO-SSLs

Chemicals	TRVs mg dw/kg bw-day						Dose Diet					Soil Concentration (mg/kg)					
	NOAEL			LOAEL			FIR					NOAEL-Based			LOAEL-Based		
	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined	kg dw/kg bw-day	P_{soil}	$P_{mammals}$	BAF	AUF	Unbounded	Bounded	Combined	Unbounded	Bounded	Combined
Metals																	
Antimony	30.80	3.27	0.059	0.20	15.9	2.76	0.13	0.043	1	5.00E-02	1	2548	270	4.9	17	1315	228
Arsenic	1.74	4.48	1.04	2.78	10.0	4.55	0.13	0.043	1	4.05E-03	1	284	732	170	454	1637	744
Barium	21.8	123	51.8	0.74	269	82.7	0.13	0.043	1	6.83E-04	1	3637	21676	9122	130	47316	14555
Beryllium	0.95	--	0.53	0.67	--	0.67	0.13	0.043	1	2.25E-03	1	162	--	90	114	--	114
Cadmium	1.94	1.75	0.77	5.63	8.72	6.87	0.13	0.043	1	2.75E-02	1	212	190	84	614	951	749
Chromium III	2.40	--	2.40	58.2	--	58.2	0.13	0.043	1	5.96E-02	1	180	--	180	4363	--	4363
Chromium VI	2.64	28.8	9.24	28.7	55.4	38.4	0.13	0.043	1	3.87E-02	1	249	2716	870	2707	5219	3613
Cobalt	7.05	8.03	7.33	18.8	19.3	18.9	0.13	0.043	1	7.70E-02	1	452	515	470	1205	1238	1212
Copper	15.1	120	5.60	24.3	155	82.7	0.13	0.043	1	3.39E-02	1	1514	11972	560	2431	15489	8270
Lead	46.0	34.9	4.70	216	137	186	0.13	0.043	1	3.56E-02	1	4502	3419	460	21119	13382	18245
Manganese	44.9	76.3	51.4	68.5	212	146	0.13	0.043	1	2.05E-02	1	5439	9245	6232	8302	25728	17647
Nickel	6.37	9.98	1.70	4.55	33.2	14.8	0.13	0.043	1	5.76E-02	1	487	763	130	348	2537	1130
Selenium	0.48	0.40	0.14	0.55	0.84	0.66	0.13	0.043	1	3.47E-01	1	9.4	8.0	2.8	11	17	13
Silver	--	--	6.02	119	--	119	0.13	0.043	1	4.00E-03	1	--	--	985	19414	--	19414
Vanadium	10.1	1.06	4.16	10.1	7.67	9.44	0.13	0.043	1	1.22E-02	1	1413	148	580	1410	1070	1316
Zinc	65.6	146	75.4	137	895	298	0.13	0.043	1	1.50E-02	1	8696	19377	9997	18148	118635	39466
Pesticides																	
DDT	9.15	4.47	0.15	2.91	14.4	5.56	0.13	0.043	1	5.38E+01	1	1.31	0.64	0.02	0.42	2.06	0.79
Dieldrin	1.42	0.67	0.02	0.99	1.74	1.27	0.13	0.043	1	1.77E+01	1	0.62	0.29	0.0065	0.43	0.76	0.55
Pentachlorophenol	13.5	5.45	8.43	23.7	22.0	22.7	0.13	0.057	1	5.28E-02	1	946	382	590	1657	1540	1587
PAHs																	
LMW-PAHs	184	153	65.6	248	435	356	0.13	0.043	1	0	1	32845	27359	11735	44430	77758	63670
HMW-PAHs	32.6	13.8	0.62	33.7	40.7	38.4	0.13	0.043	1	0	1	5832	2466	110	6037	7275	6869

-- - No information was available to calculate an Eco-SSL

mg dw/kg bw-day - milligrams (dry weight) per kilogram body weight per day

mg/kg - milligrams per kilograms

NOAEL - No Observed Adverse Effect Level

LOAEL - Lowest Observed Effect Level

TRVs - Toxicity Reference Values

FIR - Food Ingestion Rate

Px - Portion of Diet

BAF - Bioaccumulation Factor

AUF - Area Use Factor

Soil Concentration = $TRV/(((FIR*P_{soil})+(FIR*P_x*BAF))*AUF)$

Attachment 7: Summary of the Receptor-Specific LOAEL EcoSSLs

	Birds			Mammals		
	Mourning dove	American Woodcock	Red-tailed hawk	Vole	Short-tailed shrew	Long-tailed weasel
Metals						
Antimony	--	--	--	471	**13**	228
Arsenic	134	**94**	2191	748	**201**	744
Barium	--	--	--	5024	**3268**	14555
Beryllium	--	--	--	**27**	43	114
Cadmium	121	**4.29**	2508	651	**3.2**	749
Chromium III	457	**183**	3660	9107	**828**	4363
Chromium VI	--	--	--	6007	**546**	3613
Cobalt	724	**366**	2451	5469	**595**	1212
Copper	655	**292**	12162	16244	**726**	8270
Lead	1263	**366**	11317	47594	**2221**	18245
Manganese	**9091**	9390	118393	14999	**11315**	17647
Nickel	**581**	--	7002	2955	--	**1130**
Selenium	6.3	**4.2**	185	12	**2.91**	13
Silver	2080	**163**	26994	29471	**274**	19414
Vanadium	62	**40**	638	2926	**627**	1316
Zinc	2464	**155**	73359	26837	**312**	39466
Pesticides						
DDT	75	**1.4**	10	908	2.4	**0.79**
dieldrin	7.7	**0.33**	11	33	**0.41**	0.55
Pentachlorophenol	**45**	117	9685	43	**7.4**	1587
PAHs						
LMW PAHs	--	--	--	1917	**555**	63670
HMW PAHs	--	--	--	2435	**70**	6869

note: these LOAEL-based EcoSSLs were calculated using the "combined" toxicity reference values

bolded values indicate the most conservative EcoSSL

Attachment 8: Summary of the Original and Re-Calculated NOAEL and the new LOAEL EcoSSLs

Chemical	NOAEL EcoSSLs (mg/kg)						LOAEL EcoSSLs (mg/kg)	
	Plants	Invertebrates	Birds		Mammals			
	original	original	original	re-calculated	original	re-calculated	Birds	Mammals
Metals								
Antimony	--	78	--	--	0.27	0.27	--	13
Arsenic	18	--	43	43	46	46	94	201
Barium	--	330	--	--	2000	2048	--	3268
Beryllium	--	40	--	--	21	21	--	27
Cadmium	32	140	0.77	0.77	0.36	0.36	4.29	3.2
Chromium III	--	--	26	26	34	34	183	828
Chromium VI	--	--	--	--	130	132	--	546
Cobalt	13	--	120	124	230	231	366	595
Copper	70	80	28	28	49	49	292	726
Lead	120	1700	11	11	56	56	366	2221
Manganese	220	450	4300	4300	4000	3996	9091	11315
Nickel	38	280	210	210	130	130	581	1130
Selenium	0.52	4.1	1.2	1.2	0.63	0.63	4.2	2.91
Silver	560	--	4.2	4.3	14	14	163	274
Vanadium	--	--	7.8	7.8	280	276	40	627
Zinc	160	120	46	46	79	79	155	312
Pesticides								
DDT	--	--	0.093	0.09	0.021	0.02	1.4	0.79
dieldrin	--	--	0.022	0.02	0.0049	0.005	0.33	0.41
Pentachlorophenol	5.0	31	2.1	2.2	2.8	2.8	45	7.4
PAHs								
LMW PAHs	--	29	--	--	100	102	--	555
HMW PAHs	--	18	--	--	1.1	1.1	--	70

APPENDIX 1

Table 1: Calculating LOAEL-based Mammalian TRVs for **Antimony**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			0.0590	0.590	0.0590	0.590
	835				835	
Growth (GRO)	0.533				0.533	
	0.664				0.664	
			5.60	42.0	5.60	42.0
	67.0				67.0	
			106	161	106	161
	1410				1410	
		0.0590				0.0590
		0.678				0.678
Survival (MOR)	46.0				46.0	
	60.9				60.9	
	66.6				66.6	
			108	161	108	161
			557	835	557	835
	673				673	
	826				826	
	1408				1408	
	2440				2440	
		0.533				0.533
Geomean (REP+GRO)	**30.8**	**0.20**	**3.27**	**15.9**	**0.059***	**2.76**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Antimony. Interim Final. OSWER Directive 9285.7-61

Table 2: Calculating LOAEL-based Avian TRVs for **Arsenic**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	2.24				2.24	
Growth (GRO)	2.24				2.24	
		1.49				1.49
		3.55				3.55
		17.3				17.3
Survival (MOR)	2.24				2.24	
	3.55				3.55	
	3.72				3.72	
	17.3				17.3	
Geomean (REP+GRO)	**2.24**	**4.51**			**2.24***	**4.51**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Arsenic. Interim Final. OSWER Directive 9285.7-62

Table 3: Calculating LOAEL-based Mammalian TRVs for **Arsenic**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	0.601				0.601	
			0.750	3.0	0.750	3.0
	7.47				7.47	
			24.0	48.0	24.0	48.0
		0.00650				0.00650
		0.548				0.548
		5.66				5.66
		43.4				43.4
Growth (GRO)	0.0859				0.0859	
	0.447				0.447	
	0.533				0.533	
	0.571				0.571	
	0.913				0.913	
			1.04	1.66	1.04	1.66
	1.39				1.39	
	1.65				1.65	
	1.88				1.88	
			2.25	5.62	2.25	5.62
	2.52				2.52	
			2.84	5.69	2.84	5.69
	3.22				3.22	
	3.78				3.78	
			4.43	9.42	4.43	9.42
	5.52				5.52	
	6.00				6.00	
			6.43	32.4	6.43	32.4
	7.47				7.47	
	7.69				7.69	
			9.40	10.7	9.40	10.7
			9.84	19.7	9.84	19.7
			10.3	20.6	10.3	20.6
		0.663				0.663
		0.665				0.665
		0.844				0.844
		5.00				5.00
		5.0				5.0
		5.0				5.0
		5.0				5.0
		5.00				5.00
		6.36				6.36
		9.44				9.44
		14.4				14.4
		14.4				14.4
Survival (MOR)	0.533				0.533	
			0.750	3.00	0.750	3.00
	1.39				1.39	
	1.65				1.65	
	1.88				1.88	
			2.25	5.62	2.25	5.62
			2.25	5.62	2.25	5.62
			2.25	4.50	2.25	4.50
	3.22				3.22	
			5.0	7.5	5.0	7.5
	5.81				5.81	
	9.63				9.63	
			9.65	19.3	9.65	19.3
			9.99	20.0	9.99	20.0
			24.0	48.0	24.0	48.0
	32.0				32.0	
		0.675				0.675
		14.4				14.4
		14.4				14.4
		43.4				43.4
Geomean (REP+GRO)	**1.74**	**2.78**	**4.48**	**10.0**	**1.04***	**4.55**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value

NOAEL = no observed adverse effect level

LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Arsenic. Interim Final. OSWER Directive 9285.7-62

Table 4: Calculating LOAEL-based Mammalian TRVs for **Barium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	121				121	
			138	198	138	198
			165	499	165	499
Growth (GRO)	0.57				0.57	
	16.5				16.5	
			61.1	121	61.1	121
			165	436	165	436
	198				198	
		0.74				0.74
Survival (MOR)			61.1	121	61.1	121
			137	197	137	197
			165	436	165	436
Geomean (REP+GRO)	**21.8**	**0.7**	**123**	**269**	**51.8**	**82.7**

TRV = toxicity reference value

NOAEL = no observed adverse effect level

LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Barium. Interim Final. OSWER Directive 9285.7-63

Table 5: Calculating LOAEL-based Mammalian TRVs for **Beryllium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Growth (GRO)	0.953				0.953	
		0.630				0.630
		0.718				0.718
Survival (MOR)	0.532				0.532	
Geomean (GRO)	**0.95**	**0.67**			**0.532***	**0.67**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Beryllium. Interim Final. OSWER Directive 9285.7-64

Table 6: Calculating LOAEL-based Avian TRVs for **Cadmium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			0.593	2.37	0.593	2.37
			0.593	2.37	0.593	2.37
			0.799	2.40	0.799	2.40
			1.53	21.1	1.53	21.1
			1.53	21.1	1.53	21.1
	4.20				4.20	
		2.40				2.40
		3.71				3.71
		7.65				7.65
		10.4				10.4
Growth (GRO)	0.125				0.125	
	0.260				0.260	
			0.708	7.08	0.708	7.08
			0.826	3.30	0.826	3.30
	0.858				0.858	
	1.25				1.25	
			1.55	4.66	1.55	4.66
			1.72	3.44	1.72	3.44
			1.72	3.44	1.72	3.44
	4.20				4.20	
	4.24				4.24	
	5.76				5.76	
	6.44				6.44	
			12.5	37.6	12.5	37.6
		1.05				1.05
		4.26				4.26
		4.80				4.80
		4.90				4.90
		5.63				5.63
		9.57				9.57
		9.75				9.75
		12.2				12.2
		12.8				12.8
		13.0				13.0
		13.8				13.8
		14.7				14.7
Survival (MOR)	3.00				3.00	
	4.24				4.24	
	5.78				5.78	
	8.59				8.59	
			9.57	14.3	9.57	14.3
	10.5				10.5	
	13.4				13.4	
	14.2				14.2	
			15.3	30.6	15.3	30.6
	16.9				16.9	
	21.1				21.1	
			22.3	44.6	22.3	44.6
		4.90				4.90
		66.9				66.9
Geomean (REP+ GRO)	**1.66**	**6.68**	**1.32**	**5.88**	**1.47**	**6.35**

TRV = toxicity reference value

NOAEL = no observed adverse effect level

LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Cadmium. Interim Final. OSWER Directive 9285.7-65

Table 7: Calculating LOAEL-based Mammalian TRVs for **Cadmium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	0.0069				0.0069	
			0.0939	15.6	0.0939	15.6
			0.651	4.88	0.651	4.88
	0.890				0.890	
			1.00	10.0	1.00	10.0
			1.00	10.0	1.00	10.0
			1.14	2.28	1.14	2.28
			1.57	4.50	1.57	4.50
	2.53				2.53	
			4.00	40.0	4.00	40.0
	4.00				4.00	
			5.40	54.0	5.40	54.0
			6.00	10.0	6.00	10.0
			6.13	18.4	6.13	18.4
	6.44				6.44	
	7.41				7.41	
	11.4				11.4	
	12.5				12.5	
	13.9				13.9	
	25.0				25.0	
	41.1				41.1	
			50.0	75	50.0	75
	50.0				50.0	
		0.661				0.661
		1.42				1.42
		1.45				1.45
		1.87				1.87
		2.14				2.14
		3.93				3.93
		4.61				4.61
		5.59				5.59
		5.82				5.82
		6.30				6.30
		7.28				7.28
		236				236
Growth (GRO)	0.00690				0.00690	
	0.00792				0.00792	
	0.00884				0.00884	
	0.0187				0.0187	
	0.0584				0.0584	
	0.0793				0.0793	
			0.100	1.0	0.100	1.0
			0.100	1.0	0.100	1.0
	0.179				0.179	
			0.207	1.6	0.207	1.6
			0.268	1.3	0.268	1.3
	0.323				0.323	
			0.400	4.0	0.400	4.0
			0.448	0.909	0.448	0.909
	0.478				0.478	
	0.579				0.579	
			0.581	1.2	0.581	1.2
	0.593				0.593	
			0.645	1.6	0.645	1.6
			0.770	7.70	0.770	7.70
	0.890				0.890	
	0.890				0.890	
			1.00	10.0	1.00	10.0
			1.04	5.2	1.04	5.2

Table 7: Calculating LOAEL-based Mammalian TRVs for **Cadmium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
			1.08	10.8	1.08	10.8
	1.36				1.36	
	1.78				1.78	
			1.84	6.13	1.84	6.13
	1.85				1.85	
	2.22				2.22	
	2.53				2.53	
			2.65	10.6	2.65	10.6
	2.78				2.78	
			3.00	10.0	3.00	10.0
			3.08	15.4	3.08	15.4
	3.73				3.73	
			4.05	12.1	4.05	12.1
			4.36	8.71	4.36	8.71
			4.44	44.4	4.44	44.4
	4.97				4.97	
	4.99				4.99	
			5.40	54.0	5.40	54.0
	5.54				5.54	
			6.06	15.2	6.06	15.2
	7.23				7.23	
	7.38				7.38	
	8.53				8.53	
			8.54	17.1	8.54	17.1
	8.61				8.61	
	10.5				10.5	
	11.8				11.8	
	12.5				12.5	
	12.5				12.5	
	12.6				12.6	
	16.9				16.9	
	21.3				21.3	
	31.3				31.3	
			43.0	85.9	43.0	85.9
			50.0	100	50.0	100
		0.0744				0.0744
		0.143				0.143
		1.00				1.00
		1.97				1.97
		3.01				3.01
		3.21				3.21
		3.43				3.43
		3.88				3.88
		4.06				4.06
		4.58				4.58
		5.08				5.08
		5.18				5.18
		5.44				5.44
		5.74				5.74
		5.82				5.82
		6.13				6.13
		6.89				6.89
		9.54				9.54
		9.70				9.70
		10.0				10.0
		10.4				10.4
		13.2				13.2
		14.7				14.7
		16.8				16.8

Table 7: Calculating LOAEL-based Mammalian TRVs for **Cadmium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
		20.7				20.7
		75.8				75.8
		103				103
		571				571
Survival (MOR)	0.00690				0.00690	
	1.36				1.36	
			1.87	4.99	1.87	4.99
	2.22				2.22	
	2.53				2.53	
	2.61				2.61	
			4.00	40.0	4.00	40.0
	4.00				4.00	
	6.61				6.61	
	10.0				10.0	
	10.0				10.0	
	12.5				12.5	
	21.3				21.3	
	41.1				41.1	
	67.3				67.3	
	103				103	
			571	2160	571	2160
		0.551				0.551
		0.620				0.620
		5.74				**5.74**
Geomean (REP+GRO)	**1.94**	**5.63**	**1.75**	**8.72**	**0.770***	**6.87**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value

NOAEL = no observed adverse effect level

LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Cadmium. Interim Final. OSWER Directive 9285.7-65

Table 8: Calculating LOAEL-based Avian TRVs for **Trivalent Chromium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	0.238				0.238	
	0.483				0.483	
	0.494				0.494	
			0.569	2.78	0.569	2.78
	0.744				0.744	
	0.988				0.988	
			37.7	75.4	37.7	75.4
Growth (GRO)	0.483				0.483	
	1.45				1.45	
	6.42				6.42	
	85.9				85.9	
	359				359	
		9.91				9.91
		28.7				28.7
Survival (MOR)	0.0248				0.0248	
			0.557	2.78	0.557	2.78
	85.9				85.9	
	359				359	
Geomean (REP+GRO)	**2.38**	**16.9**	**4.63**	**14.5**	**2.66**	**15.6**

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Chromium. Interim Final. OSWER Directive 9285.7-66

Table 9: Calculating LOAEL-based Mammalian TRVs for **Trivalent Chromium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)						
		9.62				9.62
		36.2				36.2
		91.1				91.1
		228				228
Growth (GRO)	0.00663				0.00663	
	0.00933				0.00933	
	0.537				0.537	
	0.595				0.595	
	0.927				0.927	
	8.09				8.09	
	44.6				44.6	
	228				228	
	1770				1770	
		92.1				92.1
Survival (MOR)	10.0				10.0	
		2.82				2.82
Geomean (REP+GRO)	**2.40**	**58.17**	**--**	**--**	**2.40**	**58.17**

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Chromium. Interim Final. OSWER Directive 9285.7-66

Table 10: Calculating LOAEL-based Mammalian TRVs for **Hexavalent Chromium**

Biological Endpoint	Unbounded		Bounded Values		All Values	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	0.0322				0.0322	
	0.146				0.146	
	8.48				8.48	
			20.0	40.0	20.0	40.0
	30.3				30.3	
	32.5				32.5	
			44.2	82.9	44.2	82.9
			49.4	98.7	49.4	98.7
		10.8				10.8
		26.8				26.8
		33.2				33.2
		33.7				33.7
		35.1				35.1
		38.7				38.7
		40.5				40.5
		43.7				43.7
		98.7				98.7
		246				246
Growth (GRO)	0.0322				0.0322	
	0.146				0.146	
			5.66	12.0	5.66	12.0
	8.48				8.48	
			13.8	28.0	13.8	28.0
			20.0	40.0	20.0	40.0
			33.2	60.6	33.2	60.6
			33.7	67.4	33.7	67.4
			40.5	82.8	40.5	82.8
	43.2				43.2	
			44.2	82.9	44.2	82.9
			84.0	123	84.0	123
	246				246	
		0.730				0.730
		7.20				7.20
		26.8				26.8
		98.7				98.7
Survival (MOR)	8.48				8.48	
	10.0				10.0	
	30.3				30.3	
	32.5				32.5	
	25.0				25.0	
	25.4				25.4	
			33.2	60.6	33.2	60.6
	63.7				63.7	
			82.1	121	82.1	121
	131				131	
	163				163	
Geomean (REP+GRO)	**2.64**	**28.74**	**28.84**	**55.43**	**9.24**	**38.37**

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.2 in Ecological Soil Screening Levels for Chromium. Interim Final. OSWER Directive 9285.7-66

Table 11: Calculating LOAEL-based Avian TRVs for **Cobalt**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Growth (GRO)			3.89	7.80	3.89	7.80
			4.10	8.20	4.10	8.20
			4.29	8.59	4.29	8.59
			14.8	148	14.8	148
	25.2				25.2	
		17.0				17.0
		12.0				12.0
		21.5				21.5
		22.3				22.3
		29.5				29.5
Survival (MOR)	4.59				4.59	
			5.74	11.5	5.74	11.5
			12.3	26.7	12.3	26.7
	17.0				17.0	
	15.0				15.0	
	22.0				22.0	
		38.0				38.0
Geomean (GRO)	**25.20**	**19.59**	**5.64**	**16.89**	**7.61**	**20.16**

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Cobalt. Interim Final. OSWER Directive 9285.7-67

Table 12: Calculating LOAEL-based Mammalian TRVs for **Cobalt**

Biological Endpoint	Unbounded TRV		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			5.00	20.0	5.00	20.0
			5.45	10.9	5.45	10.9
	24.9				24.9	
	81.7				81.7	
		10.0				10.0
		13.7				13.7
		20.0				20.0
		24.2				24.2
		43.4				43.4
		55.9				55.9
Growth (GRO)	0.300				0.300	
	1.47				1.47	
	2.41				2.41	
			19.0	33.0	19.0	33.0
	20.0				20.0	
	20.0				20.0	
		0.963				0.963
		6.23				6.23
		20.2				20.2
		43.4				43.4
		122				122
Survival (MOR)	19.3				19.3	
	81.7				81.7	
		20.0				20.0
Geomean (REP+GRO)	**7.05**	**18.79**	**8.03**	**19.30**	**7.33**	**18.90**

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Cobalt. Interim Final. OSWER Directive 9285.7-67

Table 13: Calculating LOAEL-based Avian TRVs for **Copper**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			4.05	12.1	4.05	12.1
			13.9	19.5	13.9	19.5
			15.6	23.3	15.6	23.3
			16.7	34.0	16.7	34.0
			17.0	25.5	17.0	25.5
			18.0	28.0	18.0	28.0
			19.4	29.0	19.4	29.0
			20.5	30.7	20.5	30.7
	21.6				21.6	
			22.4	44.8	22.4	44.8
			22.5	45.0	22.5	45.0
			23.2	29.9	23.2	29.9
	23.9				23.9	
			27.2	54.4	27.2	54.4
			27.5	40.6	27.5	40.6
			29.1	47.5	29.1	47.5
	30.4				30.4	
			33.4	40.1	33.4	40.1
	35.2				35.2	
			40.0	50.0	40.0	50.0
	43.3				43.3	
			239	318	239	318
		19.7				19.7
		22.6				22.6
		536				536
Growth (GRO)	1.92				1.92	
			2.34	4.68	2.34	4.68
	2.70				2.70	
	2.75				2.75	
	2.97				2.97	
			3.83	7.67	3.83	7.67
	4.15				4.15	
	4.43				4.43	
	4.65				4.65	
	4.75				4.75	
	5.43				5.43	
	5.56				5.56	
			5.82	46.6	5.82	46.6
	6.28				6.28	
	7.55				7.55	
	7.63				7.63	
	8.19				8.19	
	8.40				8.40	
			8.59	42.9	8.59	42.9
			8.59	42.9	8.59	42.9
			9.52	19.0	9.52	19.0
	9.72				9.72	
			10.2	51.6	10.2	51.6
	11.1				11.1	
	11.5				11.5	
	11.9				11.9	
			12.2	24.3	12.2	24.3
	12.6				12.6	
			13.3	26.6	13.3	26.6

Table 13: Calculating LOAEL-based Avian TRVs for **Copper**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	13.4				13.4	
	14.2				14.2	
	14.2				14.2	
			14.3	28.7	14.3	28.7
			14.3	28.7	14.3	28.7
			14.3	28.7	14.3	28.7
			14.3	28.7	14.3	28.7
			14.3	28.7	14.3	28.7
	14.3				14.3	
	14.3				14.3	
	14.3				14.3	
			15.7	25.8	15.7	25.8
			16.5	24.7	16.5	24.7
			16.7	33.4	16.7	33.4
			17.2	25.8	17.2	25.8
	17.5				17.5	
			17.8	31.1	17.8	31.1
			17.8	35.5	17.8	35.5
			18.0	28.0	18.0	28.0
	18.2				18.2	
	18.3				18.3	
	18.3				18.3	
	18.4				18.4	
			18.5	37.1	18.5	37.1
	18.6				18.6	
			19.6	30.5	19.6	30.5
	19.7				19.7	
			20.5	30.7	20.5	30.7
	20.9				20.9	
			21.3	42.7	21.3	42.7
			21.5	42.9	21.5	42.9
	21.5				21.5	
	21.6				21.6	
	21.7				21.7	
			21.9	34.0	21.9	34.0
			22.4	44.8	22.4	44.8
			22.7	34.1	22.7	34.1
			23.0	30.7	23.0	30.7
			23.2	29.9	23.2	29.9
			23.3	31.0	23.3	31.0
	23.9				23.9	
	24.7				24.7	
			26.4	35.2	26.4	35.2
	26.6				26.6	
			26.9	40.4	26.9	40.4
			27.9	35.3	27.9	35.3
	28.4				28.4	
			28.7	57.4	28.7	57.4
	28.7				28.7	
	29.5				29.5	
			29.7	59.3	29.7	59.3
	30.4				30.4	
	30.7				30.7	
			33.0	43.3	33.0	43.3

Table 13: Calculating LOAEL-based Avian TRVs for **Copper**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	34.1				34.1	
			34.6	51.9	34.6	51.9
			35.2	63.9	35.2	63.9
	35.5				35.5	
	35.5				35.5	
	36.3				36.3	
	36.6				36.6	
	37.1				37.1	
	40.1				40.1	
	41.0				41.0	
	43.3				43.3	
			49.5	74.2	49.5	74.2
	50.0				50.0	
	50.1				50.1	
			50.9	55.9	50.9	55.9
			56.8	109	56.8	109
			60.0	120	60.0	120
	65.4				65.4	
	82.0				82.0	
	103				103	
	143				143	
		2.69				2.69
		4.88				4.88
		10.3				10.3
		14.3				14.3
		17.5				17.5
		21.3				21.3
		22.6				22.6
		22.7				22.7
		26.4				26.4
		26.4				26.4
		28.7				28.7
		31.4				31.4
		34.9				34.9
		35.2				35.2
		35.5				35.5
		35.5				35.5
		42.9				42.9
		50.1				50.1
		55.2				55.2
		57.2				57.2
		59.0				59.0
		60.0				60.0
		75.5				75.5
		85.9				85.9
		92.9				92.9
		138				138
Survival (MOR)	2.75				2.75	
	3.55				3.55	
	6.69				6.69	
	7.63				7.63	
			8.14	16.3	8.14	16.3
	8.40				8.40	
	9.72				9.72	

Table 13: Calculating LOAEL-based Avian TRVs for **Copper**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	11.7				11.7	
	13.4				13.4	
	14.2				14.2	
			14.3	28.7	14.3	28.7
			14.3	28.7	14.3	28.7
	14.3				14.3	
	14.3				14.3	
	18.1				18.1	
	18.3				18.3	
	19.9				19.9	
	21.3				21.3	
	21.6				21.6	
	26.6				26.6	
			28.7	57.4	28.7	57.4
			28.7	57.4	28.7	57.4
	28.7				28.7	
	28.7				28.7	
	28.7				28.7	
	28.7				28.7	
	28.7				28.7	
	29.7				29.7	
	29.7				29.7	
	30.8				30.8	
	31.6				31.6	
			33.0	43.3	33.0	43.3
	35.2				35.2	
	35.4				35.4	
	35.5				35.5	
	43.3				43.3	
	46.6				46.6	
	48.3				48.3	
	50.0				50.0	
			60.0	120	60.0	120
	62.7				62.7	
			81.6	122	81.6	122
	85.9				85.9	
	92.9				92.9	
	201				201	
		2.69				2.69
		78.5				78.5
		79.6				79.6
		201				201
		536				536
Geomean (REP+GRO)	**17.54**	**33.52**	**19.57**	**35.53**	**4.05***	**34.87**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Copper. Interim Final. OSWER Directive 9285.7-68

Table 14: Calculating LOAEL-based Mammalian TRVs for **Copper**

Biological Endpoint	Unbounded TRV		Bounded TRV		Combined TRV	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			3.40	6.79	3.40	6.79
	6.51				6.51	
	50.7				50.7	
			90.9	136	90.9	136
			90.9	136	90.9	136
	107				107	
	304				304	
	358				358	
	48300				48300	
		5.51				5.51
		41.2				41.2
Growth (GRO)	0.812				0.812	
	0.852				0.852	
	1.33				1.33	
	1.48				1.48	
	2.07				2.07	
	3.60				3.60	
	4.25				4.25	
	4.37				4.37	
	5.43				5.43	
	5.51				5.51	
			5.60	9.34	5.60	9.34
	5.89				5.89	
	6.67				6.67	
	6.90				6.90	
	7.19				7.19	
	7.34				7.34	
	7.36				7.36	
	7.37				7.37	
	7.63				7.63	
	7.66				7.66	
	7.68				7.68	
	7.72				7.72	
	7.84				7.84	
	8.08				8.08	
	8.21				8.21	
	8.29				8.29	
	8.43				8.43	
	8.44				8.44	
	8.50				8.50	
	8.68				8.68	
	9.60				9.60	
	9.93				9.93	
			10.2	19.6	10.2	19.6
			10.3	26.9	10.3	26.9
	12.0				12.0	
	12.4				12.4	
	12.7				12.7	
	13.8				13.8	
			16.2	27.6	16.2	27.6

Table 14: Calculating LOAEL-based Mammalian TRVs for **Copper**

Biological Endpoint	Unbounded TRV		Bounded TRV		Combined TRV	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	16.4				16.4	
	16.5				16.5	
	16.7				16.7	
			17.2	51.6	17.2	51.6
	17.5				17.5	
	17.8				17.8	
	22.9				22.9	
			27.7	45.7	27.7	45.7
	28.4				28.4	
	33.4				33.4	
			33.8	101	33.8	101
	37.1				37.1	
	43.1				43.1	
	45.8				45.8	
			49.8	99.6	49.8	99.6
			50.0	64.0	50.0	64.0
	59.0				59.0	
	73.4				73.4	
	75.7				75.7	
			82.5	165	82.5	165
			91.7	183	91.7	183
			146	293	146	293
			179	358	179	358
	229				229	
			259	400	259	400
			494	988	494	988
	690				690	
			812	1740	812	1740
			1430	3400	1430	3400
			2110	4670	2110	4670
			19500	47500	19500	47500
		1.47				1.47
		3.00				3.00
		5.78				5.78
		7.46				7.46
		15.5				15.5
		23.5				23.5
		39.8				39.8
		39.8				39.8
		106				106
		122				122
		274				274
		285				285
Survival (MOR)	4.25				4.25	
	5.51				5.51	
			5.60	9.34	5.60	9.34
			10.2	19.6	10.2	19.6
			16.3	32.5	16.3	32.5
			23.3	35.0	23.3	35.0
	25.9				25.9	

Table 14: Calculating LOAEL-based Mammalian TRVs for **Copper**

Biological Endpoint	Unbounded TRV		Bounded TRV		Combined TRV	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
			33.3	111	33.3	111
	33.4				33.4	
			33.8	101	33.8	101
	45.5				45.5	
	59.0				59.0	
			91.7	183	91.7	183
	107				107	
	229				229	
			259	400	259	400
	307				307	
			457	548	457	548
	690				690	
	760				760	
	798				798	
			1430	3400	1430	3400
	4160				4160	
	47500				47500	
	48300				48300	
		5.09				5.09
		7.57				7.57
		8.08				8.08
		15.5				15.5
		114				114
Geomean (REP+GRO)	**15.1**	**24.3**	**120**	**155**	**5.60***	**82.7**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Copper. Interim Final. OSWER Directive 9285.7-68

Table 15: Calculating LOAEL-based Avian TRVs for Lead

Biological Endpoint	Unbounded		Bounded Values		All Values	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			0.194	1.94	0.194	1.94
			1.63	3.26	1.63	3.26
			2.69	4.04	2.69	4.04
	5.63				5.63	
	12.0				12.0	
			12.6	126	12.6	126
			67.4	135	67.4	135
	125				125	
		0.110				0.110
		0.194				0.194
		3.26				3.26
		11.8				11.8
		93.1				93.1
		377				377
Growth (GRO)			1.56	15.6	1.56	15.6
	2.77				2.77	
	4.64				4.64	
			5.93	59.3	5.93	59.3
			6.14	61.4	6.14	61.4
			7.10	71.0	7.10	71.0
			11.1	111	11.1	111
			11.2	112	11.2	112
			12.6	126	12.6	126
			13.5	67.4	13.5	67.4
	14.2				14.2	
	20.0				20.0	
			25.0	125	25.0	125
	28.4				28.4	
	34.5				34.5	
	54.3				54.3	
			61.3	123	61.3	123
	66.9				66.9	
		38.2				38.2
		53.1				53.1
		64.3				64.3
		76.3				76.3
		124				124
		152				152
		163				163
		200				200
		262				262
		270				270
		273				273
		282				282
Survival (MOR)	2.47				2.47	
			12.5	25.0	12.5	25.0
	14.2				14.2	
	28.4				28.4	
	54.3				54.3	
	66.9				66.9	

Table 15: Calculating LOAEL-based Avian TRVs for Lead

Biological Endpoint	Unbounded		Bounded Values		All Values	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
			125	625	125	625
			160	320	160	320
	163				163	
	196				196	
		6.25				6.25
		194				194
		400				400
Geomean (REP+GRO)	**18.90**	**46.31**	**7.33**	**42.68**	**1.63***	**44.63**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Lead. Interim Final. OSWER Directive 9285.7-70

Table 16:Calculating LOAEL-based Mammalian TRVs for **Lead**

Biological Endpoint	Unbounded		Bounded Values		All Values	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			0.710	7.00	0.710	7.00
			1.00	5.00	1.00	5.00
			2.60	26.0	2.60	26.0
			3.00	6.0	3.00	6.0
	4.50				4.50	
			5.00	10.0	5.00	10.0
	5.50				5.50	
			7.50	74.9	7.50	74.9
	8.90				8.90	
			9.10	45.0	9.10	45.0
			12.4	170	12.4	170
			18.0	180	18.0	180
	25.4				25.4	
	27.5				27.5	
			31.6	63.2	31.6	63.2
	32.5				32.5	
			33.3	111	33.3	111
			41.0	54.6	41.0	54.6
			47.3	82.0	47.3	82.0
			56.0	285	56.0	285
	64.8				64.8	
	64.9				64.9	
			90.1	270	90.1	270
			100	150	100	150
	115				115	
	116				116	
	120				120	
			144	1440	144	1440
			202	506	202	506
			202	506	202	506
			276	552	276	552
			294	587	294	587
	441				441	
	600				600	
			601	1500	601	1500
	639				639	
		2.00				2.00
		2.49				2.49
		2.94				2.94
		3.62				3.62
		5.50				5.50
		6.76				6.76
		16.6				16.6
		46.4				46.4
		49.6				49.6
		50.0				50.0
		55.5				55.5
		61.2				61.2
		78.6				78.6
		99.8				99.8
		137				137
		139				139
		154				154

Table 16:Calculating LOAEL-based Mammalian TRVs for **Lead**

Biological Endpoint	Unbounded		Bounded Values		All Values	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
		171				171
		175				175
		178				178
		198				198
		200				200
		218				218
		221				221
		222				222
		230				230
		258				258
		330				330
		354				354
		360				360
		360				360
		362				362
		364				364
		381				381
		381				381
		381				381
		404				404
		420				420
		437				437
		579				579
		600				600
		635				635
		646				646
		651				651
		750				750
		762				762
		828				828
		833				833
		991				991
		1370				1370
		1770				1770
		1990				1990
		2570				2570
		2570				2570
		2570				2570
		2840				2840
		3630				3630
		6170				6170
Growth (GRO)	0.150				0.150	
	0.500				0.500	
			1.00	5.00	1.00	5.00
			1.27	13.0	1.27	13.0
	1.99				1.99	
	2.40				2.40	
	2.98				2.98	
			4.70	8.90	4.70	8.90
	4.71				4.71	
			5.64	28.2	5.64	28.2
			5.80	29.0	5.80	29.0
	7.79				7.79	

Table 16:Calculating LOAEL-based Mammalian TRVs for Lead

Biological Endpoint	Unbounded		Bounded Values		All Values	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	9.10				9.10	
	10.0				10.0	
			10.6	532	10.6	532
			10.7	50.4	10.7	50.4
	10.7				10.7	
	15.1				15.1	
	15.4				15.4	
	15.5				15.5	
	16.1				16.1	
			16.3	163	16.3	163
			18.0	180	18.0	180
	18.3				18.3	
	18.9				18.9	
	24.3				24.3	
	32.5				32.5	
	32.7				32.7	
	38.5				38.5	
	43.0				43.0	
	50.0				50.0	
			71.5	178	71.5	178
			75.0	225	75.0	225
	100				100	
			120	383	120	383
			136	1360	136	1360
	137				137	
	139				139	
			169	508	169	508
	171				171	
	180				180	
			187	373	187	373
	200				200	
	200				200	
	218				218	
			230	460	230	460
	285				285	
	362				362	
	364				364	
			400	800	400	800
			400	800	400	800
	431				431	
	441				441	
	534				534	
			632	1264	632	1264
	651				651	
	750				750	
			1260	2530	1260	2530
	1500				1500	
		3.30				3.30
		15.0				15.0
		28.7				28.7
		29.0				29.0
		29.0				29.0
		29.5				29.5

Table 16:Calculating LOAEL-based Mammalian TRVs for **Lead**

Biological Endpoint	Unbounded		Bounded Values		All Values	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
		29.9				29.9
		30.4				30.4
		46.4				46.4
		50.0				50.0
		61.5				61.5
		100				100
		173				173
		200				200
		272				272
		328				328
		354				354
		371				371
		400				400
		400				400
		404				404
		442				442
		638				638
		748				748
		991				991
		1000				1000
		1430				1430
		1600				1600
		2390				2390
		2400				2400
		2650				2650
Survival (MOR)	3.50				3.50	
			4.00	8.00	4.00	8.00
	7.79				7.79	
			10.7	50.4	10.7	50.4
			10.9	42.4	10.9	42.4
			16.0	43.0	16.0	43.0
	24.7				24.7	
	29.2				29.2	
	30.2				30.2	
	40.3				40.3	
	46.4				46.4	
	64.8				64.8	
	64.9				64.9	
	74.9				74.9	
	78.9				78.9	
			87.5	163	87.5	163
	104				104	
	170				170	
	170				170	
	200				200	
	379				379	
			400	800	400	800
			400	800	400	800
	404				404	
	639				639	
			2000	2400	2000	2400
	3200				3200	
		0.569				0.569

Table 16:Calculating LOAEL-based Mammalian TRVs for **Lead**

Biological Endpoint	Unbounded		Bounded Values		All Values	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
		2.70				2.70
		2.87				2.87
		3.10				3.10
		20.0				20.0
		61.5				61.5
		328				328
		400				400
		400				400
		635				635
		670				670
		670				670
Geomean (REP+GRO)	45.99	215.8	34.93	136.7	4.70*	186.4

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Lead. Interim Final. OSWER Directive 9285.7-70

Table 17: Calculating LOAEL-based Avian TRVs for **Manganese**

Biological Endpoint	Unbounded		Bounded Values		All Values	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	191				191	
	202				202	
	575				575	
Growth (GRO)	23.1				23.1	
	24.3				24.3	
	50.2				50.2	
	67.0				67.0	
	71.8				71.8	
	87.7				87.7	
	97.6				97.6	
	110				110	
	197				197	
	202				202	
	213				213	
	213				213	
			215	431	215	431
	252				252	
			261	348	261	348
			302	356	302	356
	435				435	
	437				437	
	439				439	
	575				575	
	1120				1120	
Survival (MOR)	216				216	
	356				356	
Geomean (REP+GRO)	**170**	**--**	**257**	**377**	**179**	**377**

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Manganese. Interim Final. OSWER Directive 9285.7-71

Table 18: Calculating LOAEL-based Mammalian TRVs for **Manganese**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	2.83				2.83	
			21.0	71.0	21.0	71.0
	78.3				78.3	
	112				112	
	125				125	
	136				136	
			153	620	153	620
			276	415	276	415
	291				291	
			1069	2139	1069	2139
	1996				1996	
		26.4				26.4
		71.0				71.0
Growth (GRO)	1.30				1.30	
	1.86				1.86	
	2.74				2.74	
	2.83				2.83	
	5.89				5.89	
	7.05				7.05	
	7.37				7.37	
	13.8				13.8	
			14.4	144	14.4	144
	20.0				20.0	
	20.0				20.0	
			21.0	71.0	21.0	71.0
			21.7	65.0	21.7	65.0
			59.4	119	59.4	119
	71.0				71.0	
	73.8				73.8	
	78.3				78.3	
	86.3				86.3	
	102				102	
			112	223	112	223
	112				112	
	125				125	
	136				136	
			162	271	162	271
	262				262	
	270				270	
	394				394	
	554				554	
		10.0				10.0
		284				284
		284				284
Survival (MOR)			21.0	71.0	21.0	71.0
	78.3				78.3	
	112				112	
	125				125	
	136				136	
Geomean (REP+GRO)	**44.9**	**68.5**	**76.3**	**212**	**51.4**	**146**

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Manganese. Interim Final. OSWER Directive 9285.7-71

Table 19: Calculating LOAEL-based Avian TRVs for **Nickel**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	149				149	
		8.16				8.16
Growth (GRO)	0.136				0.136	
	0.195				0.195	
			5.76	11.5	5.76	11.5
			8.95	17.9	8.95	17.9
	22.9				22.9	
			28.3	30.2	28.3	30.2
			31.0	31.5	31.0	31.5
	8.95					8.95
	10.7					10.7
	23.9					23.9
	71.8					71.8
Survival (MOR)			10.7	47.0	10.7	47.0
	22.9				22.9	
	23.0				23.0	
			23.9	39.9	23.9	39.9
Geomean (REP+GRO)	**7.88**	**8.16**	**14.6**	**21.0**	**6.71**	**18.6**

TRV = toxicity reference value

NOAEL = no observed adverse effect level

LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Nickel. Interim Final. OSWER Directive 9285.7-76

Table 20: Calculating LOAEL-based Mammalian TRVs for **Nickel**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Comined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			1.10	3.31	1.10	3.31
			1.35	2.71	1.35	2.71
			1.70	3.40	1.70	3.40
	9.30				9.30	
	45.3				45.3	
			85.3	171.0	85.3	171.0
	90.6				90.6	
	112				112	
			164	327	164	327
	205				205	
		0.551				0.551
		0.797				0.797
		1.33				1.33
		1.35				1.35
		1.59				1.59
		4.70				4.70
		25.0				25.0
Growth (GRO)	0.0844				0.0844	
	0.101				0.101	
	0.335				0.335	
	1.17				1.17	
			1.33	6.80	1.33	6.80
	1.36				1.36	
			1.47	22.0	1.47	22.0
			1.64	6.55	1.64	6.55
	2.97				2.97	
	4.56				4.56	
	4.56				4.56	
	5.44				5.44	
	5.89				5.89	
	6.75				6.75	
			7.00	14.6	7.00	14.6
	7.78				7.78	
			9.11	91.1	9.11	91.1
	9.30				9.30	
			9.49	47.4	9.49	47.4
	11.4				11.4	
			11.7	23.4	11.7	23.4
	12.5				12.5	
	20.0				20.0	
			29.4	309	29.4	309
			45.0	112	45.0	112
	45.3				45.3	
			85.3	171	85.3	171
			107	148	107	148
		2.81				2.81
		8.20				8.20
		24.7				24.7
		208				208

Table 20: Calculating LOAEL-based Mammalian TRVs for **Nickel**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Comined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Survival (MOR)	2.71				2.71	
	4.56				4.56	
	5.42				5.42	
	6.47				6.47	
			29.4	309	29.4	309
	45.3				45.3	
	90.6				90.6	
	112				112	
	138				138	
	205				205	
		0.620				0.620
		0.716				0.716
Geomean (REP+GRO)	**6.37**	**4.55**	**9.98**	**33.18**	**1.70***	**14.77**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Nickel. Interim Final. OSWER Directive 9285.7-76

Table 21: Calculating LOAEL-based Avian TRVs for **Selenium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			0.092	0.368	0.092	0.368
			0.212	0.425	0.212	0.425
			0.214	0.429	0.214	0.429
			0.219	0.438	0.219	0.438
			0.247	0.412	0.247	0.412
			0.273	0.546	0.273	0.546
	0.284				0.284	
	0.292				0.292	
	0.378				0.378	
			0.644	1.29	0.644	1.29
	0.890				0.890	
	0.896				0.896	
			1.03	2.58	1.03	2.58
	1.37				1.37	
	3.64				3.64	
		0.0911				0.0911
		0.0988				0.0988
		0.120				0.120
		0.127				0.127
		0.355				0.355
		0.456				0.456
		0.524				0.524
		0.546				0.546
		0.580				0.580
		0.614				0.614
		0.675				0.675
		0.702				0.702
		0.780				0.780
		0.826				0.826
		0.898				0.898
		1.19				1.19
		4.49				4.49
Growth (GRO)	0.0632				0.0632	
			0.0740	0.370	0.0740	0.370
	0.0859				0.0859	
			0.18	0.721	0.18	0.721
			0.204	0.408	0.204	0.408
			0.213	0.426	0.213	0.426
	0.284				0.284	
	0.292				0.292	
	0.319				0.319	
	0.371				0.371	
	0.379				0.379	
	0.429				0.429	
			0.429	0.859	0.429	0.859
			0.617	1.23	0.617	1.23
			0.69	1.73	0.69	1.73
			0.718	1.44	0.718	1.44
	0.909				0.909	
	1.06				1.06	
			1.13	4.53	1.13	4.53

Table 21: Calculating LOAEL-based Avian TRVs for **Selenium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
			1.23	4.94	1.23	4.94
	1.38				1.38	
	1.42				1.42	
			1.45	2.90	1.45	2.90
			1.74	3.48	1.74	3.48
			2.13	4.26	2.13	4.26
	3.04				3.04	
			4.16	8.32	4.16	8.32
			5.75	11.5	5.75	11.5
			6.34	11.9	6.34	11.9
	7.31				7.31	
		0.0912				0.0912
		0.127				0.127
		0.130				0.130
		0.180				0.180
		0.275				0.275
		0.306				0.306
		0.50				0.50
		0.50				0.50
		0.629				0.629
		0.788				0.788
		0.855				0.855
		0.859				0.859
		0.896				0.896
		1.08				1.08
		1.20				1.20
		1.38				1.38
		1.55				1.55
		1.72				1.72
		1.78				1.78
		2.27				2.27
		2.76				2.76
		3.64				3.64
Survival (MOR)			0.093	0.371	0.093	0.371
	0.153				0.153	
			0.290	0.579	0.290	0.579
	0.292				0.292	
	0.368				0.368	
	0.378				0.378	
			0.412	0.823	0.412	0.823
			0.563	1.13	0.563	1.13
			0.572	1.14	0.572	1.14
	0.610				0.610	
	0.629				0.629	
	0.64				0.64	
			0.699	4.19	0.699	4.19
			0.702	1.40	0.702	1.40
	0.780				0.780	
	0.844				0.844	
	0.859				0.859	
	0.890				0.890	

Table 21: Calculating LOAEL-based Avian TRVs for **Selenium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	0.896				0.896	
	0.909				0.909	
	0.910				0.910	
	0.944				0.944	
	1.01				1.01	
	1.06				1.06	
	1.08				1.08	
			1.13	4.53	1.13	4.53
			1.20	4.80	1.20	4.80
			1.22	2.44	1.22	2.44
			1.23	4.94	1.23	4.94
	1.37				1.37	
	1.38				1.38	
	1.42				1.42	
	1.72				1.72	
	1.87				1.87	
	2.03				2.03	
			2.38	4.75	2.38	4.75
	3.04				3.04	
			3.04	6.08	3.04	6.08
			3.07	6.14	3.07	6.14
			3.08	12.3	3.08	12.3
			3.49	6.99	3.49	6.99
	3.64				3.64	
	3.72				3.72	
			3.99	7.98	3.99	7.98
			5.84	11.7	5.84	11.7
	7.31				7.31	
			28.2	29.0	28.2	29.0
		0.50				0.50
		1.78				1.78
		3.44				3.44
		5.75				5.75
Geomean (REP+GRO)	**0.62**	**0.59**	**0.59**	**1.39**	**0.290***	**0.82**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Selenium. Interim Final. OSWER Directive 9285.7-72

Table 22: Calculating LOAEL-based Mammalian TRVs for **Selenium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			0.072	0.145	0.072	0.145
	0.108				0.108	
	0.173				0.173	
			0.384	0.768	0.384	0.768
			0.388	0.776	0.388	0.776
			0.393	0.763	0.393	0.763
	0.456				0.456	
			0.735	1.51	0.735	1.51
	0.780				0.780	
	0.945				0.945	
			1.21	6.03	1.21	6.03
	1.60				1.60	
	2.28				2.28	
			2.54	25.4	2.54	25.4
			3.20	6.39	3.20	6.39
	3.20				3.20	
	7.0				7.0	
		0.089				0.089
		0.130				0.130
		0.296				0.296
		0.434				0.434
		0.504				0.504
		0.550				0.550
		0.749				0.749
		4.18				4.18
		4.57				4.57
		5.01				5.01
Growth (GRO)			0.053	0.265	0.053	0.265
	0.0642				0.0642	
			0.0838	0.763	0.0838	0.763
	0.0869				0.0869	
	0.090				0.090	
	0.110				0.110	
			0.112	0.157	0.112	0.157
			0.137	0.273	0.137	0.273
			0.143	0.215	0.143	0.215
			0.146	0.273	0.146	0.273
			0.151	0.304	0.151	0.304
	0.153				0.153	
			0.155	0.221	0.155	0.221
	0.163				0.163	
			0.165	0.330	0.165	0.330
			0.170	0.510	0.170	0.510
	0.173				0.173	
	0.175				0.175	
	0.181				0.181	
			0.183	0.548	0.183	0.548
	0.189				0.189	
	0.191				0.191	
	0.198				0.198	
	0.202				0.202	
	0.214				0.214	

Table 22: Calculating LOAEL-based Mammalian TRVs for **Selenium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
			0.217	0.435	0.217	0.435
			0.217	0.470	0.217	0.470
	0.217				0.217	
			0.227	0.340	0.227	0.340
	0.236				0.236	
			0.240	0.580	0.240	0.580
	0.254				0.254	
			0.261	0.521	0.261	0.521
	0.265				0.265	
			0.274	0.540	0.274	0.540
	0.277				0.277	
	0.296				0.296	
	0.318				0.318	
			0.356	0.712	0.356	0.712
			0.367	0.489	0.367	0.489
	0.367				0.367	
			0.368	0.564	0.368	0.564
	0.371				0.371	
			0.374	0.747	0.374	0.747
	0.375				0.375	
			0.384	0.523	0.384	0.523
			0.384	0.768	0.384	0.768
			0.388	0.776	0.388	0.776
			0.393	0.763	0.393	0.763
	0.407				0.407	
			0.425	0.567	0.425	0.567
	0.426				0.426	
			0.432	0.577	0.432	0.577
			0.435	0.869	0.435	0.869
			0.435	0.869	0.435	0.869
			0.435	0.869	0.435	0.869
			0.438	1.31	0.438	1.31
			0.452	0.904	0.452	0.904
	0.464				0.464	
	0.490				0.490	
	0.500				0.500	
			0.515	1.54	0.515	1.54
			0.610	1.21	0.610	1.21
	0.652				0.652	
			0.680	0.88	0.680	0.88
			0.735	1.51	0.735	1.51
	0.780				0.780	
			0.781	1.23	0.781	1.23
			0.784	1.21	0.784	1.21
			0.810	1.62	0.810	1.62
	0.945				0.945	
			0.996	1.59	0.996	1.59
			0.996	1.59	0.996	1.59
	1.09				1.09	
			1.14	2.27	1.14	2.27
	1.26				1.26	
	1.60				1.60	

Table 22: Calculating LOAEL-based Mammalian TRVs for **Selenium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	1.96				1.96	
			3.20	6.39	3.20	6.39
	3.20				3.20	
	4.57				4.57	
	4.57				4.57	
	10.0				10.0	
			10.0	20.0	10.0	20.0
		0.0908				0.0908
		0.0968				0.0968
		0.156				0.156
		0.163				0.163
		0.166				0.166
		0.205				0.205
		0.209				0.209
		0.215				0.215
		0.232				0.232
		0.235				0.235
		0.254				0.254
		0.267				0.267
		0.274				0.274
		0.276				0.276
		0.282				0.282
		0.303				0.303
		0.307				0.307
		0.323				0.323
		0.345				0.345
		0.352				0.352
		0.378				0.378
		0.390				0.390
		0.411				0.411
		0.420				0.420
		0.425				0.425
		0.441				0.441
		0.454				0.454
		0.490				0.490
		0.493				0.493
		0.498				0.498
		0.521				0.521
		0.543				0.543
		0.550				0.550
		0.570				0.570
		0.589				0.589
		0.653				0.653
		0.667				0.667
		0.704				0.704
		0.754				0.754
		0.767				0.767
		0.769				0.769
		0.794				0.794
		0.794				0.794
		0.794				0.794
		0.794				0.794

Table 22: Calculating LOAEL-based Mammalian TRVs for **Selenium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
		0.809				0.809
		0.817				0.817
		0.823				0.823
		0.903				0.903
		0.968				0.968
		0.984				0.984
		0.988				0.988
		1.02				1.02
		1.11				1.11
		1.59				1.59
		1.59				1.59
		1.79				1.79
		1.94				1.94
		3.54				3.54
		3.74				3.74
		4.18				4.18
Survival (MOR)			0.0961	0.385	0.0961	0.385
			0.101	0.168	0.101	0.168
	0.181				0.181	
	0.186				0.186	
			0.217	0.435	0.217	0.435
			0.217	0.435	0.217	0.435
	0.221				0.221	
	0.239				0.239	
			0.274	0.540	0.274	0.540
	0.334				0.334	
	0.350				0.350	
	0.375				0.375	
			0.393	0.763	0.393	0.763
			0.426	1.28	0.426	1.28
			0.435	0.869	0.435	0.869
			0.435	0.869	0.435	0.869
			0.474	0.632	0.474	0.632
			0.564	0.769	0.564	0.769
			0.576	0.720	0.576	0.720
			0.587	0.733	0.587	0.733
			0.595	0.892	0.595	0.892
			0.639	1.19	0.639	1.19
	0.652				0.652	
	0.652				0.652	
			0.653	0.980	0.653	0.980
	0.680				0.680	
	0.704				0.704	
	0.754				0.754	
	0.769				0.769	
	0.794				0.794	
	0.820				0.820	
			0.857	1.71	0.857	1.71
	0.881				0.881	
			0.904	1.81	0.904	1.81
	0.953				0.953	
			1.14	2.28	1.14	2.28

Table 22: Calculating LOAEL-based Mammalian TRVs for **Selenium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	1.17				1.17	
	1.17				1.17	
	1.21				1.21	
	1.21				1.21	
	1.26				1.26	
			1.49	5.96	1.49	5.96
	1.51				1.51	
	1.60				1.60	
			2.27	4.55	2.27	4.55
	2.28				2.28	
			2.28	4.57	2.28	4.57
			3.0	6.0	3.0	6.0
			3.18	6.36	3.18	6.36
			3.20	6.39	3.20	6.39
	3.20				3.20	
	3.53				3.53	
	4.18				4.18	
			10.0	20	10.0	20
	15.4				15.4	
		0.275				0.275
		0.440				0.440
		0.809				0.809
		0.817				0.817
		0.823				0.823
		0.975				0.975
		0.984				0.984
		1.11				1.11
		1.79				1.79
		1.94				1.94
		3.54				3.54
		3.74				3.74
		4.17				4.17
		5.01				5.01
Geomean (REP+GRO)	**0.48**	**0.55**	**0.40**	**0.84**	**0.143***	**0.66**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Selenium. Interim Final. OSWER Directive 9285.7-72

Table 23: Calculating LOAEL-based Avian TRVs for **Silver**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Growth (GRO)		20.2				20.2
		65.5				65.5
		70.8				70.8
		72.8				72.8
		81.1				81.1
		88.4				88.4
Survival (MOR)		71.4				71.4
		72.8				72.8
		81.1				81.1
		98.6				98.6
		401				401
Geomean (REP+GRO)		60.5			2.02*	60.5

* NOAEL values were not available for reproduction or growth. EPA derived the final combined NOAEL TRV by selecting the lowest LOAEL for growth or reproduction and dividing this value by a safety factor of 10.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Silver. Interim Final. OSWER Directive 9285.7-77

Table 24: Calculating LOAEL-based Mammalian TRVs for **Silver**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)		188				188
Growth (GRO)		60.2				60.2
		80.2				80.2
		126				126
		140				140
		174				174
Survival (MOR)	60.2				60.2	
	116				116	
		125				125
		140				140
Geomean (REP+GRO)	--	**119**	--	--	**6.02***	**119**

* NOAEL values were not available for reproduction or growth. EPA derived the final combined NOAEL TRV by selecting the lowest LOAEL for growth or reproduction and dividing this value by a safety factor of 10.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Silver. Interim Final. OSWER Directive 9285.7-77

Table 25: Calculating of LOAEL-based Avian TRVs for **Vanadium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			0.275	0.413	0.275	0.413
			0.325	0.524	0.325	0.524
	0.366				0.366	
			0.988	1.98	0.988	1.98
			0.988	1.98	0.988	1.98
			1.25	2.50	1.25	2.50
	3.95				3.95	
			4.94	14.8	4.94	14.8
	39.0				39.0	
		0.319				0.319
		0.475				0.475
		0.494				0.494
		0.669				0.669
		0.740				0.740
		0.988				0.988
		0.988				0.988
		1.31				1.31
		1.33				1.33
		1.98				1.98
		2.75				2.75
Growth (GRO)			0.244	0.489	0.244	0.489
	0.279				0.279	
	0.284				0.284	
			0.295	0.589	0.295	0.589
			0.344	0.688	0.344	0.688
	0.366				0.366	
	0.475				0.475	
			0.711	1.42	0.711	1.42
			0.711	1.42	0.711	1.42
			0.904	2.26	0.904	2.26
			0.988	1.98	0.988	1.98
			1.050	1.59	1.050	1.59
			1.22	3.05	1.22	3.05
			1.26	2.51	1.26	2.51
			1.84	6.13	1.84	6.13
	1.98				1.98	
	1.98				1.98	
	2.20				2.20	
			2.34	4.08	2.34	4.08
	2.36				2.36	
			2.68	3.58	2.68	3.58
			2.87	5.74	2.87	5.74
	46.1				46.1	
		0.339				0.339
		0.429				0.429
		0.859				0.859
		0.859				0.859
		0.859				0.859
		0.968				0.968
		1.32				1.32
		1.33				1.33
		1.72				1.72
		1.77				1.77

Table 25: Calculating of LOAEL-based Avian TRVs for **Vanadium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
		1.78				1.78
		2.00				2.00
		2.12				2.12
		2.13				2.13
		2.15				2.15
		2.15				2.15
		2.15				2.15
		2.15				2.15
		2.75				2.75
		2.84				2.84
		2.87				2.87
		2.87				2.87
		3.55				3.55
		3.55				3.55
		4.29				4.29
		4.29				4.29
		4.76				4.76
		5.74				5.74
		8.36				8.36
Survival (MOR)			0.859	2.15	0.859	2.15
			0.962	1.92	0.962	1.92
	1.72				1.72	
			2.15	4.294	2.15	4.294
	2.15				2.15	
	2.15				2.15	
	2.36				2.36	
			2.50	4.99	2.50	4.99
			2.87	5.74	2.87	5.74
			2.87	5.74	2.87	5.74
	3.55				3.55	
	4.76				4.76	
			5.74	11.5	5.74	11.5
			6.37	10.6	6.37	10.6
	7.15				7.15	
	12.0				12.0	
	13.4				13.4	
	14.8				14.8	
	98.7				98.7	
		1.72				1.72
		2.15				2.15
		4.29				4.29
		5.74				5.74
Geomean (REP+GRO)	**1.73**	**1.61**	**0.94**	**1.89**	**0.344***	**1.70**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Vanadium. Interim Final. OSWER Directive 9285.7-75

Table 26: Calculating LOAEL-based Mammalian TRVs for **Vanadium**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			4.16	8.31	4.16	8.31
		2.18				2.18
		6.26				6.26
		7.55				7.55
		28.7				28.7
Growth (GRO)			0.0220	11.0	0.0220	11.0
	0.534				0.534	
	0.674				0.674	
			1.03	5.11	1.03	5.11
	2.23				2.23	
			3.43	6.85	3.43	6.85
	3.84				3.84	
			4.16	8.31	4.16	8.31
	4.93				4.93	
	5.46				5.46	
	5.69				5.69	
	5.69				5.69	
	7.06				7.06	
	7.64				7.64	
	9.68				9.68	
	10.8				10.8	
	11.6				11.6	
	24				24	
	136				136	
	21695				21695	
		1.88				1.88
		3.58				3.58
		6.26				6.26
		6.82				6.82
		7.55				7.55
		9.03				9.03
		11.6				11.6
		21.2				21.2
		26.4				26.4
		29.0				29.0
		108				108
Survival (MOR)	0.701				0.701	
			4.16	8.31	4.16	8.31
			9.6	17.9	9.6	17.9
	11.6				11.6	
	30.2				30.2	
		1.93				1.93
		8.33				8.33
		29.0				29.0
Geomean (REP+GRO)	**10.1**	**10.1**	**1.06**	**7.67**	**4.16***	**9.44**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Vanadium. Interim Final. OSWER Directive 9285.7-75

Table 27: Calculating LOAEL-based Avian TRVs for **Zinc**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	13.8				13.8	
	14.4				14.4	
			24.7	98.8	24.7	98.8
			55	105	55	105
			57.3	66.5	57.3	66.5
			63.9	76.7	63.9	76.7
			64.1	123	64.1	123
			67.8	84.8	67.8	84.8
	106				106	
		31.2				31.2
		88				88
		101				101
		205				205
		367				367
		988				988
		988				988
Growth (GRO)	14.4				14.4	
	15.0				15.0	
	16.1				16.1	
	21.5				21.5	
	28.7				28.7	
	35.4				35.4	
	36.6				36.6	
			43.3	86.6	43.3	86.6
			55.0	105	55.0	105
	55.1				55.1	
			55.3	111	55.3	111
	63.2				63.2	
			70.6	106	70.6	106
			74.3	111	74.3	111
			74.7	112	74.7	112
			75.0	150	75.0	150
			75.7	114	75.7	114
			85.9	172	85.9	172
			86.8	174	86.8	174
			92.3	185	92.3	185
			96.9	145	96.9	145
			99.1	149	99.1	149
	103				103	
	103				103	
	129				129	
			129	194	129	194
	142				142	
			143	286	143	286
			148	297	148	297
			155	232	155	232
			158	237	158	237
			177	354	177	354
			252	503	252	503
			367	480	367	480
		21.6				21.6
		31.0				31.0
		39.0				39.0
		65.7				65.7
		88				88

Table 27: Calculating LOAEL-based Avian TRVs for **Zinc**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
		101				101
		126				126
		132				132
		143				143
		252				252
		190				190
		284				284
		315				315
		433				433
		757				757
		914				914
		988				988
		1370				1370
Survival (MOR)	21.5				21.5	
	31.0				31.0	
	35.4				35.4	
	55.1				55.1	
	63.2				63.2	
			68.8	87.1	68.8	87.1
	75.6				75.6	
	89.5				89.5	
			109	219	109	219
	115				115	
	120				120	
	121				121	
			143	286	143	286
			159	239	159	239
	172				172	
			183	366	183	366
			252	503	252	503
	255				255	
	272				272	
	319				319	
	320				320	
			327	491	327	491
	741				741	
		126				126
		401				401
		803				803
Geomean (REP+ GRO)	**39.8**	**192**	**89.2**	**154**	**66.1**	**171**

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Zinc. Interim Final. OSWER Directive 9285.7-73

Table 28: Calculating LOAEL-based Mammalian TRVs for **Zinc**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			8.23	82.3	8.23	82.3
	8.89				8.89	
	9.64				9.64	
	14.4				14.4	
	30.0				30.0	
	34.0				34.0	
			37.9	75.9	37.9	75.9
	41.2				41.2	
	42.1				42.1	
	42.5				42.5	
	60.0				60.0	
	88.0				88.0	
	89.6				89.6	
	89.6				89.6	
	97.8				97.8	
	101				101	
	110				110	
	167				167	
			181	452	181	452
			234	2514	234	2514
	347				347	
			458	4927	458	4927
			479	4878	479	4878
	975				975	
	2486				2486	
		12.2				12.2
		81.1				81.1
		232				232
		326				326
		326				326
		353				353
		424				424
Growth (GRO)	4.33				4.33	
	4.78				4.78	
	4.78				4.78	
	9.64				9.64	
			10.3	103	10.3	103
	11.7				11.7	
	13.5				13.5	
	14.4				14.4	
	14.9				14.9	
	15.7				15.7	
	15.7				15.7	
	18.0				18.0	
	20.2				20.2	
	28.9				28.9	
	30.0				30.0	
	30.4				30.4	
	30.6				30.6	
	33.2				33.2	
	34				34	
	42.1				42.1	
	42.5				42.5	
			43.5	87.1	43.5	87.1
	63.7				63.7	
	56				56	
	60.0				60.0	
	88.0				88.0	
	97.5				97.5	

Table 28: Calculating LOAEL-based Mammalian TRVs for **Zinc**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	99.1				99.1	
	103				103	
	106				106	
	110				110	
			234	2514	234	2514
	282				282	
	295				295	
			458	4927	458	4927
	470				470	
			479	4878	479	4878
	597				597	
	825				825	
	845				845	
	846				846	
			1419	2838	1419	2838
	1684				1684	
	2486				2486	
		8.71				8.71
		16.1				16.1
		28.2				28.2
		75.7				75.7
		81.1				81.1
		89.1				89.1
		424				424
		667				667
		956				956
		968				968
Survival (MOR)	8.89				8.89	
	12.0				12.0	
	30.0				30.0	
	42.5				42.5	
			43.5	87.1	43.5	87.1
					60.0	
			82.9	99.5	82.9	99.5
	83.7				83.7	
	88.0				88.0	
	165				165	
	297				297	
	324				324	
	327				327	
			458	4927	458	4927
	2486				2486	
	2514				2514	
	4878				4878	
		99.1				99.1
Geomean (REP+ GRO)	**65.6**	**137**	**146**	**895**	**75.4**	**298**

TRV = toxicity reference value

NOAEL = no observed adverse effect level

LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Zinc. Interim Final. OSWER Directive 9285.7-73

Table 29: Calculating LOAEL-based Avian TRVs for **Pentachlorophenol**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Growth (GRO)			6.73	67.3	6.73	67.3
			40.9	92.9	40.9	92.9
		22.5				22.5
Survival (MOR)	90.0				90.0	
	111				111	
Geomean (GRO)	--	**22.5**	**16.6**	**79.1**	**6.73***	**52.0**

*Only two NOAEL values for growth were available. EPA selected the lowest NOAEL for growth or survival as the final combined NOAEL TRV.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Pentachlorophenol Interim Final. OSWER Directive 9285.7-58

Table 30: Calculating LOAEL-based Mammalian TRVs for **Pentachlorophenol**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	0.0753				0.0753	
	1.0				1.0	
			2.36	9.45	2.36	9.45
			2.71	27.1	2.71	27.1
			3.96	12.9	3.96	12.9
			5.13	13.3	5.13	13.3
			5.51	31.7	5.51	31.7
			14.7	29.4	14.7	29.4
		0.571				0.571
		29.4				29.4
		29.4				29.4
		30.7				30.7
		30.7				30.7
		74.3				74.3
Growth (GRO)	0.427				0.427	
			2.50	10.0	2.50	10.0
			2.71	27.1	2.71	27.1
			4.23	23.7	4.23	23.7
			4.95	27.7	4.95	27.7
			12.9	42.6	12.9	42.6
			13.3	30.7	13.3	30.7
			14.7	29.4	14.7	29.4
	27.8				27.8	
	29.4				29.4	
	30.7				30.7	
	31.7				31.7	
	52.7				52.7	
	54.8				54.8	
	57.6				57.6	
	70.7				70.7	
	122				122	
		29.4				29.4
		30.7				30.7
		74.3				74.3
Survival (MOR)	0.0753				0.0753	
	23.7				23.7	
	27.7				27.7	
	42.6				42.6	
	70.7				70.7	
		52.7				52.7
Geomean (REP+GRO)	**13.5**	**23.7**	**5.45**	**22.0**	**8.43**	**22.7**

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Pentachlorophenol Interim Final. OSWER Directive 9285.7-58

Table 31: Calculating LOAEL-based Avian TRVs for **DDT and Metabolites**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			0.0396	0.396	0.0396	0.396
			0.0563	0.281	0.0563	0.281
			0.0754	0.754	0.0754	0.754
			0.113	1.13	0.113	1.13
			0.197	1.97	0.197	1.97
			0.370	0.494	0.370	0.494
			0.563	1.892	0.563	1.892
	0.563				0.563	
	0.592				0.592	
			1.30	5.20	1.30	5.20
	1.93				1.93	
	1.94				1.94	
	1.95				1.95	
	1.98				1.98	
	2.47				2.47	
	2.47				2.47	
	2.47				2.47	
	2.72				2.72	
	2.74				2.74	
	2.74				2.74	
	2.83				2.83	
	2.83				2.83	
	2.99				2.99	
	3.01				3.01	
	3.03				3.03	
	3.08				3.08	
			4.51	6.07	4.51	6.07
	4.67				4.67	
	4.67				4.67	
	5.20				5.20	
			5.28	21.1	5.28	21.1
	6.09				6.09	
	6.09				6.09	
			6.50	32.5	6.50	32.5
			9.37	46.9	9.37	46.9
	9.85				9.85	
	11.5				11.5	
	12.3				12.3	
	12.7				12.7	
	14.1				14.1	
			14.2	42.5	14.2	42.5
			14.5	29.0	14.5	29.0
	16.4				16.4	
	22.4				22.4	
	22.9				22.9	
			25.0	37.5	25.0	37.5
	25.0				25.0	
			25.7	51.5	25.7	51.5
	37.6				37.6	
		0.211				0.211
		0.281				0.281
		0.294				0.294
		0.366				0.366
		0.473				0.473
		0.494				0.494
		0.494				0.494

Table 31: Calculating LOAEL-based Avian TRVs for **DDT and Metabolites**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
		0.562				0.562
		0.563				0.563
		0.563				0.563
		0.563				0.563
		0.563				0.563
		0.563				0.563
		0.563				0.563
		1.12				1.12
		1.13				1.13
		1.14				1.14
		1.14				1.14
		1.24				1.24
		1.36				1.36
		1.44				1.44
		1.68				1.68
		2.25				2.25
		2.20				2.20
		2.25				2.25
		2.25				2.25
		2.25				2.25
		2.25				2.25
		2.25				2.25
		2.25				2.25
		2.41				2.41
		2.41				2.41
		2.73				2.73
		2.8				2.8
		2.81				2.81
		4.22				4.22
		4.57				4.57
		4.58				4.58
		4.94				4.94
		5.19				5.19
		6.02				6.02
		6.29				6.29
		12.5				12.5
		13.0				13.0
		13.0				13.0
		13.8				13.8
		14.8				14.8
		36.0				36.0
Growth (GRO)			0.227	2.27	0.227	2.27
			0.558	2.79	0.558	2.79
	1.10				1.10	
			1.47	2.95	1.47	2.95
	1.93				1.93	
	2.99				2.99	
	3.01				3.01	
	9.85				9.85	
	11.5				11.5	
	12.2				12.2	
	12.3				12.3	
	13.4				13.4	
	13.8				13.8	
	14.1				14.1	
			14.2	42.5	14.2	42.5

Table 31: Calculating LOAEL-based Avian TRVs for **DDT and Metabolites**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	16.4				16.4	
	18.0				18.0	
	21.1				21.1	
	22.4				22.4	
	25.0				25.0	
	25.1				25.1	
	28.5				28.5	
	30.7				30.7	
	35.6				35.6	
	37.6				37.6	
	72.0				72.0	
		0.592				0.592
		0.713				0.713
		1.04				1.04
		3.08				3.08
		6.02				6.02
		6.02				6.02
		13.0				13.0
		18.9				18.9
		42.5				42.5
Survival (MOR)	0.211				0.211	
	0.324				0.324	
			0.325	1.30	0.325	1.30
			0.411	4.51	0.411	4.51
	0.713				0.713	
			0.754	7.54	0.754	7.54
			1.04	5.21	1.04	5.21
	1.10				1.10	
			1.42	2.85	1.42	2.85
			1.46	2.93	1.46	2.93
	1.93				1.93	
			2.03	20.3	2.03	20.3
	2.25				2.25	
			2.27	22.7	2.27	22.7
	2.72				2.72	
	2.74				2.74	
	2.74				2.74	
	3.08				3.08	
			3.44	13.8	3.44	13.8
	4.58				4.58	
	4.6				4.6	
			5.19	130	5.19	130
	5.20				5.20	
			6.02	21.9	6.02	21.9
	6.09				6.09	
	6.09				6.09	
			6.3	25.1	6.3	25.1
			9.84	85.3	9.84	85.3
	10.5				10.5	
	11.0				11.0	
	11.5				11.5	
	11.8				11.8	
			11.9	59.4	11.9	59.4
	13.5				13.5	
	13.5				13.5	
	13.6				13.6	

Table 31: Calculating LOAEL-based Avian TRVs for **DDT and Metabolites**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
			13.8	25.0	13.8	25.0
			14.2	43.5	14.2	43.5
	16.7				16.7	
	21.1				21.1	
			23.7	35.6	23.7	35.6
			25.7	51.5	25.7	51.5
	26.8				26.8	
			29.0	58.1	29.0	58.1
	36.1				36.1	
			66.2	132	66.2	132
			100	200	100	200
		0.293				0.293
		0.294				0.294
		0.298				0.298
		0.713				0.713
		1.10				1.10
		11.5				11.5
		18.0				18.0
		28.5				28.5
		37.8				37.8
		55.7				55.7
		76.0				76.0
Geomean (REP+GRO)	**7.07**	**2.14**	**1.37**	**5.32**	**0.227***	**2.70**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for DDT and Meetabolites. Interim Final. OSWER Directive 9285.7-57

Table 32: Calculating LOAEL-based Mammalian TRVs for **DDT and Metabolites**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			0.110	0.274	0.110	0.274
			0.139	0.694	0.139	0.694
			0.147	0.735	0.147	0.735
	0.371				0.371	
	0.731				0.731	
			0.894	1.79	0.894	1.79
	1.30				1.30	
	1.65				1.65	
			1.71	17.1	1.71	17.1
	2.28				2.28	
	2.40				2.40	
	2.57				2.57	
	5.1				5.1	
	6.7				6.7	
	7.07				7.07	
			7.62	19.0	7.62	19.0
			9.90	99.0	9.90	99.0
			10.0	50.0	10.0	50.0
	12.4				12.4	
			17.1	85.3	17.1	85.3
	17.2				17.2	
			25.8	38.8	25.8	38.8
	32.2				32.2	
			47.8	95.6	47.8	95.6
	50.0				50.0	
	60.7				60.7	
	99				99	
	100				100	
		0.020				0.020
		0.020				0.020
		0.636				0.636
		0.70				0.70
		0.731				0.731
		1.0				1.0
		2.0				2.0
		2.0				2.0
		3.0				3.0
		3.82				3.82
		4.22				4.22
		6.60				6.60
		9.90				9.90
		16.2				16.2
		25.3				25.3
		200				200
Growth (GRO)	0.694				0.694	
	0.735				0.735	
	1.27				1.27	
	1.42				1.42	
			1.43	4.19	1.43	4.19
	1.50				1.50	
	1.77				1.77	

Table 32: Calculating LOAEL-based Mammalian TRVs for **DDT and Metabolites**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	2.00				2.00	
	2.04				2.04	
	6.54				6.54	
	7.07				7.07	
	12.4				12.4	
	13.5				13.5	
	13.5				13.5	
	13.6				13.6	
	13.7				13.7	
			16.9	33.7	16.9	33.7
	17.5				17.5	
	17.6				17.6	
	19.4				19.4	
	19.4				19.4	
	19.5				19.5	
	19.6				19.6	
	22.6				22.6	
	26.5				26.5	
			48.3	96.5	48.3	96.5
	60.7				60.7	
	76.2				76.2	
			90.3	137	90.3	137
	96.3				96.3	
	98.8				98.8	
	200				200	
		0.20				0.20
		1.75				1.75
		7.5				7.5
		15.0				15.0
		47.3				47.3
		62.9				62.9
Survival (MOR)	0.863				0.863	
	0.989				0.989	
			1.55	5.18	1.55	5.18
	2.04				2.04	
	2.40				2.40	
	2.57				2.57	
			6.10	24.39	6.10	24.39
	8.22				8.22	
	9.95				9.95	
			12.7	25.4	12.7	25.4
	17.5				17.5	
	17.6				17.6	
	19.4				19.4	
	19.4				19.4	
	19.5				19.5	
	22.6				22.6	
	25.3				25.3	
			25.4	81.2	25.4	81.2
	31.9				31.9	
	32.2				32.2	

Table 32: Calculating LOAEL-based Mammalian TRVs for **DDT and Metabolites**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
			34.9	69.7	34.9	69.7
			90.3	137	90.3	137
	96.5				96.5	
	119				119	
		15.3				15.3
		39.8				39.8
		62.9				62.9
Geomean (REP+GRO)	**9.15**	**2.91**	**4.47**	**14.4**	**0.147***	**5.56**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for DDT and Meetabolites. Interim Final. OSWER Directive 9285.7-57

Table 33: Calculating LOAEL-based Avian TRVs for **Dieldrin**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			0.0671	0.223	0.0671	0.223
	0.118				0.118	
			0.260	0.519	0.260	0.519
			0.450	0.675	0.450	0.675
	0.563				0.563	
			0.852	1.70	0.852	1.70
	0.880				0.880	
	0.900				0.900	
			0.905	1.51	0.905	1.51
	1.05				1.05	
	1.09				1.09	
	1.17				1.17	
	1.17				1.17	
			1.30	2.60	1.30	2.60
	4.32				4.32	
	4.42				4.42	
	10.5				10.5	
		0.0445				0.0445
		0.122				0.122
		0.226				0.226
		0.403				0.403
		0.674				0.674
		1.18				1.18
		1.52				1.52
		2.60				2.60
Growth (GRO)			0.0709	3.78	0.0709	3.78
	0.118				0.118	
			0.260	0.519	0.260	0.519
	0.574				0.574	
	0.650				0.650	
	1.09				1.09	
	1.17				1.17	
			2.02	10.1	2.02	10.1
	3.33				3.33	
			4.15	5.93	4.15	5.93
	10.0				10.0	
		0.236				0.236
		0.439				0.439
		0.960				0.960
Survival (MOR)	0.0445				0.0445	
			0.0537	0.179	0.0537	0.179
			0.0709	3.78	0.0709	3.78
			0.270	0.540	0.270	0.540
			0.281	0.563	0.281	0.563
			0.625	1.25	0.625	1.25
	0.650				0.650	
			0.852	1.70	0.852	1.70
	0.880				0.880	
	1.17				1.17	
			1.17	2.35	1.17	2.35

Table 33: Calculating LOAEL-based Avian TRVs for **Dieldrin**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
			1.30	2.60	1.30	2.60
	1.36				1.36	
			1.48	4.15	1.48	4.15
			2.00	4.00	2.00	4.00
			2.21	4.42	2.21	4.42
			10.00	15.00	10.00	15.00
	10.1				10.1	
		0.438				0.438
		0.546				0.546
		0.651				0.651
		1.67				1.67
Geomean (REP+GRO)	1.21	0.45	0.51	1.51	0.0709*	0.801

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for Dieldrin. Interim Final. OSWER Directive 9285.7-56

Table 34: Calculating LOAEL-based Mammalian TRVs for **Dieldrin**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			0.015	0.030	0.015	0.030
	0.050				0.050	
			0.140	0.720	0.140	0.720
	0.810				0.810	
	4.00				4.00	
	5.00				5.00	
	5.22				5.22	
		0.228				0.228
		0.278				0.278
		0.564				0.564
		0.646				0.646
Growth (GRO)	0.050				0.050	
			0.392	1.96	0.392	1.96
			0.600	2.00	0.600	2.00
	0.810				0.810	
	0.839				0.839	
			0.87	1.74	0.87	1.74
			1.02	2.05	1.02	2.05
	1.26				1.26	
	1.43				1.43	
			2.61	5.22	2.61	5.22
			2.61	5.22	2.61	5.22
	4.00				4.00	
	8.0				8.0	
			9.02	18.0	9.02	18.0
	11.8				11.8	
		0.140				0.140
		0.400				0.400
		0.700				0.700
		2.64				2.64
		4.31				4.31
		5.00				5.00
		16.5				16.5
Survival (MOR)			0.113	0.225	0.113	0.225
			0.133	1.33	0.133	1.33
			0.449	0.749	0.449	0.749
	0.564				0.564	
			0.600	2.00	0.600	2.00
	0.650				0.650	
	0.720				0.720	
			0.784	3.92	0.784	3.92
			0.791	3.96	0.791	3.96
	0.810				0.810	
			0.87	1.74	0.87	1.74
	1.14				1.14	
	1.19				1.19	
	1.28				1.28	
			1.67	2.23	1.67	2.23
			1.76	3.53	1.76	3.53
	2.05				2.05	
			2.61	5.22	2.61	5.22

Table 34: Calculating LOAEL-based Mammalian TRVs for **Dieldrin**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	4.00				4.00	
	5.22				5.22	
			6.05	24.2	6.05	24.2
	8.0				8.0	
			9.42	18.8	9.42	18.8
	12.8				12.8	
		3.00				3.00
		5.82				5.82
Geomean (REP+GRO)	**1.42**	**0.99**	**0.67**	**1.74**	**0.015***	**1.27**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 6.1 in Ecological Soil Screening Levels for Dieldrin. Interim Final. OSWER Directive 9285.7-56

Table 35: Calculating LOAEL-based Mammalian TRVs for **Low Molecular Weight PAHs**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)	120				120	
	133				133	
			150	450	150	450
			250	630	250	630
	267				267	
	294				294	
	400				400	
		300				300
		300				300
Growth (GRO)			50.0	150	50.0	150
	50.0				50.0	
			52.7	110	52.7	110
			53.0	267	53.0	267
			65.6	328	65.6	328
	104				104	
	120				120	
	133				133	
			250	630	250	630
	294				294	
	300				300	
	400				400	
			725	1460	725	1460
			735	1470	735	1470
		50.0				50.0
		300				300
		700				700
Survival (MOR)	50.0				50.0	
	120				120	
	133				133	
			250	500	250	500
			250	630	250	630
	267				267	
	294				294	
	400				400	
	450				450	
		300				300
		300				300
Geomean (REP+GRO)	**184**	**248**	**153**	**435**	**65.6***	**356**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value
NOAEL = no observed adverse effect level
LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for PAHs. Interim Final. OSWER Directive 9285.7-78

Table 36: Calculating LOAEL-based Mammalian TRVs for **High Molecular Weight PAHs**

Biological Endpoint	Unbounded TRVs		Bounded TRVs		Combined TRVs	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Reproduction (REP)			10.0	40.0	10.0	40.0
			13.3	26.4	13.3	26.4
		45.9				45.9
Growth (GRO)			3.09	12.4	3.09	12.4
			5.0	50.0	5.0	50.0
	10.0				10.0	
			11.8	24.0	11.8	24.0
			13.3	26.4	13.3	26.4
			21.1	63.4	21.1	63.4
	28.5				28.5	
	31.7				31.7	
			49.0	98.0	49.0	98.0
			53.9	118	53.9	118
	125				125	
		20.7				20.7
		27.3				27.3
		50.0				50.0
Survival (MOR)			0.615	3.07	0.615	3.07
			13.3	26.4	13.3	26.4
	27.3				27.3	
	31.7				31.7	
Geomean (REP+GRO)	**32.6**	**33.7**	**13.8**	**40.7**	**0.615***	**38.4**

*The geometric mean of the combined NOAEL TRVs exceeded the lowest-bounded LOAEL for reproduction, growth, or survival. As a result, EPA selected as the final combined NOAEL TRV the highest-bounded NOAEL which fell below the lowest-bounded LOAEL for reproduction, growth, or survival.

TRV = toxicity reference value

NOAEL = no observed adverse effect level

LOAEL = lowest oberved adverst effect level

Source: Table 5.1 in Ecological Soil Screening Levels for PAHs. Interim Final. OSWER Directive 9285.7-78

Attachment 4

ROBERTS ENVIRONMENTAL CONSULTING, INC.

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MEMORANDUM

TO: Warren Diesl, Sean Czarniecki DATE: October 16, 2011
FROM: Deborah Roberts
SUBJECT: Peterson Puritan - BERA Refinement Values Review

INTRODUCTION

This memo has been prepared to document the reasoning behind the revision of input values utilized during refinement of the wildlife modeling performed for the ecological risk assessment for the Peterson/Puritan, Inc. Superfund Site, Operable Unit 2 (OU2). Discussion follows which documents evaluation of input values used in the original models presented in the Baseline Ecological Risk Assessment (BERA).

The BERA for the Peterson Puritan Site, Operable Unit 2, was written by Arcadis BBL in June of 2007 and revised in November of 2007 and September of 2008 based on regulator comments. Following the September 2008 revision, the US EPA (EPA) still had substantial concerns regarding the interpretation of risks in the BERA. EPA undertook a revision of substantial portions of the BERA text and issued alternative text that was incorporated into an Agency Revision document in August 2009.

In July 2011, as the site moved into the FS phase, EPA found that, for some contaminants, the risks presented in the BERA were more extensive than expected based on site knowledge. This was especially true for bis(2-ethylhexyl)phthalate (BEHP), which is rarely a risk-driving chemical in ecological risk assessments. Zinc and lead also seemed to have HQs above what would typically be seen in a BERA based on the concentrations found on site. These unusual findings, combined with the overall difficulty in setting Remedial Action Outcomes (RAOs) for terrestrial risk, prompted EPA to re-examine the assumptions in the food chain models to see if further refinement would provide a clearer picture of risks for OU 2.

The revisions to the model were originally presented in a Draft Internal Memo by Bart Hoskins dated July 21, 2011. In response to comments from the State of Rhode Island Department of Environmental Management (RIDEM), EPA was asked to specifically discuss why the former values for toxicity reference values (TRVs)for lead and zinc, and biota-to-soil accumulation factors (BSoilAFs) for zinc and BEHP were found to be lacking and replaced by updated values during the model refinement.

TOXICITY REFERENCE VALUES

Lead

The TRVs for lead used for large and small omnivorous birds in the BERA were listed in Table 7-4a (Attachment 1) as 0.0114 mg/kgBW/day for the no observed effects level (NOAEL) and 0.114

mg/kgBW/day for the lowest observed effects level. Both of these values were low compared to frequently used values in risk assessment, but were accepted for use in the BERA during revisions, as they were considered conservative. The BERA refers to a citation from the U.S. Department of the Navy (USDON), 2004 as the source for these values. However, USDON, 2004 is a reference to a BERA for a Navy facility, and not a primary source. The values of 0.014/0.14 mg/kgBW/day are cited elsewhere in literature as the lead TRVs for birds and the 0.014 mg/kgBW/day is cited by the EPA Region 9 Biological Technical Advisory Group (BTAG) as originating from a study of Japanese quail, not kestrel (Attachment 2). There is no American kestrel study cited in the Eco-SSL database resulting in a NOAEL TRV of 0.0114 mg/KgBW/day and there is no NOAEL TRV in the Eco-SSL database (of over 100 NOAEL or LOAEL values) that is as low as 0.0114 mg/kg BW/day (Attachment 3). The NOAEL of 0.014 mg/kgBW/day is presented by EPA Region 9 BTAG as the low TRV values in both the 2002 and 2009 revision of the BTAG recommended TRVs for birds (Attachment 2). The source of this value is cited by Region 9 BTAG as the quail study by Edens, et al. (1967). However, in Sample, et al., (1999), this study is cited as resulting in a NOAEL dose of lead acetate at the 10 ppm level which corresponded to a NOAEL TRV of 1.113 mg/kgBW/day, whereas the EPA (2005a) citation for this study reports observed effects on Japanese quail at a dose of 1.0 ppm, and a calculated reproductive LOAEL of 0.111 mg/kgBW/day (Attachment 3). Although the values in the BERA used for the TRVs for lead were close to the lowest value found in the literature for avian receptors, the use of this value was very conservative, and the primary source of the study from which it was derived could not be verified. A weakness of this selection is that it was based on a single study, with one form of lead, and a single species that may or may not be representative of the sensitivity of the receptor species at the site. During the refinement of risk step, a more robust TRV is preferred so that evaluation does not result in overly-protective risk scenarios; in the refinement, selected TRVs incorporate data from a large number of studies, species, and endpoints, which is preferable if these data are available.

Zinc

The TRVs for zinc used for large and small omnivorous birds in the BERA were listed in Table 7-4a (Attachment 1) as 14.5 mg/kgBW/day for the no observed effects level (NOAEL) and 131 mg/kgBW/day for the lowest observed effects level. The cited source of these values was Sample, et al., 1996. The primary source for this study was a study on white leghorn chickens (Stahl, et al., 1990), fed zinc sulfate with a chronic reproductive endpoint.

Similar to lead, a weakness of this selection is that it was based on a single study, with one form of zinc, and a single species that may or may not be representative of the sensitivity of the receptor species at the site. During the refinement of risk step, a more robust TRV is preferred so that evaluation does not result in overly-protective risk scenarios; the selected TRVs should incorporate data from a large number of studies, species, and endpoints if these data are available.

BIOTA-TO-SOIL ACCUMULATION FACTORS

Zinc

The BSoilAF for zinc shown in Table 7-3 of the BERA and used to estimate the concentration of zinc in the diet of omnivorous birds was 13.7 (Attachment 4). This value is very high and indicates strong bioaccumulation of zinc into tissue of earthworms to a concentration 13.7 times higher than the surrounding soil. Table 7-3 of the BERA cited USEPA (2005b; Eco-SSL guidance) as the source for this value. However, this guidance document provides an uptake equation from soil to earthworms. It is unclear why the BERA selected the highly conservative uptake value of 13.7 rather than using the equation in the Eco-SSL guidance. Selection of a single uptake value indicates a linear relationship of the concentration of zinc in the soil and the concentration of zinc in the tissue of earthworms. Field data with metal uptake by organisms often demonstrates that a linear model does not best represent the data.

Bis-2-exylhexyl phthalate (BEHP)

The BSoilAF for BEHP used in the BERA to estimate the concentration of BEHP in the diet of omnivorous birds was 129 (Attachment 4). This value appears to be derived in the BERA from physical/chemical properties and a formula used to estimate BSoilAF values presented in the Eco SSL Development Guidance document (EPA, 2005b). This method of estimating a BSoilAF is only recommended when no chemical specific data are available. In comparison to similar non-ionic organic compounds, this uptake value is very high. The value used in the BERA was adequate for a conservative estimate of uptake to earthworms, however, chemical specific data would be preferred, if available, during refinement of risk.

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ATTACHMENT 1

TABLE 7-4a
AVIAN TOXICITY BENCHMARKS

BASELINE ECOLOGICAL RISK ASSESSMENT
PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

Chemical Name	CAS No.	NOAEL (mg/kgBW/day)	LOAEL (mg/kgBW/day)	Test Species	Source
PCBs					
Aroclor 1016	12674-11-2	--	--		
Aroclor 1221	11104-28-2	--	--		
Aroclor 1232	11141-16-5	--	--		
Aroclor 1242	53469-21-9	0.41	0.82	screech owl	Sample et al. (1996)
Aroclor 1248	12672-29-6	--	--		
Aroclor 1254	11097-69-1	0.18	1.8	ring-necked pheasant	Sample et al. (1996)
Aroclor 1260	11096-82-5	--	--		
Metals					
Aluminum	7429-90-5	109.7	1,097	ringed dove	Sample et al. (1996)
Antimony	7440-36-0	--	--		
Arsenic	7440-38-2	1.85	3.88	brown-headed cow bird	USDON (2004)
Barium	7440-39-3	20.8	41.7	1-day old chicks	Sample et al. (1996)
Beryllium	7440-41-7	--	--		
Cadmium	7440-43-9	1.45	3.05	mallard duck	Sample et al. (1996)/USDON (2004)
Chromium	7440-47-3	1	5	black duck	Sample et al. (1996)/USDON (2004)
Cobalt	7440-48-4	--	--		
Copper	7440-50-8	22.3	31.5	1-day old chicks	USDON (2004)
Cyanide	57-12-5	--	--		
Iron	7439-89-6	--	--		
Lead	7439-92-1	0.0114	0.114	American kestrel	USDON (2004)
Manganese	7439-96-5	77.6	776	Japanese quail	USDON (2004)
Mercury	7439-97-6	0.0064	0.064	Japanese quail	Sample et al. (1996)
Nickel	7440-02-0	25.1	45.3	mallard duckling	USDON (2004)
Selenium	7782-49-2	0.4	0.603	mallard duck/black-crowned night heron	Sample et al. (1996)/USDON (2004)
Silver	7440-22-4	9.36	19.2	bounded NOAEL & lowest LOAEL	USDON (2004)
Thallium	7440-28-0	--	--		
Vanadium	7440-62-2	11.4	22.8	mallard duck	Sample et al. (1996)
Zinc	7440-66-6	14.5	131	white leghorn hen	Sample et al. (1996)/USDON (2004)

Notes:
Shaded cells indicates a LOAEL is not available for birds. Value is estimated as 2 times the NOAEL value.
-- - not listed
CAS - chemical abstract number
NOAEL - no observable adverse effect level
LOAEL - lowest observable adverse effect level

ATTACHMENT 2

U.S. EPA Region 9 Biological Technical Assistance Group (BTAG) Recommended Toxicity Reference Values for Birds (Revision Date 02/24/09)

Chemical	Low TRV mg/kg-day	High TRV mg/kg-day	Test Species	Toxic Endpoint(s)	Reference
Arsenic	5.5	22.0	Mallard	Reproductive	Stanley *et al.*, 1994
Butyltins	0.73	45.9	Quail	Reproductive	Schlatterer *et al.*, 1993
Cadmium	0.7	-	Wood duck	Kidney histology	Mayack et al., 1981
	-	1.0 LOAEL	Mallard	Kidney histology	Cain et al., 1983
	-	10.4 Mid-Range Adverse Effect Level	Mallard	Reproductive, multiple systemic effects	Richardson *et al.*, 1974
Copper	2.3	-	Chicken	Growth	Norvell *et al.*, 1975
	-	52.3	Chicken	Growth, gizzard erosion	Jensen & Maurice, 1978
DDT and Metabolites	0.009	-	Pelican	Reproductive	USEPA (Great Lakes), 1995
	-	1.5	Mallard	Reproductive	USEPA (Great Lakes), 1995
DDE	-	0.6	Mallard	Reproductive	USEPA (Great Lakes), 1995
Lead	0.014	-	Quail	Reproductive	Edens *et al.*, 1967
	-	8.75	Chicken	Reproductive	Edens & Garlich, 1983
Manganese	77.6	776	Quail	Neurobehavioral	Laskey & Edens, 1985
Mercury	0.039	-	Mallard	Reproductive	USEPA (Great Lakes), 1995
	-	0.18	Mallard	Mortality, neurological	USEPA (Great Lakes), 1995
Nickel	1.38	-	Mallard	Growth	Cain & Pafford, 1981
	-	56.3	Mallard	Growth	Cain & Pafford, 1981
PCBs	0.09	-	Chicken	Reproductive	Platonow & Reinhart, 1973
	-	1.27	Chicken	Reproductive	Britton & Huston, 1973
Selenium	0.23	0.93	Mallard	Reproductive	Heinz *et al.*, 1989
Zinc	17.2	172	Mallard	Growth, reproductive, multiple organs	Gasaway & Buss, 1972

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ATTACHMENT 3

Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Lead
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Ref			Exposure																				Effects						Conversion to mg/kg bw/day				Result		Data Evaluation Score											
Result #	Ref N.		Chemical Form	MW%	Test Species	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in kg/day or L/day	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Source	Dose Route	Test Concentrations	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total
Biochemical																																													
1	2860	Scheuhammer, 1987	Lead nitrate	100	Zebra finch (*Poephila guttata*)	7	0/1/5/10/30/50/100	ug/g diet	N		ADL	U	FD	35	d	NR	NR	AD	M	C	Lab	ENZ	ALAD	BL	1.0	5.0	N	0.99	N	0.0578	0.0584	0.292	10	10	5	10	5	1	8	10	6	4	69
2	2608	Edens and Garlich, 1983	Lead acetate	100	Japanese quail (*Coturnix japonica*)	4	0/1/10/100	mg/kg diet	N		ADL	U	FD	5	w	6	w	JV	F	C	Lab	CHM	CALC	BL	1.0	10.0	N	0.155	Y	0.030	0.194	1.94	10	10	5	5	5	1	8	10	10	4	68
3	2608	Edens and Garlich, 1983	Lead acetate	100	Japanese quail (*Coturnix japonica*)	4	0/1/10/100	mg/kg diet	N		ADL	U	FD	5	w	6	d	JV	F	C	Lab	CHM	CALC	BL	1.0	10.0	Y	0.155	Y	0.030	0.194	1.94	10	10	5	5	7	1	8	10	10	4	70
4	2624	Finley et al., 1976	Lead nitrate	100	Mallard (*Anas platyrhynchos*)	4	0/1.76/5.13/21.63	mg/kg diet	Y	10.4	ADL	M	FD	12	w	1	yr	AD	M	C	Lab	ENZ	ALAD	BL	1.76	5.13	Y	1.162	Y	0.119	0.201	0.586	10	10	10	10	7	1	10	10	6	4	78
5	2608	Edens and Garlich, 1983	Lead acetate	100	Chicken (*Gallus domesticus*)	5	0/50/100/200/400	mg/kg diet	N		ADL	U	FD	2	w	NR	NR	AD	F	C	Lab	CHM	CALC	BL	100	200	Y	1.78	Y	0.111	6.24	12.5	10	10	5	5	7	1	10	10	10	4	72
6	2779	Morgan et al., 1975	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/1/10/100/1000	mg/kg diet	N		ADL	U	FD	5	w	6	d	JV	NR	C	Lab	CHM	HMGL	BL	100	1000	Y	0.11	N	0.0138	12.6	126	10	10	5	5	6	1	8	10	10	4	69
7	2779	Morgan et al., 1975	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/10/100/500/1000	mg/kg diet	N		ADL	U	FD	5	w	1	d	JV	NR	C	Lab	CHM	HMGL	BL	100	500	Y	0.09	N	0.0121	13.5	67.4	10	10	5	5	6	1	8	10	10	4	69
8	6463	Stone et al., 1981	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/25/50/100/200	mg/kg diet	N		NR	U	FD	14	d	1	d	JV	B	C	Lab	CHM	HMGL	BL	200		N	0.0444	N	0.0077	34.5		10	10	5	10	5	1	4	10	10	4	69
9	2606	Edens et al., 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/1/10/100/1000	ug/g diet	N		ADL	U	FD	12	w	0	d	JV	F	C	Lab	CHM	CALC	BL		1.0	N	0.159	N	0.0152		0.111	10	10	5	5	5	1	4	10	10	7	67
10	2636	Franson et al., 1983	Lead metallic	100	American kestrel (*Falco sparverius*)	3	0/9.67/54.0	mg/kg diet	Y	56.7	DLY	M	FD	6	mo	1-6	yr	AD	B	C	FieldA	ENZ	ALAD	BL		9.67	Y	0.1505	N	0.0170		2.52	10	10	10	10	6	1	4	10	6	4	71
11	14770	Kendall and Scanlon, 1982	Lead acetate	100	Ringed Turtle Dove (*Streptopelia risoria*)	4	0.0/25.0/50.0/75.0	mg/kg bw/d	N		1 per d	U	GV	7	d	NR	NR	AD	M	V	Lab	ENZ	ALAD	BL		25.0	Y	0.1392	N	0.0161		25.0	10	8	10	5	10	1	4	10	6	4	68
12	11651	Hoffman et al, 1985	Metallic lead powder	100	American kestrel (*Falco sparverius*)	4	0/25/125/625	mg/kg bw/d	Y		DLY	U	GV	10	d	1	d	JV	NR	V	Lab	CHM	HMGL	BL		25.0	N	0.0753	N	0.0108		26.3	10	8	10	10	10	1	4	10	10	4	77
13	2609	Edens and Melvin, 1989	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/500	mg/kg diet	N		ADL	U	FD	7	w	14	w	JV	F	C	Lab	CHM	CALC	PL		500	Y	0.145	Y	0.027		93.1	10	10	5	5	7	1	4	10	10	4	66
Behavior																																													
14	2624	Finley et al., 1976	Lead nitrate	100	Mallard (*Anas platyrhynchos*)	4	0/1.76/5.13/21.63	mg/kg diet	Y	10.4	ADL	M	FD	12	w	1	yr	AD	M	C	Lab	FDB	FCNS	WO	21.6		Y	1.162	Y	0.119	2.47		10	10	10	10	7	4	4	1	6	4	66
15	2608	Edens and Garlich, 1983	Lead acetate	100	Chicken (*Gallus domesticus*)	5	0/50/100/200/400	mg/kg diet	N		ADL	U	FD	10	w	NR	NR	AD	F	C	Lab	FDB	FCNS	WO	50.0	100	Y	1.81	Y	0.118	3.26	6.52	10	10	5	5	7	4	10	10	10	4	75
16	14768	Damron et al, 1969	Lead acetate	100	Chicken (*Gallus domesticus*)	4	0/10/100/1000	mg/kg diet	N		DLY	U	FD	4	w	4	w	JV	NR	C	Lab	FDB	FEFF	WO	100	1000	N	1.042	Y	0.0740	7.10	71.0	10	10	5	5	6	4	8	10	10	4	72
17	2809	Pattec 1984	Metallic lead	100	American kestrel (*Falco sparverius*)	3	0/19.80/104.40	mg/kg diet	N		DLY	M	FD	6	mo	1-6	yr	AD	B	C	FieldA	FDB	FCNS	WO	104		Y	0.1439	N	0.0165	12.0		10	10	10	10	6	4	4	1	10	10	75
18	14768	Damron et al, 1969	Lead acetate	100	Chicken (*Gallus domesticus*)	4	0/100/1000/2000	mg/kg diet	N		DLY	U	FD	4	w	4	w	JV	NR	C	Lab	FDB	FEFF	WO	1000	2000	N	1.042	Y	0.0640	61.4	123	10	10	5	5	6	4	10	10	10	4	74
19	1285	Donaldson and McGowan, 1989	Lead acetate	100	Chicken (*Gallus domesticus*)	5	0/500/1000/1500/2000	mg/kg diet	N		NR	U	FD	20	d	1	d	JV	M	C	Lab	FDB	FEFF	WO	2000		Y	0.378	N	0.0309	163		10	10	5	5	6	4	4	10	10	4	68
20	2517	Bafundo et al.	Lead acetate trihydrate	100	Chicken (*Gallus domesticus*)	4	0/1100/2200/3300	mg/kg diet	N		ADL	U	FD	14	d	8	d	JV	M	C	Lab	BEH	FEFF	WO	2200	3300	N	0.084	N	0.0116	304	456	10	10	5	5	5	4	10	10	10	4	73
21	2608	Edens and Garlich, 1983	Lead acetate	100	Japanese quail (*Coturnix japonica*)	4	0/1/10/100	mg/kg diet	N		ADL	U	FD	5	w	1	d	JV	F	C	Lab	FDB	FCNS	WO	10.0	100	Y	0.155	Y	0.0300	1.94	19.4	10	10	5	5	7	4	8	10	10	4	71
22	2526	Barthalmus et al., 1977	Lead acetate	100	Pigeon (*Columba livia*)	4	0/6.25/12.5/25.0	mg/kg bw/d	N		DLY	U	GV	17	d	NR	NR	AD	M	C	Lab	BEH	NMVM	WO		6.25	Y	0.48	N	0.0361		6.25	10	8	10	5	10	4	4	10	6	4	71
23	2898	Stone and Soares, 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	3	0/500/1000	mg/kg diet	N		ADL	U	FD	32	d	NR	NR	AD	F	C	Lab	FDB	FCNS	WO		500	Y	0.103	N	0.0133		64.3	10	10	5	5	6	4	4	10	10	4	68
24	2609	Edens and Melvin, 1989	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/500	mg/kg diet	N		ADL	U	FD	7	w	14	w	JV	F	C	Lab	FDB	FCNS	WO		500	Y	0.145	Y	0.027		93.1	10	10	5	5	7	4	4	10	10	4	69
25	2517	Bafundo et al.	Lead acetate trihydrate	100	Chicken (*Gallus domesticus*)	2	0/3300	mg/kg diet	N		ADL	U	FD	14	d	8	d	JV	M	C	Lab	BEH	FEFF	WO		3300	N	0.084	N	0.0116		456	10	10	5	5	5	4	4	10	10	4	67
Physiology																																													
26	2608	Edens and Garlich, 1983	Lead acetate	100	Chicken (*Gallus domesticus*)	5	0/50/100/200/400	mg/kg diet	N		ADL	U	FD	10	w	NR	NR	AD	F	C	Lab	PHY	SKIR	FE	100	200	Y	1.78	Y	0.111	6.24	12.5	10	10	5	5	7	4	10	10	10	4	75
Pathology																																													
27	2624	Finley et al., 1976	Lead nitrate	100	Mallard (*Anas platyrhynchos*)	4	0/1.76/5.13/21.63	mg/kg diet	Y	10.4	ADL	M	FD	12	w	1	yr	AD	M	C	Lab	GRS	BDWT	WO	21.6		Y	1.162	Y	0.119	2.33		10	10	10	10	7	4	4	1	6	4	66
28	6291	Stone and Fox, 1984	Lead acetate	100	Japanese quail (*Coturnix japonica*)	3	0/5.4/16.2	mg/kg diet	N		ADL	U	FD	14	d	1	d	JV	B	C	Lab	ORW	ORWT	LI	16.2		Y	0.0455	N	0.007786	2.77		10	10	5	5	6	4	4	10	10	4	68
29	2897	Stone et al., 1977	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/25	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	NR	C	Lab	ORW	SMIX	KI	25.0		Y	0.036	N	0.006685	4.64		10	10	5	5	6	4	4	8	10	4	66
30	2608	Edens and Garlich, 1983	Lead acetate	100	Chicken (*Gallus domesticus*)	5	0/50/100/200/400	mg/kg diet	N		ADL	U	FD	10	w	NR	NR	AD	F	C	Lab	GRS	BDWT	WO	100	200	Y	1.78	Y	0.111	6.24	12.5	10	10	5	5	7	4	10	10	10	4	75
31	2606	Edens et al., 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/1/10/100/1000	ug/g diet	N		ADL	U	FD	12	w	0	d	JV	M	C	Lab	ORW	ORWT	LI	100	1000	Y	0.127	N	0.0153	11.9	119	10	10	5	5	6	4	8	10	10	7	75
32	2809	Pattec 1984	Metallic lead	100	American kestrel (*Falco sparverius*)	3	0/19.80/104.40	mg/kg diet	N		DLY	M	FD	6	mo	1-6	yr	AD	B	C	FieldA	GRS	BDWT	WO	104		Y	0.1439	N	0.0165	12.0		10	10	10	10	6	4	4	10	10	10	84
33	2526	Barthalmus et al., 1977	Lead acetate	100	Pigeon (*Columba livia*)	4	0/6.25/12.5/25.0	mg/kg bw/d	N		DLY	U	GV	55	d	NR	NR	AD	M	C	Lab	GRS	BDWT	WO	12.5	25.0	N	0.48	N	0.0361	12.5	25.0	10	8	10	5	10	4	4	10	10	4	77
34	2636	Franson et al., 1983	Lead metallic	100	American kestrel (*Falco sparverius*)	3	0/9.67/54.0	mg/kg diet	Y	56.7	DLY	M	FD	6	mo	1-6	yr	AD	B	C	FieldA	ORW	SMIX	MT	54.0		Y	0.1505	N	0.0170	14.1		10	10	10	10	6	4	4	6	6	4	70
35	2576	Cory-Slechta et al., 1980	Lead acetate	100	Pigeon (*Columba livia*)	4	0/18/53/107	mg/kg bw/d	N		1 per d	U	GV	35	d	NR	NR	AD	M	C	Lab	ITX	GITX	WO	18.0	53.0	Y	0.676	N	0.045104	18.0	53.0	10	8	10	5	7	4	4	10	10	6	4	77
36	2696	Hoffman et al., 1985	Lead powder	100	American kestrel (Falco sparverius)	4	0/25/125/625	mg/kg bw	N		DLY	U	GV	10	d	1	d	JV	NR	V	FieldA	ORW	ORWT	BR	25.0	125	Y	0.0753	N	0.0108	25.0	125	10	8	10	10	10	4	8	10	10	4	84
37	2779	Morgan et al., 1975	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/10/100/500/1000	mg/kg diet	N		ADL	U	FD	5	w	1	d	JV	M	C	Lab	ORW	SMIX	AR	500	1000	Y	0.09	N	0.0121	67.4	135	10	10	5	5	6	4	10	10	10	4	74
38	14770	Kendall and Scanlon, 1982	Lead acetate	100	Ringed Turtle Dove (*Streptopelia risoria*)	4	0.0/25.0/50.0/75.0	mg/kg bw/d	N		1 per d	U	GV	7	d	NR	NR	AD	M	V	Lab	GRS	BDWT	WO	75.0		Y	0.1253	N	0.0151	75.0		10	8	10	5	10	4	4	8	6	4	69
39	2609	Edens and Melvin, 1989	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/500	mg/kg diet	N		ADL	U	FD	7	w	14	w	JV	F	C	Lab	ORW	SMIX	FM	500		Y	0.145	Y	0.027	93.1		10	10	5	5	7	4	4	8	10	4	67
40	2605	Edens, 1985	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/1/10/100/1000	mg/kg diet	N		NR	U	FD	12	w	1	w	JV	F	C	NR	ORW	SMIX	BR	1000		Y	0.131	N	0.015498	118		10	10	5	5	6	4	4	10	10	4	68
41	14384	Vengris and Mare, 1974	Lead acetate	100	Chicken (*Gallus domesticus*)	7	0/20/40/80/160/320/640	mg/kg bw	N		DLY	U	GV	35	d	6	w	JV	B	C	Lab	ITX	ANR	WO	160	320	N	0.0016	N	0.00088	160	320	10	8	10	5	10	4	4	10	10	4	81
42	818	Rao et al., 1989	Lead acetate	54.61	Duck (*Anas platyrhynchos*)	2	0/80	mg/kg diet	N		ADL	U	FD	12	w	7	mo	JV	F	C	Lab	HIS	GLBM	KI		80.0	N	3.12	N	0.122		1.71	10	10	5	5	4	4	10	10	4	67
43	817	Rao et al. 1989	Lead acetate	54.61	Duck (*Anas platyrhynchos*)	2	0/80	mg/kg diet	N		NR	U	FD	13	w	7	mo	JV	F	C	NR	HIS	GHIS	KI		80.0	N	1.1	N	0.0619		2.46	10	10	5	5	4	4	10	10	4	67
44	2513	Anders et al., 1982	Lead acetate	100	Pigeon (*Columba livia*)	2	0/6.25	mg/kg bw/d	N		DLY	U	GV	5	w	NR	NR	AD	M	C	Lab	HIS	GHIS	KI		6.25	Y	0.605	N	0.0420		6.25	10	8	10	5	10	4	4	10	3	4	68
45	1285	Donaldson and McGowan, 1989	Lead acetate	100	Chicken (*Gallus domesticus*)	5	0/500/1000/1500/2000	mg/kg diet	N		NR	U	FD	20	d	1	d	JV	M	C	Lab	ORW	ORWT	LI		500	N	0.46	N	0.0351		38.2	10	10	5	5	4	4	10	10	4	67
46	2898	Stone and Soares, 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	3	0/500/1000	mg/kg diet	N		ADL	U	FD	32	d	NR	NR	AD	F	C	Lab	ORW	SMIX	LI		500	Y	0.103	N	0.0133		64.3	10	10	5	5	6	4	4	10	10	4	68
47	2579	Cupo and Donaldson, 1987	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/2000	mg/kg diet	N		ADL	U	FD	21	d	1	d	JV	M	C	Lab	ORW	ORWT	AR		2000	Y	0.233	N	0.0225		194	10	10	5	5	6	4	4	10	10	4	68
48	2724	Johnsen and Damron 1982	Lead acetate	100	Goose (*Anser cygnides*)	5	0/500/1000/1500/2000	mg/kg diet	N		ADL	U	FD	12	w	26	w	JV	NR	C	FieldA	HIS	GHIS	LI		2000	N	2.27	Y	0.222		196	10	10	5	5	6	4	4	10	10	4	68
49	2898	Stone and Soares, 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/3000	mg/kg diet	N		ADL	U	FD	27	d	NR	NR	AD	F	C	Lab	ORW	SMIX	TB		3000	Y	0.11	N	0.0138		377	10	10	5	5	6	4	4	10	10	4	68
Reproduction																																													
50	2608	Edens and Garlich, 1983	Lead acetate	100	Japanese quail (*Coturnix japonica*)	4	0/1/10/100	mg/kg diet	N		ADL	U	FD	5	w	6	w	LB	F	C	Lab	REP	PROG	WO	1.0	10.0	N	0.155	Y	0.030	0.194	1.94	10	10	5	5	5	10	8	10	10	4	77

Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Lead
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Ref			Exposure																		Effects						Conversion to mg/kg bw/day				Result		Data Evaluation Score										
Result #	Ref N.		Chemical Form	MW%	Test Species	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in kg/day or L/day	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Source	Dose Route	Test Concentration	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total
51	2608	Edens and Garlich, 1983	Lead acetate	100	Chicken (*Gallus domesticus*)	3	0/25/50	mg/kg diet	N		ADL	U	FD	4	w	NR	NR	LB	F	C	Lab	REP	PROG	WO	25.0	50.0	N	1.81	Y	0.118	1.63	3.26	10	10	5	5	5	10	10	10	4	79
52	2771	Meluzzi et al., 1996	Lead oxide	100	Chicken (*Gallus domesticus*)	4	0/20/30/100	mg/kg diet	N		NR	U	FD	30	d	22	w	LB	F	C	Lab	EGG	ALWT	EG	20.0	30.0	N	1.042	Y	0.1403	2.69	4.04	10	10	5	10	6	10	10	10	6	81
53	2668	Haegele et al. 1974	Lead mixture	100	Mallard (*Anas platyrhynchos*)	2	0/100	mg/kg diet	N		ADL	U	FD	76	d	NR	NR	AD	F	C	FieldA	EGG	ESTH	EG	100		N	1.1	N	0.0619	5.63		10	10	5	10	5	10	4	10	3	4	71
54	2809	Pattec 1984	Metallic lead	100	American kestrel (*Falco sparverius*)	3	0/19.80/104.40	mg/kg diet	N		DLY	M	FD	6	mo	1-6	yr	AD	F	C	FieldA	REP	RSUC	WO	104		Y	0.1439	N	0.0165	12.0		10	10	10	10	6	10	4	10	10	10	90
55	2779	Morgan et al., 1975	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/1/10/100/1000	mg/kg diet	N		ADL	U	FD	5	w	6	d	JV	M	C	Lab	REP	TEWT	TE	100	1000	Y	0.11	N	0.0138	12.6	126	10	10	5	5	6	10	8	10	10	4	78
56	2779	Morgan et al., 1975	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/10/100/500/1000	mg/kg diet	N		ADL	U	FD	5	w	1	d	JV	M	C	Lab	REP	TEWT	TE	500	1000	Y	0.09	N	0.0121	67.4	135	10	10	5	5	6	10	10	10	10	4	80
57	2898	Stone and Soares, 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	3	0/500/1000	mg/kg diet	N		ADL	U	FD	32	d	NR	NR	AD	F	C	Lab	REP	PROG	WO	1000		Y	0.113	N	0.0141	125		10	10	5	5	6	10	4	3	10	4	67
58	2606		Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/1/10/100/1000	ug/g diet	N		ADL	U	FD	12	w	0	d	LB	B	C	Lab	REP	EGPN	EG		1.0	Y	0.159	N	0.0175			10	10	5	5	6	10	4	10	10	7	77
59	2608	Edens and Garlich, 1983	Lead acetate	100	Japanese quail (*Coturnix japonica*)	4	0/1/10/100	mg/kg diet	N		ADL	U	FD	12	w	NR	NR	LB	F	C	Lab	REP	PROG	WO		1.0	Y	0.155	Y	0.030		0.194	10	10	5	5	7	10	4	10	10	4	75
60	2608	Edens and Garlich, 1983	Lead acetate	100	Chicken (*Gallus domesticus*)	5	0/50/100/200/400	mg/kg diet	N		ADL	U	FD	10	w	NR	NR	LB	F	C	Lab	REP	PROG	WO		50.0	Y	1.81	Y	0.118		3.26	10	10	5	5	7	10	4	10	10	4	75
61	2734	Kendall and Scanlon, 1981	Lead acetate	100	Ringed Turtle Dove (*Streptopelia risoria*)	2	0/100	mg/L	N		ADL	U	DR	11	w	NR	NR	AD	M	C	Lab	REP	TEWT	TE		100	N	0.123	N	0.014491		11.8	10	5	5	5	5	10	4	10	10	4	68
62	2609	Edens and Melvin, 1989	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/500	mg/kg diet	N		ADL	U	FD	1	w	14	w	JV	F	C	Lab	REP	TPRD	WO		500	Y	0.145	Y	0.027		93.1	10	10	5	5	7	10	4	10	10	4	75
63	2898	Stone and Soares, 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/3000	mg/kg diet	N		ADL	U	FD	27	d	NR	NR	AD	F	C	Lab	REP	PROG	WO		3000	Y	0.11	N	0.0138		377	10	10	5	5	6	10	4	10	10	4	74
Growth																																												
64	2608	Edens and Garlich, 1983	Lead acetate	100	Japanese quail (*Coturnix japonica*)	4	0/1/10/100	mg/kg diet	N		ADL	U	FD	5	w	1	d	JV	F	C	Lab	GRO	BDWT	WO	10.0	100	Y	0.147	Y	0.0230	1.56	15.6	10	10	5	5	7	8	8	10	10	4	77
65	6291	Stone and Fox, 1984	Lead acetate	100	Japanese quail (*Coturnix japonica*)	3	0/5.4/16.2	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	B	C	Lab	GRO	BDWT	WO	16.2		Y	0.0455	N	0.007786	2.77		10	10	5	5	6	8	4	10	10	4	72
66	2897	Stone et al., 1977	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/25	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	NR	C	Lab	GRO	BDWT	WO	25.0		Y	0.036	N	0.006685	4.64		10	10	5	5	6	8	4	8	10	4	70
67	2609	Edens and Melvin, 1989	Lead acetate	100	Japanese quail (*Coturnix japonica*)	3	0/50/500	mg/kg diet	N		ADL	U	FD	4	w	0	d	JV	F	C	Lab	GRO	BDWT	WO	50.0	500	Y	0.13	N	0.0154	5.93	59.3	10	10	5	5	6	8	8	10	10	4	76
68	14768	Damron et al, 1969	Lead acetate	100	Chicken (*Gallus domesticus*)	4	0/100/1000/2000	mg/kg diet	N		DLY	U	FD	4	w	4	w	JV	NR	C	Lab	GRO	BDWT	WO	100	1000	N	1.042	Y	0.0640	6.1	61.4	10	10	5	5	6	8	8	10	10	4	76
69	14768	Damron et al, 1969	Lead acetate	100	Chicken (*Gallus domesticus*)	4	0/10/100/1000	mg/kg diet	N		DLY	U	FD	4	w	4	w	JV	NR	C	Lab	GRO	BDWT	WO	100	1000	N	1.042	Y	0.0740	7.1	71.0	10	10	5	5	6	8	8	10	10	4	76
70	2606	Edens et al., 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/1/10/100/1000	ug/g diet	N		ADL	U	FD	12	w	0	d	JV	F	C	Lab	GRO	BDWT	WO	100	1000	Y	0.157	N	0.0174	11.1	111	10	10	5	5	6	8	8	10	10	7	79
71	2605	Edens, 1985	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/1/10/100/1000	mg/kg diet	N		NR	U	FD	12	w	1	w	JV	F	C	NR	GRO	BDWT	WO	100	1000	Y	0.154	N	0.0172	11.2	112	10	10	5	5	6	8	8	10	10	4	76
72	2779	Morgan et al., 1975	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/1/10/100/1000	mg/kg diet	N		ADL	U	FD	2	w	6	d	JV	NR	C	Lab	GRO	BDWT	WO	100	1000	Y	0.11	N	0.0138	12.6	126	10	10	5	5	6	8	8	10	10	4	76
73	2779	Morgan et al., 1975	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/10/100/500/1000	mg/kg diet	N		ADL	U	FD	1	w	1	d	JV	NR	C	Lab	GRO	BDWT	WO	100	500	Y	0.09	N	0.0121	13.5	67.4	10	10	5	5	6	8	8	10	10	4	76
74	1387	Howell and Hill, 1978	Lead dichloride	100	Chicken (*Gallus domesticus*)	2	0/200	mg/kg diet	N		ADL	U	FD	21	d	1	d	JV	B	C	Lab	GRO	BDWT	WO	200		N	0.564	N	0.0401	14.2		10	10	5	10	5	8	4	1	10	4	67
75	2718	Jeng et. al, 1979	Lead nitrate	100	Duck (*Anas platyrhynchos*)	3	0/10/20	mg/kg bw/d	N		DLY	U	GV	3	mo	24	w	MA	F	C	Lab	GRO	BDWT	WO	20.0		Y	1.4	N	0.0725	20.0		10	8	10	10	10	8	4	10	10	7	87
76	2696	Hoffman et al., 1985	Lead powder	100	American kestrel (*Falco sparverius*)	4	0/25/125/625	mg/kg bw	N		DLY	U	GV	10	d	1	d	JV	NR	V	FieldA	GRO	BDWT	WO	25.0	125	Y	0.0753	N	0.0108	25.0	125	10	8	10	10	10	8	8	10	10	4	88
77	1387	Howell and Hill, 1978	Lead dichloride	100	Chicken (*Gallus domesticus*)	2	0/400	mg/kg diet	N		ADL	U	FD	20	d	1	d	JV	B	C	Lab	GRO	BDWT	WO	400		N	0.564	N	0.0401	28.4		10	10	5	10	5	8	4	1	10	4	67
78	6463	Stone et al., 1981	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/25/50/100/200	mg/kg diet	N		NR	U	FD	14	d	1	d	JV	B	C	Lab	GRO	BDWT	WO	200		Y	0.0444	N	0.007662	34.5		10	10	5	10	6	8	4	10	10	4	77
79	2581	Custer et al., 1984	Lead acetate	100	American kestrel (*Falco sparverius*)	4	0/119.7/212.05/448.3	mg/kg diet	N	68.2	7 per w	M	FD	60	d	1-2	yr	AD	B	C	Lab	GRO	BDWT	WO	448		Y	0.1224	N	0.0148	54.3		10	10	10	5	6	8	4	1	10	4	68
80	2534	Berg et al., 1980	Lead carbonate	100	Chicken (*Gallus domesticus*)	5	0/500/1000/1500/2000	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	M	C	Lab	GRO	BDWT	WO	500	1000	Y	0.118	N	0.0145	61.3	123	10	10	5	10	6	8	10	10	10	4	83
81	2638	Frederick, 1976	Lead nitrate	100	Mallard (*Anas platyrhynchos*)	4	0/5/50/500	mg/kg diet	N		ADL	U	FD	8	d	9	d	JV	NR	V	FieldA	GRO	BDWT	WO	500		N	0.092	N	0.0123	66.9		10	10	5	10	5	8	4	1	10	4	67
82	1285	Donaldson and McGowan, 1989	Lead acetate	100	Chicken (*Gallus domesticus*)	5	0/500/1000/1500/2000	mg/kg diet	N		NR	U	FD	20	d	1	d	JV	M	C	Lab	GRO	BDWT	WO		500	Y	0.46	N	0.0351		38.2	10	10	5	5	6	8	4	10	10	4	72
83	2744	Latta and Donaldson, 1986	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/1000	mg/kg diet	N		ADL	U	FD	3	w	1	d	JV	M	C	Lab	GRO	BDWT	WO		1000	N	1.3	N	0.0690		53.1	10	10	5	5	5	8	4	10	10	4	71
84	2898	Stone and Soares, 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	3	0/500/1000	mg/kg diet	N		ADL	U	FD	32	d	NR	NR	AD	F	C	Lab	GRO	BDWT	WO		500	Y	0.103	N	0.0133		64.3	10	10	5	5	6	8	4	10	10	4	72
85	2748	Leeming and Donaldson, 1984	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/1000	mg/kg diet	N		ADL	U	FD	19	d	1	d	JV	M	C	Lab	GRO	BDWT	WO		1000	N	0.46	N	0.0351		76.3	10	10	5	5	5	8	4	10	10	4	71
86	2534	Berg et al., 1980	Lead carbonate	100	Chicken (*Gallus domesticus*)	3	0/1000/2000	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	M	C	Lab	GRO	BDWT	WO		1000	Y	0.114	N	0.0142		124	10	10	5	10	6	8	4	10	10	4	77
87	2517	Bafundo et al.	Lead acetate trihydrate	100	Chicken (*Gallus domesticus*)	4	0/1100/2200/3300	mg/kg diet	N		ADL	U	FD	14	d	8	d	JV	M	C	Lab	GRO	BDWT	WO		1100	N	0.084	N	0.0116		152	10	10	5	5	8	4	10	10	4	71
88	2600	Donaldson, 1986	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/2000	mg/kg diet	N		NR	U	FD	20	d	1	d	JV	M	C	Lab	GRO	BDWT	WO		2000	Y	0.384	N	0.0312		163	10	10	5	6	8	4	10	10	4	72
89	5507	Khan, et al, 1993	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/200	mg/kg bw/d	N		EOD	U	OR	4	w	NR	NR	JV	B	C	Lab	GRO	BDWT	WO		200	Y	1.865	N	0.0873		200	10	8	5	5	10	8	4	10	10	4	74
90	2579	Cupo and Donaldson, 1987	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/2000	mg/kg diet	N		ADL	U	FD	7	d	1	d	JV	M	C	Lab	GRO	BDWT	WO		2000	Y	0.098	N	0.0128		262	10	10	5	5	6	8	4	10	10	4	72
91	2534	Berg et al., 1980	Lead carbonate	100	Chicken (*Gallus domesticus*)	2	0/2000	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	M	C	Lab	GRO	BDWT	WO		2000	Y	0.09	N	0.0121		270	10	10	5	10	6	8	4	10	10	4	77
92	2635	Franson and Custer, 1982	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/1850	mg/kg diet	N		ADL	U	FD	7	d	1	d	IM	NR	C	Lab	GRO	BDWT	WO		1850	Y	0.0692	N	0.0102		273	10	10	5	5	6	8	4	10	10	4	72
93	2517	Bafundo et al.	Lead acetate trihydrate	100	Chicken (*Gallus domesticus*)	2	0/3300	mg/kg diet	N		ADL	U	FD	14	d	8	d	JV	M	C	Lab	GRO	BDWT	WO		3300	N	0.084	N	0.0116		282	10	10	5	5	5	8	4	10	10	4	71
Survival																																												
94	2624	Finley et al., 1976	Lead nitrate	100	Mallard (*Anas platyrhynchos*)	4	0/1.76/5.13/21.63	mg/kg diet	Y	10.4	ADL	M	FD	12	w	1	yr	AD	M	C	Lab	MOR	MORT	WO	21.6		Y	1.162	Y	0.119	2.47		10	10	10	10	7	9	4	10	6	4	80
95	2526	Barthalmus et al., 1977	Lead acetate	100	Pigeon (*Columba livia*)	4	0/6.25/12.5/25.0	mg/kg bw/d	N		DLY	U	GV	40	d	NR	NR	AD	M	C	Lab	MOR	MORT	WO	12.5	25.0	N	0.48	N	0.0361	12.5	25.0	10	8	10	5	10	9	10	10	6	4	82
96	1387	Howell and Hill, 1978	Lead dichloride	100	Chicken (*Gallus domesticus*)	2	0/200	mg/kg diet	N		ADL	U	FD	21	d	1	d	JV	B	C	Lab	MOR	MORT	WO	200		N	0.564	N	0.0401	14.2		10	10	5	10	5	9	4	10	10	4	77
97	1387	Howell and Hill, 1978	Lead dichloride	100	Chicken (*Gallus domesticus*)	2	0/400	mg/kg diet	N		ADL	U	FD	20	d	1	d	JV	B	C	Lab	MOR	MORT	WO	400		N	0.564	N	0.0401	28.4		10	10	5	10	5	9	4	10	10	4	77
98	2581	Custer et al., 1984	Lead acetate	100	American kestrel (*Falco sparverius*)	4	0/119.7/212.05/448.3	mg/kg diet	N		6 per w	M	FD	60	d	1-2	yr	AD	B	C	Lab	MOR	MORT	WO	448		Y	0.1224	N	0.0148	54.3		10	10	10	5	6	9	4	10	10	4	78
99	2638	Frederick, 1976	Lead nitrate	100	Mallard (*Anas platyrhynchos*)	4	0/5/50/500	mg/kg diet	N		ADL	U	FD	8	d	9	d	JV	NR	V	FieldA	MOR	MORT	WO	500		N	0.092	N	0.0123	66.9		10	10	5	10	5	9	4	10	10	4	77
100	2696	Hoffman et al., 1985	Lead powder	100	American kestrel (*Falco sparverius*)	4	0/25/125/625	mg/kg bw	N		DLY	U	GV	10	d	1	d	JV	NR	V	FieldA	MOR	SURV	WO	125	625	Y	0.0668	N	0.0100	125	625	10	8	10	10	10	9	8	10	10	4	89
101	14384	Vengris and Mare, 1974	lead acetate	100	Chicken (*Gallus domesticus*)	7	0/20/40/80/160/320/640	mg/kg bw	N		DLY	U	GV	35	d	6	w	JV	B	C	Lab	MOR	MORT	WO	160	320	N	1.6	N	0.0790	160	320	10	8	10	5	10	9	10	10	10	4	86
102	1285	Donaldson and McGowan, 1989	Lead acetate	100	Chicken (*Gallus domesticus*)	5	0/500/1000/1500/2000	mg/kg diet	N		NR	U	FD	20	d	1	d	JV	M	C	Lab	MOR	MORT	WO	2000		Y	0.378	N	0.0309	163		10	10	5	5	6	9	4	3	10	4	66
103	2724	Johnsen and Damron 1982	Lead acetate	100	Goose (Anser cygnides)	5	0/500/1000/1500/2000	mg/kg diet	N		ADL	U	FD	12	w	26	w	JV	NR	C	FieldA	MOR	MORT	WO	2000		N	2.27	Y	0.222	196		10	10	5	5	6	9	4	10	10	4	73

Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Lead

Ref			Exposure																		Effects					Conversion to mg/kg bw/day					Result		Data Evaluation Score										
Result #	Ref N.		Chemical Form	MW%	Test Species	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in kg/day or L/day	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Source	Dose Route	Test Concentrations	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total
104	2513	Anders et al., 1982	Lead acetate	100	Pigeon (*Columba livia*)	2	0/6.25	mg/kg bw/d	N		DLY	U	GV	4	w	NR	NR	AD	M	C	Lab	MOR	MORT	WO	6.25		Y	0.605	N	0.0420		6.3	10	8	10	5	10	9	4	10	3	4	73
105	2579	Cupo and Donaldson, 1987	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/2000	mg/kg diet	N		ADL	U	FD	21	d	1	d	JV	M	C	Lab	MOR	MORT	WO	2000		Y	0.233	N	0.0225		194	10	10	5	5	6	9	4	10	10	4	73
106	1415	Khan et al, 1993	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/400	mg/kg bw	N		EOD	U	GV	7	d	43	d	JV	F	C	Lab	MOR	MORT	WO	400		N	1.6	N	0.0790		400	10	8	10	5	10	9	4	10	10	4	80
Data Not Used to Derive Wildlife Toxicity Reference Value																																											
107	14638	Redig et al., 1991	Lead acetate	100	Red-tailed hawk (*Buteo jamaicensis*)	2	0/0.82	mg/kg bw/d	N		DLY	U	GV	24	d	NR	NR	AD	B	C	Lab	ITX	INTX	WO	0.820		N	1	N	na	0.820		10	8	5	5	10	4	4	1	3	4	54
108	3736	Jordan and Bhatnagar, 1990	Lead acetate	54.61	Duck (*Anas platyrhynchos*)	2	0/80	mg/kg diet	N		ADL	U	FD	12	w	7	mo	JV	F	C	Lab	ENZ	GSTR	LI	80.0		N	1.1	N	0.0619	1.71		10	10	5	5	5	1	4	6	10	4	60
109	2764	Mazliah et al., 1989	Lead acetate	54.61	Chicken (*Gallus domesticus*)	2	0/5	mg/kg bw/d	N		DLY	U	GV	25	w	1	d	JV	B	V	Lab	CHM	CALC	EG	5.0		Y	2	N	0.0914	2.73		10	8	10	5	10	1	4	1	3	4	56
110	2764	Mazliah et al., 1989	Lead acetate	54.61	Chicken (*Gallus domesticus*)	2	0/5	mg/kg bw/d	N		DLY	U	GV	25	w	42	w	JV	B	V	Lab	GRO	BDWT	WO	5.0		Y	2	N	0.0914	2.73		10	8	10	5	10	8	4	1	3	4	63
111	2764	Mazliah et al., 1989	Lead acetate	54.61	Chicken (*Gallus domesticus*)	2	0/5	mg/kg bw/d	N		DLY	U	GV	25	w	1	d	JV	F	V	Lab	REP	PROG	WO	5.0		Y	2	N	0.0914	2.73		10	8	10	5	10	10	4	1	3	4	65
112	6291	Stone and Fox, 1984	lead acetate	100	Japanese quail (*Coturnix japonica*)	3	0/5.4/16.2	mg/kg diet	N		ADL	U	FD	14	d	NR	NR	AD	B	C	Lab	CHM	HMGL	BL	16.2		Y	0.0455	N	0.0078	2.77		10	10	5	5	6	1	4	10	10	4	65
113	2608	Edens and Garlich, 1983	Lead acetate	100	Chicken (*Gallus domesticus*)	3	0/25/50	mg/kg diet	N		ADL	U	FD	4	w	NR	NR	NR	F	C	Lab	CHM	CALC	BL	50.0		N	1.81	Y	0.118	3.26		10	10	5	5	5	1	4	8	10	4	62
114	2521	Baksi and Kenny, 1979	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/0.032/0.32/3.2/16.0	mg/ml	N		NR	U	DR	15	d	1	w	JV	F	C	NR	CHM	VTD3	KI	0.032	0.32	Y	0.08	N	0.0109	4.34	43.4	10	5	5	5	6	1	8	10	10	4	64
115	2668	Haegele et al. 1974	Lead mixture	100	Mallard (*Anas platyrhynchos*)	2	0/100	mg/kg diet	N		ADL	U	FD	85	d	NR	NR	SM	F	C	FieldA	ITX	INTX	WO	100		N	1.2	N	0.0655	5.46		10	10	5	10	5	4	4	1	6	4	59
116	2668	Haegele et al. 1974	Lead mixture	100	Mallard (*Anas platyrhynchos*)	2	0/100	mg/kg diet	N		ADL	U	FD	85	d	NR	NR	SM	F	C	FieldA	MOR	MORT	WO	100		N	1.1	N	0.0619	5.63		10	10	5	10	5	9	4	1	3	4	61
117	2771	Meluzzi et al., 1996	Lead oxide	100	Chicken (*Gallus domesticus*)	4	0/20/30/100	mg/kg diet	N		NR	U	FD	75	d	22	w	JV	F	C	Lab	FDB	FCNS	WO	100		N	1.6	Y	0.1403	8.77		10	10	5	10	6	4	4	1	6	4	60
118	2591	Dietz et al., 1979	Lead acetate	100	Pigeon (*Columba livia*)	2	0/6.25	mg/org	N		7 per w	U	GV	6	d	NR	NR	AD	M	V	Lab	MOR	MORT	WO	6.25		Y	0.48	N	0.0361	13.0		10	8	5	5	6	9	4	10	3	4	64
119	25894	Dauwe, et al. 2002	Lead acetate	100	Zebra finch (*Poephila guttata*)	3	0/25/100	mg/L	N		ADL	U	DR	10	d	NR	NR	AD	M	C	Lab	MOR	MORT	WO	25.0	100	N	0.001	N	0.00058	14.4	57.7	10	5	5	5	5	9	8	10	3	4	64
120	2573	ConNr et al., 1994	Lead	100	Nrthern Bobwhites	2	0/360	mg/kg diet	N		ADL	U	FD	21	d	17	w	JV	M	C	Lab	FDB	FCNS	WO	360		N	0.16	Y	0.0110	24.8		10	10	5	4	6	4	4	1	3	4	51
121	2573	ConNr et al., 1994	Lead	100	Nrthern Bobwhites	2	0/360	mg/kg diet	N		ADL	U	FD	21	d	17	w	JV	M	C	Lab	GRO	BDWT	WO	360		N	0.16	Y	0.0110	24.8		10	10	5	4	6	8	4	1	3	4	55
122	2744	Latta and Donaldson, 1986	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/1000	mg/kg diet	N		ADL	U	FD	3	w	1	d	JV	M	C	Lab	MOR	SURV	WO	1000		N	1.3	N	0.0690	53.1		10	10	5	5	9	4	1	10	4	63
123	2638	Frederick, 1976	Lead nitrate	100	Mallard (*Anas platyrhynchos*)	4	0/5/50/500	mg/kg diet	N		ADL	U	FD	8	d	9	d	JV	NR	V	FieldA	BEH	NMVM	WO	500		N	0.092	N	0.0123	66.9		10	10	5	10	5	4	4	1	10	4	63
124	2609	Edens and Melvin, 1989	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/500	mg/kg diet	N		ADL	U	FD	7	w	14	w	JV	F	C	Lab	GRO	BDWT	WO	500		Y	0.145	Y	0.027	93.1		10	10	5	5	7	8	4	1	10	4	64
125	2779	Morgan et al., 1975	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/1/10/100/1000	mg/kg diet	N		ADL	U	FD	5	w	6	d	JV	M	C	Lab	ORW	SMIX	AR	1000		Y	0.11	N	0.0138	126		10	10	5	5	6	4	4	3	10	4	61
126	2724	Johnsen and Damron 1982	Lead acetate	100	Goose (*Anser cygnide*s)	5	0/500/1000/1500/2000	mg/kg diet	N		ADL	U	FD	12	w	26	w	JV	NR	C	FieldA	FDB	FCNS	WO	2000		N	2.27	Y	0.2220	196		10	10	5	5	6	4	4	1	10	4	59
127	2724	Johnsen and Damron 1982	Lead acetate	100	Goose (Anser cygNides)	5	0/500/1000/1500/2000	mg/kg diet	N		ADL	U	FD	12	w	26	w	JV	NR	C	FieldA	GRO	BDWT	WO	2000		N	2.27	Y	0.2220	196		10	10	5	5	6	8	4	1	10	4	63
128	2635	Franson and Custer, 1982	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/1850	mg/kg diet	N		ADL	U	FD	28	d	1	d	JV	NR	C	Lab	MOR	MORT	WO	1850		Y	0.1614	N	0.0178	203		10	10	5	5	6	9	4	1	10	4	64
129	2898	Stone and Soares, 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/3000	mg/kg diet	N		ADL	U	FD	27	d	NR	NR	AD	F	C	Lab	GRO	BDWT	WO	3000		Y	0.11	N	0.0138	377		10	10	5	5	6	8	4	3	10	4	65
130	14383	Simpson et al, 1970	Lead acetate	100	Chicken (*Gallus domesticus*)	3	0/5000/10000	mg/kg diet	N		DLY	U	FD	3	w	4	w	JV	M	C	Lab	CHM	PCLV	BL	10000		N	1.042	N	0.0598	574		10	10	5	5	5	1	4	1	10	4	55
131	2605	Edens, 1985	Lead acetate	100	Japanese quail (*Coturnix japonica*)	5	0/1/10/100/1000	mg/kg diet	N		NR	U	FD	12	w	1	w	JV	F	C	NR	ENZ	ACHE	BR		1.0	Y	0.157	N	0.0174		0.111	10	10	5	5	6	1	4	10	10	4	65
132	14638	Redig et al., 1991	Lead acetate	100	Red-tailed hawk (*Buteo jamaicensis*)	2	0/0.82	mg/kg bw/d	N		DLY	U	GV	24	d	NR	NR	AD	B	C	Lab	CHM	PORP	BL		0.82	N	1	N	na		0.820	10	8	5	5	10	1	4	10	3	4	60
133	2757	Majumdar et al., 1995	Lead nitrate	62.56	House sparrow (*Passer domesticus*)	2	0/50	ug/org/d	N		6	U	GV	6	d	0	w	SM	B	C	Lab	CHM	Other	IN		50.0	Y	0.025	Y	na		1.25	10	8	5	10	7	1	4	10	3	4	62
134	2897	Stone et al., 1977	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/25	mg/kg diet	N		ADL	U	FD	2	w	1	d	JV	NR	C	Lab	ENZ	ALAD	BL		25.0	Y	0.036	N	0.00668		4.64	10	10	5	5	6	1	4	10	10	4	65
135	2513	Anders et al., 1982	Lead acetate	100	Pigeon (*Columba livia*)	2	0/6.25	mg/kg bw/d	N		DLY	U	GV	2	w	NR	NR	AD	M	C	Lab	CHM	RBCE	BL		6.25	Y	0.605	N	0.0420		6.25	10	8	10	5	10	1	4	10	3	4	65
136	2734	Kendall and Scanlon, 1981	Lead acetate	100	Ringed Turtle Dove (*Streptopelia risoria*)	2	0/100	mg/L	N		ADL	U	DR	1	w	NR	NR	AD	F	C	Lab	GRS	BDWT	WO		100	N	0.123	N	0.0145		11.8	10	5	5	5	5	4	4	10	10	4	62
137	2591	Dietz et al., 1979	Lead acetate	100	Pigeon (*Columba livia*)	2	0/6.25	mg/org	N		7 per w	U	GV	67	d	NR	NR	AD	M	V	Lab	BEH	ACTP	WO		6.25	Y	0.48	N	0.0361		13.0	10	8	5	5	6	4	4	10	3	4	64
138	2591	Dietz et al., 1979	Lead acetate	100	Pigeon (*Columba livia*)	2	0/6.25	mg/org	N		7 per w	U	GV	56	d	NR	NR	AD	M	V	Lab	HIS	EDMA	CR		6.25	Y	0.48	N	0.0361		13.0	10	8	5	5	6	4	4	10	3	4	64
139	2744	Latta and Donaldson, 1986	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/1000	mg/kg diet	N		ADL	U	FD	3	w	1	d	JV	M	C	Lab	CHM	NPSH	LI		1000	N	1.3	N	0.0690		53.1	10	10	5	5	5	1	4	10	10	4	65
140	2576	Cory-Slechta et al., 1980	Lead acetate	100	Pigeon (*Columba livia*)	3	0/1000/3000	mg/L	N		DLY	U	DR	15	d	NR	NR	NR	M	C	Lab	GRO	BDWT	WO		1000	Y	0.628	Y	0.0400		63.7	10	5	5	5	7	8	4	10	6	4	64
141	2576	Cory-Slechta et al., 1980	Lead acetate	100	Pigeon (*Columba livia*)	3	0/1000/3000	mg/L	N		DLY	U	DR	61	d	NR	NR	NR	M	C	Lab	ITX	GITX	WO		1000	Y	0.628	Y	0.0400		63.7	10	5	5	5	7	4	4	10	3	4	57
142	2898	Stone and Soares, 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	3	0/500/1000	mg/kg diet	N		ADL	U	FD	32	d	NR	NR	AD	F	C	Lab	ENZ	ALAD	BL		500	Y	0.103	N	0.0133		64.3	10	10	5	5	6	1	4	10	10	4	65
143	2748	Leeming and Donaldson, 1984	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/1000	mg/kg diet	N		ADL	U	FD	19	d	1	d	JV	M	C	Lab	CHM	GLTH	LI		1000	N	0.46	N	0.0351		76.3	10	10	5	5	5	1	4	10	10	4	64
144	429	Donaldson, 1985	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/1000	mg/kg diet	N		ADL	U	FD	3	w	22	w	JV	M	C	Lab	CHM	NEFA	BL		1000	Y	0.458	N	0.0350		76.4	10	10	5	5	6	1	4	10	10	4	65
145	2600	Donaldson, 1986	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/2000	mg/kg diet	N		NR	U	FD	20	d	1	d	JV	M	C	Lab	CHM	NPSH	LI		2000	Y	0.384	N	0.0312		163	10	10	5	5	6	1	4	10	10	4	65
146	429	Donaldson, 1985	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/2000	mg/kg diet	N		ADL	U	FD	3	w	1	d	JV	M	C	Lab	CHM	NEFA	BL		2000	Y	0.297	N	0.0264		178	10	10	5	5	6	1	4	10	10	4	65
147	2579	Cupo and Donaldson, 1987	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/2000	mg/kg diet	N		ADL	U	FD	21	d	1	d	JV	M	C	Lab	CHM	TRYP	BL		2000	Y	0.233	N	0.0225		194	10	10	5	5	6	1	4	10	10	4	65
148	2635	Franson and Custer, 1982	Lead acetate	100	Chicken (*Gallus domesticus*)	2	0/1850	mg/kg diet	N		ADL	U	FD	7	d	1	d	JV	NR	C	Lab	CHM	HMGL	BL		1850	Y	0.0692	N	0.0102		273	10	10	5	5	6	1	4	10	10	4	65
149	2898	Stone and Soares, 1976	Lead acetate	100	Japanese quail (*Coturnix japonica*)	2	0/3000	mg/kg diet	N		ADL	U	FD	27	d	NR	NR	AD	F	C	Lab	ENZ	ALAD	BL		3000	Y	0.11	N	0.0138		377	10	10	5	5	6	1	4	10	10	4	65

The abbreviations and definitions used in coding data are provided in Attachment 4-3 of the Eco-SSL Guidance (U.S.EPA, 2003).

ATTACHMENT 4

TABLE 7-3
BIOTA-SOIL ACCUMULATION FACTORS

BASELINE ECOLOGICAL RISK ASSESSMENT
PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

Constituent	Log Kow	Kd	foc	Log Koc	Source	BSoilAF (ww/dw)	Source
VOCs[6]							
1,1-Dichloroethene	2.13	--	--	--	--	0.00	Assumption
2-Butanone	0.29	--	--	--	--	0.00	Assumption
2-Hexanone	1.38	--	--	--	--	0.00	Assumption
4-Methyl-2-pentanone	1.31	--	--	--	--	0.00	Assumption
Acetone	-0.24	--	--	--	--	0.00	Assumption
Carbon disulfide	2.16	--	--	--	--	0.00	Assumption
Chloromethane	0.91	--	--	--	--	0.00	Assumption
cis-1,2-Dichloroethene	1.86	--	--	--	--	0.00	Assumption
Cyclohexane	3.44	--	--	--	--	0.00	Assumption
Isopropylbenzene	3.66	--	--	--	--	0.00	Assumption
Methyl acetate	0.18	--	--	--	--	0.00	Assumption
Methylene chloride	1.25	--	--	--	--	0.00	Assumption
Tetrachloroethene	3.40	--	--	--	--	0.00	Assumption
Trichlorofluoromethane	2.53	--	--	--	--	0.00	Assumption
Xylene (Total)	3.12	--	--	--	--	0.00	Assumption
SVOCs							
2-Methylnaphthalene	3.86	64.5	0.01	3.81	HSDB (2007)	0.354	USEPA (2005)
2-Methylphenol	1.95	0.2	0.01	1.34	HSDB (2007)	2.27	USEPA (2005)
4-Bromophenyl-phenylether	4.94	42.0	0.01	3.62	HSDB (2007)	4.73	USEPA (2005)
4-Chloroaniline	1.83	8.1	0.01	2.91	HSDB (2007)	0.0481	USEPA (2005)
4-Methylphenol	1.94	1.6	0.01	2.20	HSDB (2007)	0.307	USEPA (2005)
4-Nitroaniline	1.39	0.3	0.01	1.49	HSDB (2007)	0.524	USEPA (2005)
Acenaphthylene	--	--	--	--	--	3.66	USEPA (2005)
Acetophenone	1.58	0.1	0.01	1.00	HSDB (2007)	2.37	USEPA (2005)
Anthracene	--	--	--	--	--	0.387	USEPA (2005)
Benzaldehyde	1.48	0.3	0.01	1.53	HSDB (2007)	0.570	USEPA (2005)
Benzo(a)anthracene	--	--	--	--	--	0.254	USEPA (2005)
Benzo(a)pyrene	--	--	--	--	--	0.213	USEPA (2005)
Benzo(b)fluoranthene	--	--	--	--	--	0.416	USEPA (2005)
Benzo(g,h,i)perylene	--	--	--	--	--	0.470	USEPA (2005)
Benzo(k)fluoranthene	--	--	--	--	--	0.416	USEPA (2005)
bis(2-Ethylhexyl)phthalate	7.60	316.2	0.01	4.50	HSDB (2007)	129	USEPA (2005)
Butylbenzylphthalate	4.73	501.2	0.01	4.70	HSDB (2007)	0.260	USEPA (2005)
Carbazole	3.72	6.4	0.01	2.80	HSDB (2007)	2.71	USEPA (2005)
Chrysene	--	--	--	--	--	0.366	USEPA (2005)
Dibenzo(a,h)anthracene	--	--	--	--	--	0.370	USEPA (2005)
Dibenzofuran	4.12	42.0	0.01	3.62	HSDB (2007)	0.914	USEPA (2005)
Di-n-octylphthalate	8.10	6100.0	0.01	5.79	HSDB (2007)	18.3	USEPA (2005)
Fluoranthene	--	--	--	--	--	0.486	USEPA (2005)
Hexachlorobutadiene	4.78	1400.0	0.01	5.15	HSDB (2007)	0.103	USEPA (2005)
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	0.458	USEPA (2005)
Isophorone	1.70	2.0	0.01	2.30	HSDB (2007)	0.151	USEPA (2005)
Naphthalene	--	--	--	--	--	0.704	USEPA (2005)
N-Nitrosodiphenylamine	3.13	12.0	0.01	3.08	HSDB (2007)	0.440	USEPA (2005)
Pentachlorophenol	--	--	--	--	--	41.0	USEPA (2005)
Phenanthrene	--	--	--	--	--	0.275	USEPA (2005)
Pyrene	--	--	--	--	--	0.280	USEPA (2005)
Pesticides							
4,4'-DDD	--	--	--	--	--	0.511	USEPA (2005)
4,4'-DDE	--	--	--	--	--	1.90	USEPA (2005)
4,4'-DDT	--	--	--	--	--	1.34	USEPA (2005)
alpha-Chlordane[3]	--	--	--	--	--	2.85	WSDE (2007)
Dieldrin	--	--	--	--	--	1.56	WSDE (2007)
Endosulfan I	3.83	26.9	0.01	3.43	Howard (1989)	0.798	USEPA (2005)
Endosulfan II[5]	3.83	26.9	0.01	3.43	Howard (1989)	0.798	USEPA (2005)
Endosulfan sulfate[5]	3.83	26.9	0.01	3.43	Howard (1989)	0.798	USEPA (2005)
Endrin	--	--	--	--	--	0.576	WSDE (2007)
Endrin aldehyde[4]	--	--	--	--	--	0.576	WSDE (2007)
Endrin ketone[4]	--	--	--	--	--	0.576	WSDE (2007)
gamma-BHC (Lindane)	--	--	--	--	--	1.62	WSDE (2007)
gamma-Chlordane[3]	--	--	--	--	--	2.85	WSDE (2007)
Heptachlor epoxide	--	--	--	--	--	1.74	WSDE (2007)
Methoxychlor	4.88	825	0.01	4.92	Howard (1989)	0.213	USEPA (2005)
Toxaphene	4.82	2,100	0.01	5.32	Howard (1989)	0.0743	USEPA (2005)

TABLE 7-3
BIOTA-SOIL ACCUMULATION FACTORS

BASELINE ECOLOGICAL RISK ASSESSMENT
PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

Constituent	Log Kow	Kd	foc	Log Koc	Source	BSoilAF (ww/dw)	Source
Metals							
Aluminum	--	--	--	--	--	0.154	Assumption
Antimony	--	--	--	--	--	0.154	USEPA (2005)
Arsenic	--	--	--	--	--	0.0386	USEPA (2005)
Barium	--	--	--	--	--	0.0146	USEPA (2005)
Cadmium	--	--	--	--	--	1.32	USEPA (2005)
Chromium	--	--	--	--	--	0.0490	USEPA (2005)
Cobalt	--	--	--	--	--	0.0195	USEPA (2005)
Copper	--	--	--	--	--	0.0824	USEPA (2005)
Cyanide	--	--	--	--	--	0.154	Assumption
Iron	--	--	--	--	--	0.154	Assumption
Lead	--	--	--	--	--	0.129	USEPA (2005)
Manganese	--	--	--	--	--	0.0713	USEPA (2005)
Mercury[2]	--	--	--	--	--	0.31	Burton et al. (2006)
Nickel	--	--	--	--	--	0.169	USEPA (2005)
Selenium	--	--	--	--	--	0.148	USEPA (2005)
Silver	--	--	--	--	--	0.327	USEPA (2005)
Thallium	--	--	--	--	--	0.154	Assumption
Vanadium	--	--	--	--	--	0.00672	USEPA (2005)
Zinc	--	--	--	--	--	13.7	USEPA (2005)

Notes:
BSoilAF - biota-to-soil accumulation factor
VOCs - volatile organic compounds
SVOCs - semivolatile organic compounds
USEPA (2005) BSoilAF values were converted from dry weight to wet weight basis assumingn 84% earthworm moisture content.
[1] log K_{ow} values from Hazardous Substance Database
[2] as total methylmercury for earthworms; reflects conversion of maximum reported BAF (3.1) from dry weight to wet weight value assumi 90% earthworm moisture content.
[3] adopted from chlordane
[4] adopted from endrin
[5] adopted from endosulfan and calculated using a relationship of Jager (1998)
[6] VOCs are not expected to accumulate in biota due to their volatility and limited persistence in the environment

Sources:
USEPA (2005) Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). OSWER Directive 9285.7-55. February, 2005. Based on data for earthworms.
WSDE (2007). http://www.ecy.wa.gov/programs/tcp/policies
Burton et al. (2006). Bioaccumulation of total mercury and monomethylmercury in the eathworm. Water Air Soil Pollut. 170: 37-54
Howard (1989). Handbook of environmental fate and exposure data. Lewis Publishing.
HSDB (2007). Hazardous Substances Data Base. http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB
USEPA (2005) used the following hierarchy of approaches to derive earthworm BSoilAFs depending on availability.
1) Existing Regression (R): If regression models were available and the r-square values were >0.2, then these were preferentially us
2) New Regression (R): If paired data (contaminant concentrations in soil organism or plant versus soil) were sufficient to establish regression models and these models were significant with r-square values >0.2, then these regression models were developed a
3) Ratio (BAF): BAFs (or ratios of the contaminant in soil to the contaminant l the food item) were available from the scientific literatu If reported ratios were not available, then paired data (contaminant in soil versus contaminant in food item) were collected from th literature to derive these ratios.
4) Estimating BAFs or Bi (M for modeled): If BAFs were not available in the literature or the paired data were not available to derive then the B_i was estimated using existing relationships that estimated B_i based on the physical or chemical parameters of the COC. Existing or new models associating contaminant parameters of the contaminant with the potential for accumulation in biota or pla tissue were used to estimate B_i.

APPENDIX D.4

04/19/12 LETTER WITH PRG TABLES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region 1
5 Post Office Square, Suite 100
Boston, MA 02109-3912

April 19, 2012

David J. Lang
Ground Water Consultants, Inc.
2 Fosters Point
Beverly, MA 01915

Re: Submittal of EPA's Determination of Preliminary Remediation Goals in Support of the Feasibility Study for Operable Unit 2 of the Peterson/Puritan, Inc. Superfund Site; Cumberland/Lincoln, Rhode Island.

Dear Mr. Lang:

The purpose of this letter is to provide you with EPA's determination of Preliminary Remediation Goals (PRGs) in support of the Feasibility Study for Operable Unit 2 of the Peterson/Puritan, Inc. Superfund Site (Site).

As you may recall, the PRP Group requested that EPA take the lead in developing PRGs for the Site. An outgrowth of this task was also to consider a refinement of certain terrestrial and sediment chemicals of concern (COCs) contained in the Baseline Ecological Risk Assessment (BERA) and to clarify further those COCs which should be used as a basis for cleanup. Thus, EPA has also drafted memoranda which explain the development of these PRGs. Finally, EPA worked very closely with the Rhode Island Department of Environmental Management (RIDEM) in identifying many of the PRGs, including, as an example, the state standards identified as PRGs for human health soils.

Enclosed, please find the following:

1. Summary Table for Human Health PRGs for Groundwater (these have not changed from what we had shared with you previously);
2. Summary Table associated Development Tables for Human Health PRGs for Soils;
3. Ecological Sediment PRGs by Area (Summary Table and Development Technical Memorandum); and
4. Ecological Soil (terrestrial) PRGs for the Unnamed Island and the J.M. Mills Landfill (Summary Table and Development Technical Memorandum).

Each of the PRG tables, and the corresponding technical memoranda (where appropriate), are considered "draft" pending your review for inclusion into the Feasibility Study. With

the enclosed information, EPA believes that further progress can now be made on completing the draft Feasibility Study for submission to EPA and RIDEM for review and comment.

Further, EPA has completed its review of the Arcadis-BBL Remedial Investigation (RI) Report submitted March 6, 2012. Results of this review are being assembled and will be sent to you in a separate correspondence within a week or two. Once you receive this correspondence concerning the RI Report, EPA anticipates that a meeting will then be scheduled shortly thereafter to resolve any outstanding issues or questions you may have prior to finalization of the RI. With the work that is now completed, EPA's case team remains optimistic that a Proposed Plan for this OU can be issued by Spring of 2013.

Lastly, I wish to remind you that EPA is looking forward to receiving your submittal of the revised draft Cultural Resources Report which is expected on April 27, 2012 (as per your email of 3/23/12).

Thank you for your efforts and please contact Ruthann Sherman at (617) 918-1886, or myself, should you have any preliminary comments on the enclosed. Further, at the appropriate time, please contact David Newton, RPM for the Site to suggest meeting dates and an agenda for a progress meeting concerning the role out of the final RI Report, any remaining PRG concerns, and FS development to be scheduled during the month of May.

Sincerely,

Larry Brill, Chief
Superfund Branch I
Office of Site Remediation and Restoration

Enclosures

cc: David Newton, EPA (via electronic)
Mike Jasinski, EPA (via electronic)
Michelle Lauterback, EPA (via electronic)
Ruthann Sherman, EPA (via electronic)
EPA Technical Team (via electronic)
Paul Kulpa, RIDEM-OWM (via electronic)

HUMAN HEALTH PRELIMINARY REMEDIATION GOALS (PRGs) FOR GROUNDWATER
DRAFT

Media/ Scenario	Contaminant	Regulatory Criteria			Risk-Based PRGs - Ingestion/Dermal/Inhalation				Additional Information				Selected PRG	Basis
		Federal MCLs	RIDEM Rem. Regs.	RI GQS	ILCR 10^{-6}	ILCR 10^{-5}	ILCR 10^{-4}	HQ = 1	Site-specific Range of Background Levels[1]	RI Background[2]	Health Advisory[3]	Non-zero MCLGs		
Groundwater - ug/L Site-wide (Residential Scenario)														
	1,4-Dichlorobenzene	75	75	75	0.42	4.2	42	392	- -	- -	- -	- -	75	MCL
	Benzene	5	5	5	0.38	3.8	38	25	- -	- -	- -	- -	5	MCL
	Chloroform	- -	- -	- -	0.19	1.9	19	70	- -	- -	- -	- -	0.19	ILCR=10^{-6}
	Ethylbenzene	700	700	700	1.2	12	124	550	- -	- -	- -	700	700	MCL
	Methyl tert-butyl ether	- -	40	40	12	117	1175	2086	- -	- -	- -	- -	40	GQS
	Trichloroethene [5]	5	5	5	0.45	4.5	45	2.3	- -	- -	- -	- -	5	MCL
	Vinyl chloride	2	2	2	0.012	0.12	1.2	27	- -	- -	- -	- -	2	MCL
	1,4-Dioxane	- -	- -	- -	0.57	5.7	57	313	- -	- -	- -	- -	0.57	ILCR=10^{-6}
	4-Chloroaniline	- -	- -	- -	0.28	2.8	28	42	- -	- -	- -	- -	0.28	ILCR=10^{-6}
	Atrazine	3	- -	3	0.23	2.3	23	365	- -	- -	- -	3	3	MCL
	Benzo(a)anthracene	- -	- -	- -	0.026	0.26	2.6	N/A	- -	- -	- -	- -	0.026	ILCR=10^{-6}
	Benzo(a)pyrene	0.2	0.2	0.2	0.0026	0.026	0.26	N/A	- -	- -	- -	- -	0.2	MCL
	Benzo(b)fluoranthene	- -	- -	- -	0.026	0.26	2.6	N/A	- -	- -	- -	- -	0.026	ILCR=10^{-6}
	bis(2-Ethylhexyl)phthalate	6	- -	6	1.8	18	179	105	- -	- -	- -	- -	6	MCL
	Indeno(1,2,3-cd)pyrene	- -	- -	- -	0.026	0.26	2.6	N/A	- -	- -	- -	- -	0.026	ILCR=10^{-6}
	Naphthalene	- -	20	100	0.14	1.4	14	6.0	- -	- -	- -	- -	20	RIDEM Rem. Regs.
	Aroclor-1242	0.5	0.5	0.5	0.028	0.28	2.8	0.21	- -	- -	- -	- -	0.5	MCL
	Aroclor-1248	0.5	0.5	0.5	0.028	0.28	2.8	0.21	- -	- -	- -	- -	0.5	MCL
	Aroclor-1254	0.5	0.5	0.5	0.028	0.28	2.8	0.21	- -	- -	- -	- -	0.5	MCL
	Aldrin	- -	- -	- -	0.0033	0.033	0.33	0.31	- -	- -	- -	- -	0.0033	ILCR=10^{-6}
	Dieldrin	- -	- -	- -	0.0022	0.022	0.22	0.36	- -	- -	- -	- -	0.0022	ILCR=10^{-6}
	Aluminum	- -	- -	- -	N/A	N/A	N/A	7242	- -	- -	- -	- -	7242	HQ = 1
	Arsenic	10	- -	10	0.038	0.38	3.8	3.1	- -	- -	- -	- -	10	MCL
	Cadmium	5	5	5	N/A	N/A	N/A	4.8	- -	- -	- -	5	5	MCL
	Cobalt	- -	- -	- -	N/A	N/A	N/A	3.1	- -	- -	- -	- -	3.1	HQ = 1
	Iron	- -	- -	- -	N/A	N/A	N/A	7300	- -	- -	- -	- -	7300	HQ = 1
	Lead[4]	15	15	15	N/A	N/A	N/A	N/A	- -	- -	- -	- -	15	Fed Actn Lvl
	Manganese	- -	- -	- -	N/A	N/A	N/A	250	- -	- -	300	- -	300	Health Adv.
	Thallium	2	2	2	N/A	N/A	N/A	0.83	- -	- -	- -	0.5	0.5	non-zero MCLG

HUMAN HEALTH PRELIMINARY REMEDIATION GOALS (PRGs) FOR GROUNDWATER
DRAFT

Notes
MCL - Maximum Contaminant Level
MCLG - Maximum Contaminant Level Goal
GQS - Rhode Island Groundwater Quality Standards, June 2010
RIDEM Rem. Regs. - RIDEM Remediation Regulations, DEM-DSR-01-93, February 2004, Table 3 (GA Objectives)
ILCR - Incremental Lifetime Cancer Risk
HQ - Hazard Quotient
N/A - Not carcinogenic, or a carcinogen was not evaluated for potential non-carcinogenic effects
1. While there are some wells which may be considered site-specific background in the RI report, the data set covers multiple flow zones and is not robust enough to use as background for PRG development; - - = not applicable
2. No specific background values are currently available from Rhode Island; - - = not applicable
3. Health Advisory on Manganese (EPA-822-R-04-003; January 2004)
4. Lead was identified in the HHRA as a risk-driver, however, it was not quantitatively evaluated. Lead is regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps to correct that.
5. On September 28, 2011, EPA released its toxicity assessment for trichloroethene with new cancer and non-cancer toxicity values. The risk-based PRGs reflect these new toxicity values and also apply the mutagenic mode of action for kidney cancer. However, as the assessment has just recently been released, there might be slight modification to these values in the future.

HUMAN HEALTH PRELIMINARY REMEDIATION GOALS (PRGs) FOR SOIL[1]
DRAFT

Contaminant	Selected PRG (mg/kg)	Basis[2]
Benzene	0.0012	ILCR = 10^{-6}
Benzo(a)anthracene	0.9	Res. DEC
Benzo(a)pyrene	0.30	Reference
Benzo(b)fluoranthene	0.9	Res. DEC
Benzo(g,h,i)perylene	0.8	Res. DEC
Benzo(k)fluoranthene	0.9	Res. DEC
bis(2-Ethylhexyl)phthalate	46	Res. DEC
Chrysene	0.4	Res. DEC
Dibenz(a,h)anthracene	0.21	ILCR = 10^{-6}
Fluoranthene	20	Res. DEC
Indeno(1,2,3-cd)pyrene	0.9	Res. DEC
Naphthalene	0.13	ILCR = 10^{-6}
Pyrene	13	Res. DEC
Dioxin TEQ	0.000023	Reference
Dieldrin	0.04	Res. DEC
Arsenic	5.1	Reference
Beryllium	0.4	Res. DEC
Lead	150	Res. DEC
Manganese	390	Res. DEC
Thallium	5.5	Res. DEC

Notes

1. Applicable to the Nunes Parcel/RIDEM Removal Area.
Cleanup goals were not developed for undetected contaminants where the laboratory detection limits were in excess of ARARs. Additional sampling will be performed during the design phase using analytical methods capable of measuring concentrations at levels below the ARARs. These data will be evaluated to assess impacts, if any, to the proposed cleanup goals. In addition, all numeric criteria included in ARARs identified for the site must also be met by the cleanup regardless of whether or not they are identified above except where reference is an issue.

2. See **Appendix X** for PRG development and basis:
Res. DEC - RIDEM Remediation Regulations, DEM-DSR-01-93, February 2004, Table 1 (Residential Direct Exposure Criteria [DEC])
Reference - If RIDEM criteria or risk-based PRGs were below reference concentrations for the site, the reference concentration was selected.

ARAR - Applicable or Relevant and Appropriate Requirement
ILCR - Incremental Lifetime Cancer Risk
HQ - Hazard Quotient

TABLE 7. POTENTIAL ECOLOGICAL SOIL PRGS FOR UNNAMED ISLAND BASED ON REVISED MODELS
PETERSON PURITAN SUPERFUND SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RI

			HQ		Potential PRGs (mg/kg)				
Area	COC	RME EPC (mg/kg) [1]	NOAEL [1]	LOAEL [1]	PRG based on NOAEL [2]	PRG based on LOAEL [2]	MATC [3]	Ref. EPC [1]	Recommended PRG [4]
J.M. Mills Landfill (small omnivorous birds)									
	Cadmium (Cd)	12	17	8.2	0.67	1.4	1.0	1.9	1.9
Unnamed Island (small omnivorous birds)									
	Lead (Pb)	1366	208	7.6	6.6	180	34	161	161
	BEHP	39.4	11	3.5	3.5	11	6.2	0.24	6.2

Notes
COC - Contaminant of Concern
RME - Reasonable Maximum Exposure (dose based on 95% UCL)
EPC - Exposure Point Concentration
HQ - Hazard Quotient
LOAEL - Lowest Observed Adverse Effects Level
NOAEL - No Observed Adverse Effects Level
PRG - Preliminary Remediation Goal
BEHP - bis(2-ethylhexyl)phthalate
MATC - Maximum Acceptable Toxic Concentration

[1] EPCs and HQs based on RME concentrations (see Table 4)
[2] Potential PRG = EPC / HQ
[3] MATC set as the geometric mean between the NOAEL and LOAEL values
[4] Recommended PRG is the maximum of the MATC and Reference RME EPC.

TABLE 3. ECOLOGICAL PRGs FOR SEDIMENT BY AREA

DRAFT

Area	Contaminant	PRG (mg/kg)	PRG Basis
Ponds on the Unnamed Island			
Ponds A, D, and E	Cadmium (Cd)	9.8	Reference[(1)] - No Effects
	Chromium (Cr)	120	Reference - No Effects
	Copper (Cu)	160	Reference - No Effects
	Lead (Pb)	300	Reference - No Effects
	Zinc (Zn)	490	Reference - No Effects
	Total PAHs	18	Reference - No Effects
Ponds Adjacent to the Blackstone River			
Pond I	Cadmium (Cd)	9.8	Reference - No Effects
	Chromium (Cr)	120	Reference - No Effects
	Copper (Cu)	160	Reference - No Effects
	Total PAHs	18	Reference - No Effects
Pond N	Cadmium (Cd)	9.8	Reference - No Effects

Notes

(1) Sample TO5BL-004

PRG - Preliminary Remediation Goal

PAHs - Polycyclic aromatic hydrocarbons

APPENDIX D.5

06/21/13 MEMORANDUM REGARDING BACKGROUND DATA

Memorandum

From: Bart Hoskins
To: Dave Newton
RE: Review of technical memorandum titled: *Background Screening Levels for Sediment and Soil Supplemental Data Collection Efforts, Peterson Puritan Site, Cumberland and Lincoln, Rhode Island.*
Date: June 21, 2013

Introduction

This review is evaluates the information provided by the Potentially Responsible Party (PRP) group in the above-referenced memorandum (Background Memorandum). The PRP group was interested in having additional data on background soil and sediment contaminant concentrations in order to help refine the remedial approaches used in development of the feasibility study for the site. It should be noted that due to the nature of land uses in the area and upstream, discussion of "background" in this memorandum as it relates to this site should actually be considered "reference," rather than unimpacted background. Arcadis, Inc., on behalf of the PRP group, conducted a sampling effort from November 26 to 29, 2012 that included soil, sediment, and earthworm tissue samples for chemical analysis. The resulting data, and proposed alternative background soil and sediment screening levels (BSLs) for various chemicals, were presented in the memorandum for regulatory agency consideration in remedial decision-making. The following are comments on the data and BSLs presented in the Background Memorandum. The comments include a statistical evaluation of the 2012 data set

Comments on the Background Memorandum

EPA evaluated the data used in the Background Memorandum to determine whether they represent an improvement over the 2005 data used to represent background concentrations during the RI process. The data sets for all chemicals presented in the Background Memorandum showed a high degree of variability, and statistical evaluations were performed to determine whether the 2012 data provide a better representation of "true" background concentrations than the 2005 data. Ideally, the selected BSLs should represent concentrations that reflect the general contamination that might be present in the industrialized Blackstone River corridor from historic deposition, without including data from point sources such as other waste sites.

A detailed statistical evaluation was made for cadmium (Cd) in soil, partly because this chemical is driving soil ecological risk in some areas, and also because the soil Cd data were thought to be reasonably representative of the other chemical data sets. The degree to which cadmium represents the other data sets was then quantitatively evaluated by comparing the standard deviations for all chemicals in soil and sediment presented in the 2012 data.

EPA determined that the 2012 Cd data set was inadequate to develop a "true" reference value. The following primary reasons are noted for this determination:

- The high variability in Cd levels (0.232 ppm to 7.52 ppm) measured in the 2012 soil reference data set suggests the presence of unexplained confounding factors. These confounding factors have not been identified and therefore can't be used to remove high or low outliers in the data.
- The resulting high variance prevents estimation of a "true" reference value with any reasonable degree of statistical confidence.
- The PRP group did not provide information typically needed to support selection of reference locations, including historic land use and proximity to known or suspected contaminant sources prior to the

sampling event. It appears likely that the 2012 data includes samples from areas influenced by other waste sites.

The matter of Data Quality Objectives (DQOs) was not resolved with the regulating agencies prior to sample collection. EPA recognizes that the project planning was limited by time constraints imposed by seasonal considerations, and has given full consideration of the data collected. In order to maximize use of the 2012 data, EPA used it in a power analysis to determine the amount of additional data which would be required to yield a background value with reasonable confidence.

EPA analyzed the data by performing a statistical power analysis using the Minitab statistical package and the Visual Sampling Plan (VSP) software. The findings of this analysis are provided in **Attachment 1**. A power analysis is essentially the approach recommended in the document *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (U.S. EPA, 2002). This guidance should be used in any future effort to refine our understanding of reference concentrations for decision-making.

The power analysis determined the statistical power of the 2012 data based on a one-sample *t*-test and a one-way ANOVA. The Cd levels measured in the eight upstream reference soil samples were used to calculate the Standard Deviation (SD) needed in the power analysis. The results indicated that the power of the upstream reference soil data set for Cd was too low for use in quantitative decision making. A simplified explanation for this outcome is that the variability and the resulting SD are too high to conclude that eight samples are enough to reliably determine the Cd levels in the upstream soils.

While the power of the existing data set was too low, the Cd data could be used as a pilot study to help determine how many reference soil samples would have to be collected in order to produce a soil Cd data set of known and acceptable statistical power. This analysis, which is also included in **Attachment 1**, shows that substantially more than eight samples would be needed in all cases to achieve acceptable power (i.e., *beta* values of 20 or lower at a minimum). Two examples of estimated number of samples required are provided from **Attachment 1** for illustration purposes:

1. 103 background soil samples would be needed based on an 80% chance of obtaining a correct estimate of the "true" mean reference concentration. This estimate assumes an area of uncertainty of 0.5 around the reference concentration where the consequences of making an incorrect decision are minor (i.e., the "gray region").

2. 238 background soil samples would be needed based on a 90% chance of obtaining a correct estimate of the "true" mean reference concentration, with a "gray region" of 0.5.

Both of these examples assume that the future data to be collected would be normally distributed. More samples would be needed if the data are not normally distributed, as shown in **Attachment 1**. More importantly, the examples assume that the intrinsic variation in Cd levels in the future soil samples would remain high, with a SD of 3.0. As few as 28 soil reference samples might be needed to obtain a 90% confidence estimate of the mean reference concentration if confounding factors could be fully identified and controlled to reduce the SD down to 1.0. Note, however, that it is also possible that even *more* samples would be needed to reliably characterize the upstream Cd soil concentrations if the variance increased as a result of the extra soil sampling.

Examples of possible confounding factors include the following:

- The selected location may be influenced by a nearby and/or upstream point or non-point source of Cd. A historical review of past site use or nearby known disposal or industrial uses could help control this confounder.

- A selected location could have a history of filling with unknown fill material, including coal ash or mixed fill containing Cd. (The Background Memorandum notes evidence of fill associated with some of the 2012 samples.)
- Conversely, a selected location could be a floodplain soil formed relatively recently through deposition or filling with clean fill, which could explain the lower values in the data set.
- The frequency of flooding by the Blackstone River can be expected to influence the frequency and magnitude of Cd deposition, if the hypothesis put forth by the PRP group is correct. In other words, all else being equal, locations higher up on the shoreline would be flooded less often and should have lower soil Cd levels.

Evaluation of these and other possible confounding factors, combined with an agreed-upon set of DQOs (including confidence values and precision of estimated mean) would be needed for a pre-design study in order to have any hope of achieving lower SDs in a future reference soil data set.

Added to the statistical uncertainties is the observation of higher mean Cd levels along the J.M. Mills Landfill floodplain than in the reference data, even within the 2012 data set. The fact that the J.M. Mills Landfill floodplain is at a higher elevation than most or all of the reference samples runs counter to the PRP hypothesis regarding deposition. Also, the J.M. Mills Landfill is known to have received wastes with the potential to contain Cd. Similar concerns exist for other contaminants evaluated in the Background Memorandum, notably for bis-(2-ethylhexy)phthalate (BEHP) and lead.

The statistical evaluation and discussion for Cd was provided as an example representing the Background Memorandum data overall. In order to confirm that the evaluation for Cd is reasonably representative of the other chemicals in soil and sediment, mean values and standard deviations were calculated for all data presented in the Background Memorandum. The standard deviations were then standardized to a mean concentration of 100 mg/kg in order to illustrate relative standard deviations from chemical to chemical within each medium. **Attachment 2** presents the calculations performed and graphs of the results.

It can be seen from the graphs in Attachment 2 that the standard deviations for other chemicals in both soil and sediment are similar to, or in some cases much greater than, those seen for Cd. It should also be noted that the lower end of the error bars in the last two graphs are below the x axis. This information can be taken as evidence that it would be similarly difficult to improve on the background data set used throughout the Remedial Investigation process. Any attempt to do so would involve fairly intensive study in order to reduce variance in the data.

Conclusions and Recommendations

The evaluation of the 2012 data suggests that significant additional effort may be required to arrive at a statistically satisfactory set of upstream reference values for risk-driving chemicals. Additional sampling does not ensure that variability of the data would be reduced, unless the sampling locations can be pre-screened in a manner that would help discard potential high or low concentration outliers.

The information provided to date, including the new data presented in the Background Memorandum, do not support making any change to the current estimate of reference values.

ATTACHMENT 1

Evaluating the statistical power and number of samples needed to characterize the Cd levels in reference floodplain soils at the Peterson Puritan Superfund Site, Cumberland and Lincoln, Rhode Island

1.0 INTRODUCTION

The Peterson Puritan Potentially Responsible Party (PRP) group collected eight reference soil samples in November of 2012 along the shoreline of the Blackstone River upstream of the Superfund Site. They also collected eight more soil samples from the floodplain at the J.M. Mills landfill. All 16 soil samples were chemically analyzed for Cadmium (Cd). The PRP group then used these data to evaluate if the reference soil Cd levels were equivalent to those measured at the J.M. Mills floodplain and to help refine the risk estimates for small omnivorous birds feeding on soil invertebrates in that floodplain.

EPA requested that ESAT statistically evaluate this dataset to determine if it was robust enough to support quantitative decision making. ESAT also used the dataset to calculate the number of samples that would be needed to support such decision making. This memorandum discusses how the data were evaluated for both of these cases.

The following statistical parameters were used to perform the analyses described below:

- **n** – The number of samples (8) in the data set.
- **Standard Deviation (SD)** – Calculated from the reference data set as shown in **Table 1** below.
- **Alpha (α)** - The probability of rejecting the null hypothesis when it is actually true (i.e., Type 1 Error). α values of 0.1 to 0.05 are typically used in environmental investigations.
- **Beta (β)** – The probability of a Type II error, or failing to reject the null hypothesis when it is actually false.
- **Power** – The probability that the null hypothesis will be correctly rejected when it is false. This can be calculated as (1 – β). Values or 0.8 or higher are often required to achieve the desired power.
- **Effect** – The acceptable difference between the actual population parameter and the hypothesized value, also known as "population effect" or simply "effect".
- **Gray Region** – The minimum detectable difference, or range of true means where the user is willing to decide that clean samples are contaminated with high probability. Note that gray region is equivalent to effect for the statistical tests discussed in this memorandum.

2.0 POWER ANALYSIS

The upstream cadmium soil data set (n = 8) was evaluated with the Minitab statistical package to determine its power using a one-sample *t*-test and a one-way ANOVA. The Power Curve for the one-sample *t*-test used the upstream reference soil data for the number of samples and the SD. **Table 1** shows a SD of 3.0 (rounded value) based on the upstream analytical results. An "acceptable difference" (i.e., effect) of 0.5 was also specified, along with α values of 0.05 to 0.1.

Note that all the data users should agree on an acceptable difference and α during the Data Quality Objective (DQO) planning process before sampling begins. Consensus-based DQOs are necessary to ensure that the number of new samples collected can support the project decisions. The values used in this technical memorandum are considered a reasonable starting point for the purposes of this evaluation.

Using these input parameters and the statistical tools described above, the calculated power of the current reference cadmium soil data set ranged from 0.11-0.2, when α was set at 0.05 to 0.1, respectively. The Power Curve for the one-way ANOVA gave similar results, ranging from 0.06-0.11. This power level is considered too low (i.e., a power level of 0.8 or higher is typically desirable), and shows that the existing upstream reference dataset for Cd in soil should not be used in quantitative decision making.

TABLE 1 – Reference Soil Cadmium Data and Summary Statistics

Upstream Reference Samples		***Site Samples***	
Sample ID	Concentration	Sample ID	Concentration
S-RA-01	7.52	S-A	7.08
S-RB-01	4.26	S-B	2.77
S-RC-01	3.11	S-C	2.18
S-RD-01	6.44	S-D	9.72
S-RE-01	0.763	S-E	7.78
S-RF-01	7.27	S-F	4.6
S-RG-01	0.432	S-G	4.4
S-RH-01	0.232	S-H	9.63
Upstream Summary Statistics		*Site Summary Statistics*	
Mean	3.753375	Mean	6.02
Standard Error	1.092315904	Standard Error	1.042765896
Median	3.685	Median	5.84
Standard Deviation	3.089535931	Standard Deviation	2.949387346
Sample Variance	9.545232268	Sample Variance	8.698885714
Kurtosis	-2.032642961	Kurtosis	-1.691831886
Skewness	0.059016832	Skewness	0.046591045
Range	7.288	Range	7.54
Minimum	0.232	Minimum	2.18
Maximum	7.52	Maximum	9.72
Sum	30.027	Sum	48.16
Count	8	Count	8
Confidence Level (95.0%)	2.582916676	Confidence Level (95.0%)	2.465749527

3.0 SAMPLE SIZE

While the power of the existing reference soil dataset was too low, the Cd data can be used in a preliminary pilot study to help determine how many reference soil samples (i.e., sample size) would have to be collected in order to produce data of known power. This section discusses how sample size was determined.

The software packages Visual Sampling Plan (VSP) and Minitab were used to determine sample size. These programs helped calculate the number of soil samples that would be needed to achieve various DQOs. Note that even though summary statistics presented in **Table 1** were calculated for both the reference and the site soil Cd results, only the former were used further in the evaluations. The reference data (i.e., specifically its SD) were used for this *post-hoc* analysis.

3.1 VSP Determination of Sample Size

The "Comparison of the Average to a Fixed Threshold" module in VSP was used to evaluate the reference soil cadmium data. A null hypothesis that the upstream samples are clean (i.e., below a value of X mg/kg) was set for all VSP evaluations. Note that the actual value of X should be determined in the DQO planning process even though it does not affect the number of samples to collect.

The SD in **Table 1,** together with various example confidence values for α (the false rejection rate), β (the false acceptance rate), and width of the "gray region" were input to determine the number of reference soil samples needed for use in decision making. Note that the α, β and gray regions used in the calculations are for testing purposes only. As part of the DQO process, EPA and the PRP group would need to determine acceptable values for α, β and gray region for any future sampling should VSP, or other statistical sampling methods, be used to determine the number of reference samples needed to generate a soil Cd dataset of known and sufficient power.

3.1.1 VSP determination of sample size for data not assumed to be normally distributed

The VSP module requires the user to assume the distribution of the future dataset for the sample size evaluation. It was first assumed that the Cd data would not be normally distributed, and that the data would not be symmetrical (i.e., the mean and the median were not the same). VSP then used the Sign Test to calculate the number of samples based on these statistical input assumptions.

Table 2 presents the results of this determination. VSP indicated that at least double the number of reference soil samples would need to be collected to achieve the defined confidence levels. For example, 15 samples are needed to achieve a 60% α with a gray region of 0.5. Note that a 60% α is considerably lower than commonly used in environmental sampling plans and/or DQOs. VSP α values of 90%, or even 95% (which are equivalent to 0.1 to 0.05 α discussed above for the Minitab power analysis), are more common. As shown in **Table 2**, the VSP analysis indicated that several hundred reference soil samples would need to be collected if these more restrictive α values were used in the calculations.

More VSP evaluations were made based on a gray region of 0.25 and 0.75, as well as a SD of 1.0 rather than 3.0 (i.e., assuming that the SD would decrease substantially with more sampling). However, in all cases the number of samples needed was still well above eight.

3.1.2 VSP determination of sample size for normally-distributed data

The data distribution assumption in VSP was changed from non-normal to normal in order to evaluate the effect of this variable on the number of samples needed to achieve a known statistical power. Once again, a SD of 3.0 and 1.0 was used along with various example confidence values for α, β, and the gray region to determine the number of samples which would need to be collected to generate a soil Cd reference dataset of know power. VSP used the one-Sample *t*-Test as the statistical test for normally distributed data. The results of this determination are also presented below in **Table 2**. Even though assuming a normal data distribution resulted in fewer samples, it still showed that more than eight samples were needed to generate a dataset of sufficient power.

TABLE 2 – Number of Reference Samples Needed According to VSP

Gray Region	Standard Dev	Alpha	Beta	Distribution Assumptions	# Samples Needed
0.5	3	60	40	Not Normal;	15
0.5	3	70	30	not symmetrical	63
0.5	3	80	20		162
0.5	3	90	10		375
0.5	3	95	5		618
0.25	3	80	20		643
0.75	3	80	20		75
0.5	1	80	20		20
0.5	1	90	10		45
0.5	3	60	40	Normal	10
0.5	3	70	30		40
0.5	3	80	20		103
0.5	3	90	10		238
0.5	3	95	5		391
0.25	3	80	20		409
0.75	3	80	20		46
0.5	1	80	20		12
0.5	1	90	10		28

3.2 Minitab Determination of Sample Size

Minitab was used to perform the same statistical tests as discussed in Section 2.1 in order to independently confirm the results of the VSP analyses. Using the one-sample *t*-test, with a difference of 0.5, power of 0.8, SD of 3.0, and α of 0.05, resulted in the need to collect 224 reference soil samples (these results were also reproduced in VSP). Minitab concluded that 164 samples were needed when the α level was changed to 0.1, but all the other parameters remained the same. Using the one-way ANOVA with a difference of 0.5, power of 0.8, SD of 3.0, and α of 0.05 resulted in the need to collect 567 reference soil samples. Finally, 446 samples were needed when α was changed to 0.1, but all other parameters remained the same. These results validated the output generated by VSP.

3.0 CONCLUSION

- The statistical analyses showed that the power of the reference soil dataset for Cd collected by the PRP group in November of 2012 was too low for use in quantitative decision making.
- Substantially more reference soil samples would be needed to increase the statistical power of the dataset.
- DQOs should be developed and agreed upon beforehand between all the stake holders if more sampling is deemed necessary to ensure that the number of new soil samples can support the project decisions.

- Even though more sampling may achieve the desired DQOs, it is also possible that the sample variance and SD may *increase* instead of decrease in response to the extra samples. If so, then more soil samples than those specified in **Table 2** may have to be collected to achieve the DQOs.

References

Minitab Version 16.1.0, 2010

Visual Sampling Plan Version 6.3, U.S. DOE, Pacific Northwest National Laboratory, 2013 (http://vsp.pnnl.gov/)

U.S. EPA Guidance for the Data Quality Objectives Process, EPA QA/G-4, August 2000

Visual Sample PlanVersion 6.0 User's Guide, U.S. DOE, Pacific Northwest National Laboratory, June 2010 (http://vsp.pnnl.gov/docs/PNNL%2019915.pdf)

ATTACHMENT 2

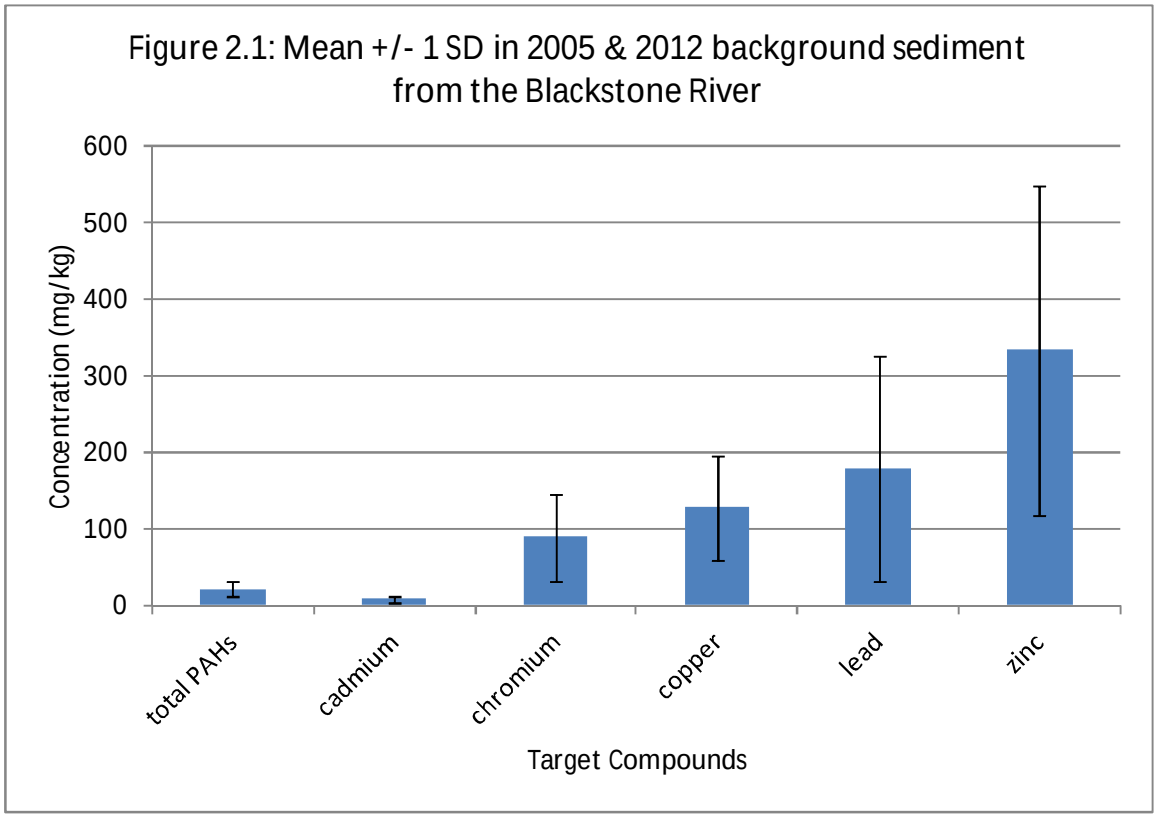
Evaluating the means and standard deviations of risk-driving contaminants in sediment and soil at the Peterson Puritan Superfund Site, Cumberland and Lincoln, RI

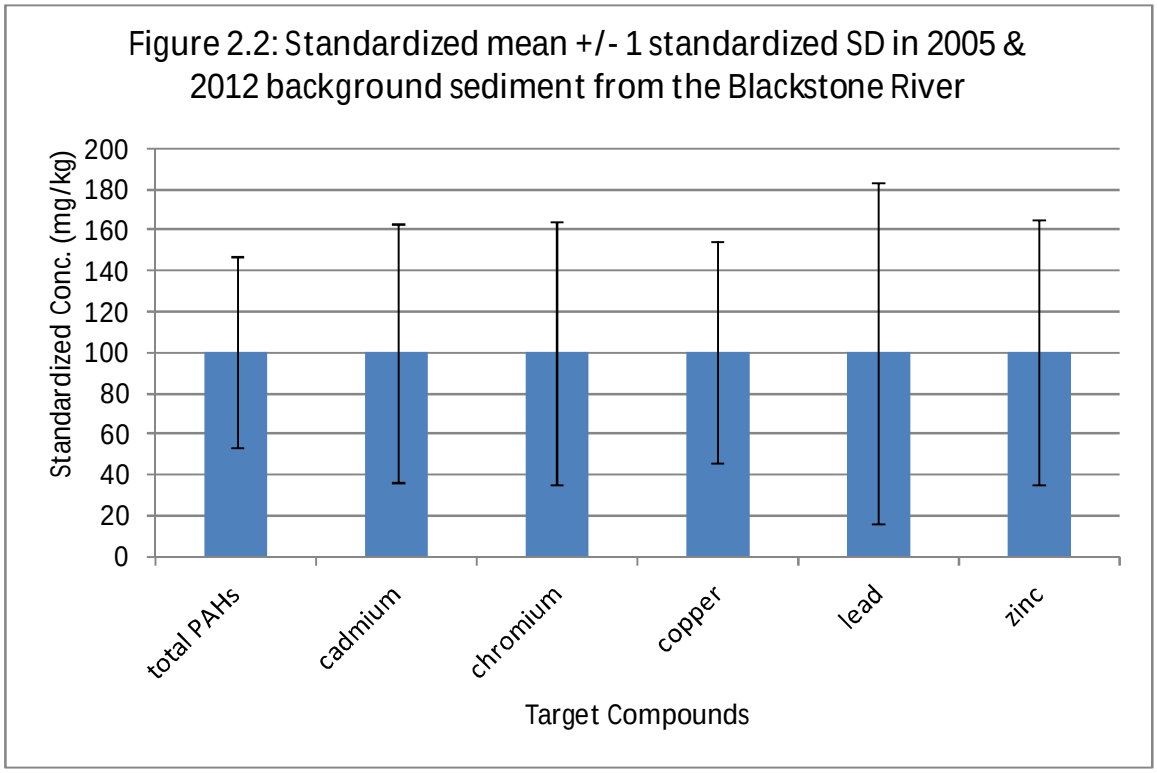
2012 Sediment Data 0 to 0.5' Depth

Table 2.1 2012 Sediment 0-0.5' depth

Target Compound	mean	SD	standardized mean	standardized SD
total PAHs	21.06	9.86	100	46.82
cadmium	7.59	4.80	100	63.24
chromium	88.18	56.76	100	64.37
copper	126.95	69.04	100	54.38
lead	178.29	148.70	100	83.4
zinc	332.95	215.44	100	64.71

T-Test analysis indicates that is acceptable to combine 2012 and 2005 sediment data. Combined means and standard deviations are shown below in Figure 2.1. Combined means standardized to 100 mg/kg with standard deviations are shown in Figure 2.2 below.



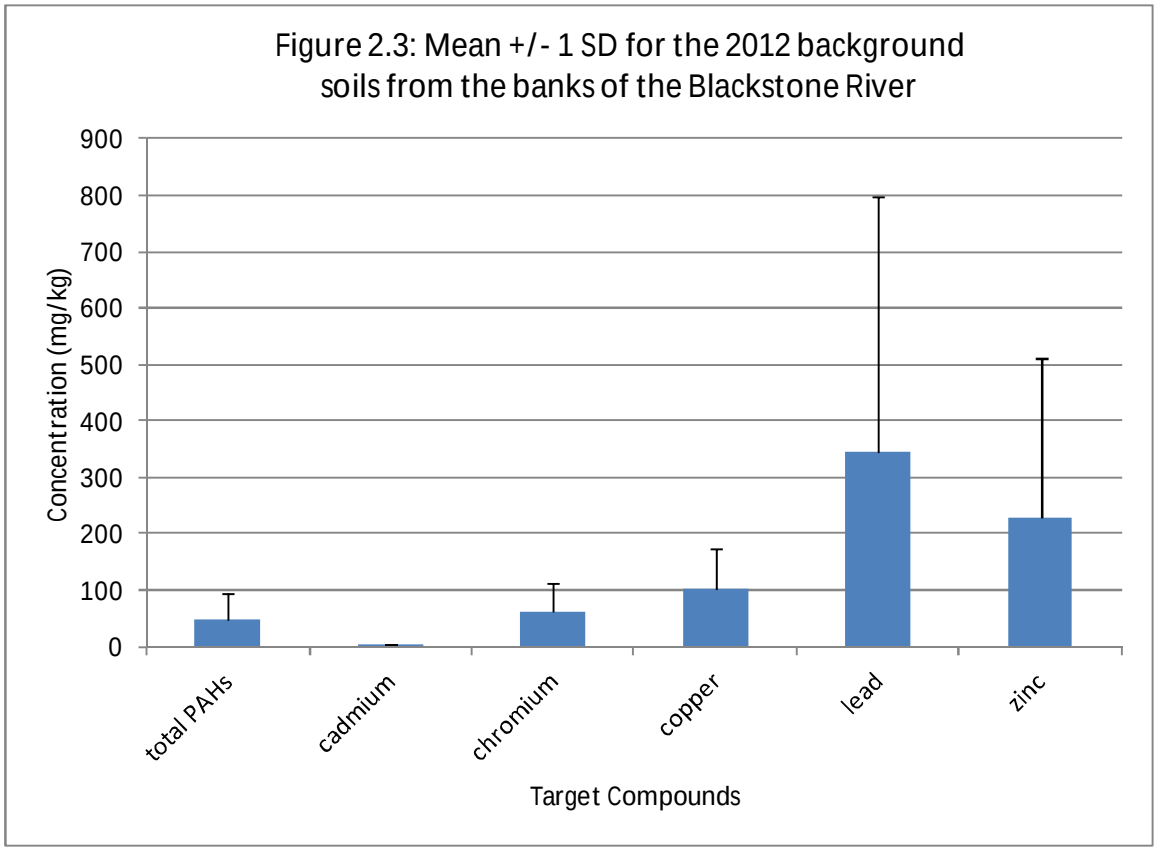


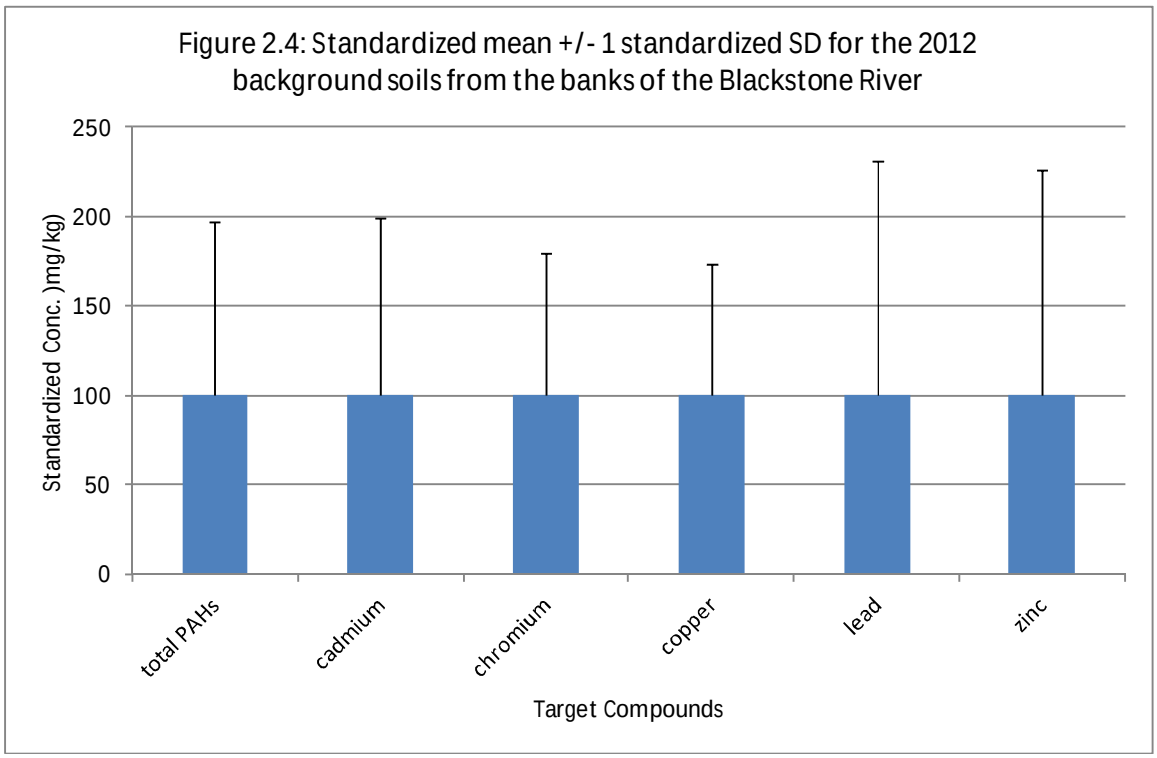
2012 Soil Data 0 to 1' Depth

Table 2.2 2012 Soil Data 0 to 1' Depth

Target Compound	mean	SD	standardized mean	standardized SD
total PAHs	47.4	46.2	100	97.5
cadmium	2.83	2.81	100	99.3
chromium	63.4	50.8	100	80
copper	100.4	73.6	100	73.3
lead	344.0	452.7	100	131.6
zinc	227.1	285.8	100	125.8

T-Test analysis indicates that is acceptable to combine 2012 and 2005 0 to 0.5' soil data sets. Combined means and standard deviations are shown below in Figure 2.3. Combined means standardized to 100 mg/kg with standard deviations are shown in Figure 2.4 below.





Conclusion: All data sets show variance similar to that observed for Cd in soil based on evaluation of standard deviations.

APPENDIX D.6

11/18/13 MEMORANDUM REVIEWING SMALL BIRD RISK MEMORANDUM

Memorandum

From: Bart Hoskins
To: Dave Newton
RE: Review of memorandum titled: *Peterson Puritan, Inc., Superfund Site Cumberland and Lincoln, Rhode Island, Small Omnivorous Bird Risks at the J.M. Mills Landfill Supplemental Data Collection Efforts*
Date: November 18, 2013

Introduction

The Baseline Ecological Risk Assessment (BERA) for the Peterson Puritan site identified potential for adverse effects to small omnivorous birds from cadmium (Cd) in soil at the J.M. Mills Landfill. For remedial decision-making, the risk levels were back-calculated to obtain corresponding No-effect and Effect soil concentrations of Cd of 0.67 ppm and 1.4 ppm, respectively. The Cd level selected as the soil background value in the BERA is also 1.9 ppm. The Preliminary Remediation Goal (PRG) for Cd in soil was set at 1.9 ppm, recognizing that CERCLA does not support cleaning sites to concentrations below background (USEPA, 2012). It should be noted that due to the nature of land uses in the area and upstream, discussion of "background" in this memorandum as it relates to this site should actually be considered "reference," rather than unimpacted background.

The Potentially Responsible Parties (PRP) group has hypothesized that concentrations of Cd and several other contaminants in floodplain soils largely reflect historic deposition from the Blackstone River upstream of the site. Arcadis, on behalf of the PRP group, conducted a sampling effort in the late fall of 2012 to investigate this hypothesis, during which they collected soil samples for analysis of risk-driving chemicals in the floodplain of the Blackstone River upstream of the site. The PRP group submitted two technical memoranda using the analytical data from this effort. The first memorandum summarized the results of 2012 sampling for all risk-driving chemicals in soil and sediment, and proposed alternative background screening values (BSLs). The second memorandum focused on risk from Cd to birds in floodplain soils at the J.M. Mills landfill based on the PRP group's proposed BSLs.

EPA reviewed the first memorandum and found that it did not provide compelling evidence for changing the reference soil and sediment concentrations used during the Remedial Investigation/Feasibility Study (RI/FS) process (USEPA, 2013). The purpose of this memorandum is to respond to the second PRP group submittal on risk to birds from Cd, and to describe a proposed change in risk calculations used in the BERA and during subsequent risk refinement that resulted from the review of the PRP memoranda.

Comments on Small Omnivorous Bird Cadmium Risk Memorandum

EPA made substantial revisions to the text portions of the original Arcadis BERA to harmonize the conclusions with the calculated risk values. Risks to birds were estimated using a food chain model in which birds were assumed to feed on soil invertebrates in floodplain soils. The BERA

calculated risk to wildlife receptors by first estimating a daily dose based on food chain modeling and then dividing this number by literature-derived Toxicity Reference Values (TRVs) to produce Hazard Quotients (HQs).

Estimated Cd doses were compared with two TRVs for birds. The No-effect TRV is a dietary dose below which no adverse effects would be expected. The Effect TRV is a dose above which adverse effects might expected. In the course of the Agency revision process, it was noted that some TRVs, notably those for lead and Cd, were lower than those typically used by EPA. It was beyond the scope of the revision to intensively review all risk calculation input values, so the conservative values used by Arcadis were not changed.

In response to the PRP group memorandum focusing on Cd risk to birds, EPA re-examined in greater depth all assumptions and data related to the determination of Cd risk to see if the acceptable risk range had been overly conservative for small omnivorous birds at the site.

This type of re-assessment was performed for Lead (Pb) in soil when the results of EPA's 2009 revised BERA were applied to the site data. EPA noted during the BERA revision process that the Pb TRV used in the food chain model calculations was more conservative than TRVs usually used by the Agency. No change was made to the Pb TRV because the 2009 revised BERA focused only on harmonizing the conclusions with the calculated risks. The resulting risk-based soil PRG for lead was so conservative that remediation would have been required in nearly the entire study area. EPA re-assessed the inputs to the risk calculations and determined that using a higher Pb TRV could be reasonably supported while remaining protective. EPA wrote a refinement memorandum which identified more clearly how Pb risks were associated with proximity to known waste disposal locations (USEPA, 2012).

A cursory check of Cd risk calculations was performed once before, and at that time, the TRV used in EPA's 2009 revised BERA was found to be acceptable (USEPA, 2012). Also, the PRG showed actionable risk only in the area of the J.M. Mills landfill floodplain, where Cd levels were substantially higher than in other exposure areas. Further study has confirmed that the original No-Effect TRV (NOAEL= 1.45 mg/kg BW-day) is unassailably defensible, as it is almost identical to the NOAEL TRV published in the EPA Eco SSL document for Cd. The effect-based TRV of 3.05 mg/kg BW-day is also fairly defensible. As a final review step, the TRVs used in the BERA were compared with BERAs developed by EPA for other sites.

Upon comparison with TRVs from other BERAs, EPA found that for another site, an effect-based avian TRV had been calculated using the toxicity studies used to develop the EcoSSL for Cd. The recalculated effect-based TRV was 6.35 mg/kg BW-day, which is about two times higher than the value used in the 2009 revised BERA. This TRV was used to update the model calculations provided by Arcadis using updated site-specific earthworm uptake data (Arcadis, 2013). Using the Arcadis model and the new TRV, which is still reasonable considering the uncertainties inherent in food chain modeling, results in an upper-bound effects threshold PRG of 3.93 ppm Cd in soil (see Attachment 1). Adoption of this TRV as an upper-bound effect threshold would allow the soil PRG for Cd to fall between 0.89 and 3.9 ppm.

EPA ecological risk assessment guidance for Superfund provides considerable flexibility for the Risk Manager in applying the findings of the BERA, with consideration of balancing criteria such as habitat destruction and the population level of receptor affected.

The balancing criteria are an important consideration in this context. The riparian habitat at J.M. Mills is a viable habitat and a potentially valuable wildlife corridor for a variety of species. Large-scale remediation of soils may require significant removal of vegetation, which may be replaced by engineered structures to ensure stability of the final landfill toe. The BERA risk estimate applies to local populations of birds with a small home range, so it follows that the strict adherence to a numerical PRG must be balanced against the potential for habitat loss in the protection of this wildlife resource. Engineered structures may also damage the value of the habitat as a wildlife corridor for other species, with implications for future Natural Resource Damage Assessments.

Food chain modeling has inherent uncertainty that result from the use of TRVs that are often developed using laboratory animals that are taxonomically very different from the species to be protected at site. For example, the TRV used for an American Robin might be based on a study of Cd toxicity to Mallard Ducks. Study design, feeding methods, and other factors can add to the uncertainty inherent in extrapolation from lab study to risk assessment. Also, given the fairly small overall area of the riparian floodplain, local (as opposed to regional) populations of birds might be affected. This is the same level of biological organization that could be negatively affected by extensive re-engineering of the floodplain.

Conclusions and Recommendations

It is recommended to append the administrative record for the site to acknowledge an alternative avian effect-based TRV for Cd of 6.35 ppm as a risk refinement step. This would allow expanding the risk range for consideration in the ROD and remedial design to include an upper bound soil PRG of 3.93 ppm. The revised PRG recognizes uncertainty in the original risk range, and allows EPA to balance habitat damage against risk in selecting an appropriate degree of remediation. While a pre-design study to refine the mean reference concentration may still be useful, the net effect of such a study may be reduced by this change.

References

Arcadis, 2013. *Small Omnivorous Bird Risks at the J.M. Mills Landfill; Supplemental Data Collection Efforts.* March 2013.

U.S. Environmental Protection Agency (USEPA), 1997. *Ecological Risk Assessment for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final,* Office of Solid Waste and Emergency Response, June, 1997, EPA 540-R-97-006.

U.S. Environmental Protection Agency (USEPA), 2002. *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C., September 2002. EPA 540-R-01-003, OSWER 9285.7.

U.S. Environmental Protection Agency (USEPA), 2012. Memorandum from Bart Hoskins to David Newton regarding Additional Refinements to Terrestrial Ecological Risk Calculations, Peterson Puritan OU 2. April 12, 2012.

U.S. Environmental Protection Agency (USEPA), 2013. Memorandum from Bart Hoskins to Dave Newton regarding Review of technical memorandum titled: *Background Screening Levels for Sediment and Soil Supplemental Data Collection Efforts, Peterson Puritan Site, Cumberland and Lincoln, Rhode Island.* June 21, 2013.

ATTACHMENT 1:

Risk of Cd in soil and developing an alternative soil PRG for Cd

Peterson-Puritan Landfill Superfund site

1.0 Summary of residual risk to terrestrial wildlife receptors exposed to Cadmium (Cd)

The Baseline Ecological Risk Assessment (BERA) used wildlife food chain modeling to calculate Contaminant of Potential Ecological Concern (COPEC)-specific Estimated Daily Doses (EDDs) for bird and mammal receptors foraging in the various terrestrial habitats at the Site. Those receptors consisted of large and small omnivorous birds, represented by the woodcock and the American robin, respectively, and large and small omnivorous mammals, represented by the red fox and the short-tailed shrew, respectively. The EDDs were calculated using Reasonable Maximum Exposures (RMEs, i.e., 95% upper confidence limits or maximum concentrations, depending on the structure of the data sets) and Central Tendency Exposures (CTEs, i.e., geometric means)

The RME and CTE EDDs were then divided by the available no effect and effect Toxicity Reference Values (TRVs) for bird and mammals to provide a four-way matrix of site risk for each COPEC, as follows: (a) RME/no effect TRV; (b) CTE/no effect TRV; (c) RME/effect TRV; and (d) CTE/effect TRV.

The same process was used with the background data collected upgradient of the Site.

COPEC-specific Residual Risks (RRs) were calculated by subtracting the COPEC-specific background HQs from the COPEC-specific site HQs. A risk is deemed unrelated to past site activities if the RR falls below 1 (i.e., if the background HQ exceeds the site HQ for a given COPEC). Conversely, a risk is site-related if the RR exceeds 1 (i.e., if the background HQ falls below the site HQ for a given COPEC).

Table 1 summarizes the RRs for large and small omnivorous birds and mammals foraging in the terrestrial habitats at the Site. The highest RRs were associated with small omnivorous birds foraging at the J.M. Mills Landfill floodplain.

2.0 Developing an alternative soil PRG for Cd

Initially, the Potentially Responsible Party (PRP) Group "back-calculated" a soil Preliminary Remediation Goal (PRG) for Cd equal to 1.0 mg/kg for small omnivorous birds feeding in floodplain areas. They used the original food chain model exposure factors provided in the BERA, which included earthworm tissue levels estimated from a literature-derived soil-to-worm bioaccumulation factor for Cd. The initial soil PRG for Cd was not retained, however, because it fell below the maximum Cd soil level measured in three upland reference soil samples collected upgradient of the Site for use in the BERA. Instead, the highest Cd level measured in those three reference soil samples (i.e., 1.9 mg/kg) was proposed as the soil Cd PRG to avoid cleaning up to below background levels.

More sampling and analysis by the PRP was performed in group in late fall 2012 to support the PRP group's hypothesis that the upland reference soil samples used in the BERA may not fully represent background soil Cd levels in the floodplain located alongside the Blackstone River. Those floodplain samples were thought to better represent the conditions found in the floodplain area at the toe of the landfill where the BERA identified risk to small omnivorous birds from exposure to Cd in soil.

The PRP group released a technical memorandum in March of 2013 entitled: "Small Omnivorous Bird Risks at the J.M. Mills Landfill. Supplemental Data Collection Efforts". The objective of this evaluation was to recalculate potential risks to small omnivorous birds using more recent soil and earthworm data collected from both reference floodplain areas along the Blackstone River and the floodplain next to the landfill. These site-specific data were used to reduce the uncertainty from the previous risk calculations by incorporating site-specific measures of Cd bioavailability.

Table 1 in the March 2013 memorandum by the PRP group summarized the analytical data for Cd measured in eight soil samples and eight co-located earthworm tissue samples collected from the landfill floodplain. The geometric mean Cd concentration for these eight soil samples and their associated earthworm tissue samples equaled **5.31 mg/kg** and 19.2 mg/kg, respectively (see Table 4 in the March 2013 PRP group memorandum).

The PRP group used these data in a food chain model to calculate an EDD for Cd in small omnivorous birds feeding at the on-Site floodplain. All the exposure parameters used in the model were identical to those presented in the original BERA, except for the Site-specific earthworm tissue data and soil data mentioned above. The CTE EDD for Cd in small omnivorous birds equaled 8.55 mg/kg-day (see Table 4 in the March 2013 PRP group memorandum).

EPA reviewed the Cd Ecological Soil Screening Level (EcoSSL) report (EPA. 2005. Ecological Soil Screening Levels for Cadmium. Interim Final. OSWER Directive 9285.7-65) as part of an effort to derive a defensible soil PRG protective of small omnivorous birds in the floodplains across from the landfill. The extensive toxicity dataset summarized in this report was used to independently derive a Lowest Observed Adverse Effect Level (LOAEL) TRV for Cd in birds equal to 6.35 mg/kg-day. This value was over two times higher than the original LOAEL TRV used in the BERA (i.e., 3.05 mg/kg-day), but was still fully defensible and conservative.

EPA recalculated the Hazard Quotient (HQ) for small omnivorous birds feeding at the on-Site floodplain by dividing the CTE EDD for Cd (i.e., 8.55 mg/kg-day) by the upgraded LOAEL TRV for birds (i.e., 6.35 mg/kg-day), which yielded a new HQ of **1.35**. This result showed a small level of risk to the target bird populations from exposure to Cd in the floodplain soils and associated earthworms.

An "upper-bound" (i.e., not to exceed) soil PRG for Cd was then calculated as the last step in the process based on a simple ratio, as follows:

$$\frac{5.31 \text{ mg/kg Cd}}{1.35} = \frac{X \text{ mg/kg Cd}}{1.0} = 3.93 \text{ mg/kg}$$

This ratio provided an answer to the following question:

> *"If a geomean Cd soil concentration of 5.31 mg/kg results in an HQ = 1.35, then what soil concentration of Cd would result in an HQ = 1.0?"*

This value, which equals 3.93 mg/kg, represents the upper-bound soil Cd level which can remain in the floodplain soils by the landfill in order to protect small omnivorous birds feeding on earthworms in that habitat.

Table 1: Summary of residual risk for terrestrial wildlife receptors exposed to cadmium				
	No Effect RR		Effect RR	
COPEC	RME	CTE	RME	CTE
TERRESTRIAL BIRDS				
Large omnivorous birds - all on-site terrestrial habitats combined[a]				
cadmium	**7**	<1	**3**	<1
Small omnivorous birds - J.M. Mills Landfill[b]				
cadmium	**14**	**2**	**7**	**1**
Small omnivorous birds - Unnamed Island[c]				
cadmium	**4**	<1	**2**	<1
Small omnivorous birds - Nunes Parcel[d]				
cadmium	**14**	<1	**7**	<1
Small omnivorous birds - Quinnville Well Field[e]				
cadmium	**3**	<1	**1**	<1
Small omnivorous birds - Wetlands A through D[f]				
cadmium	<1	<1	<1	<1
Small omnivorous birds - Pratt Dam[g]				
cadmium	**8**	**1**	**4**	<1
TERRESTRIAL MAMMALS				
Large omnivorous mammals - all on-site terrestrial habitats combined[h]				
cadmium	**2**	<1	<1	<1
Small omnivorous mammals - J.M. Mills Landfill[i]				
cadmium	**11**	**2**	**4**	<1
Small omnivorous mammals - Unnamed Island[j]				
cadmium	**3**	<1	**1**	<1
Small omnivorous mammals - Nunes Parcel[k]				
cadmium	**11**	**1**	**4**	<1
Small omnivorous mammals - Quinnville Well Field[l]				
cadmium	**2**	<1	<1	<1
Small omnivorous mammals - Wetlands A through D[m]				
cadmium	<1	<1	<1	<1
Small omnivorous mammals - Pratt Dam[n]				
cadmium	**6**	**1**	**2**	<1

CTE = central tendency exposure
RME = reasonable maximum exposure
RR = residual risk

[a] see Table 7-17b in the 2009 revised BERA
[b] see Table 7-18b in the 2009 revised BERA
[c] see Table 7-18c in the 2009 revised BERA
[d] see Table 7-18d in the 2009 revised BERA
[e] see Table 7-18e in the 2009 revised BERA
[f] see Table 7-18f in the 2009 revised BERA
[g] see Table 7-18g in the 2009 revised BERA
[h] see Table 7-22b in the 2009 revised BERA
[i] see Table 7-23b in the 2009 revised BERA
[j] see Table 7-23c in the 2009 revised BERA
[k] see Table 7-23d in the 2009 revised BERA
[l] see Table 7-23e in the 2009 revised BERA
[m] see Table 7-23f in the 2009 revised BERA
[n] see Table 7-23g in the 2009 revised BERA

APPENDIX E

SUPPLEMENTAL DATA COLLECTION

Peterson/Puritan, Inc. Superfund Site
Cumberland and Lincoln, Rhode Island

Small Omnivorous Bird Risks at the J.M. Mills Landfill
Supplemental Data Collection Efforts

Introduction

Cadmium exposure to small omnivorous birds was previously identified by the United States Environmental Protection Agency (USEPA) as a risk driver for remediation of the J.M. Mills Landfill (site or landfill). This determination was based on conservative risk calculations from the revised Baseline Ecological Risk Assessment (BERA) and the USEPA (April 12, 2012) memorandum titled "Additional Refinements to Terrestrial Ecological Risk Calculations, Peterson Puritan OU 2" (Memo). Risks to omnivorous birds were identified using site soil data and limited background soil data to derive estimates of central tendency exposure (CTE) and reasonable maximum exposure (RME). Food intake based on earthworm cadmium concentrations was modeled in the BERA using a generic Biota-Soil Accumulation Factor (BSAF) because site-specific earthworm data were not available.

The objective of this evaluation is to recalculate potential risks to small omnivorous birds using more recent soil and earthworm data collected from both reference areas along the Blackstone River and areas adjacent to the landfill. These site-specific data help to reduce the uncertainty from the previous risk calculations by incorporating site-specific measures of cadmium bioavailability.

Historic Background and Site Data and Previous Risk Calculations

The previous risk estimates relied on limited background soil data to assess reference risks to small omnivorous birds. Risk estimates were based on the results from three surface soil (0 to 1 foot) samples collected upstream of the site, and included a non-detect result (at a reporting limit of 1.1 milligrams per kilogram [mg/kg]) and detections at 1.4 and 1.9 mg/kg. The potential exposure for reference conditions included CTE using a geometric mean of 1.1 mg/kg and RME using a maximum detected concentration of 1.9 mg/kg. Risks associated with the landfill were based on 20 surface soil (0 to 1 foot) samples (including field duplicates). The cadmium results ranged from 0.95 to 23.5 mg/kg. The geometric mean of 6.8 mg/kg was used for the CTE and a 95% upper confidence limit (UCL) of 11.5 mg/kg was used for the RME. To model food intake, the BERA used a BSAF of 1.32. Exposure parameters for the small omnivorous bird model were derived in the BERA (Table 7-2b) and included in Table 8 of the Memo. The Memo provided revised small omnivorous bird dietary modeling calculations for the landfill (as shown in the Memo Table 4b), which removed the use of surface water intake from the exposure model.

Updated (2012) Earthworm and Soil Data

In November 2012, ARCADIS, on behalf of the Operable Unit 2 (OU2) Potentially Responsible Parties (PRP) Group, collected soil and earthworm samples from near-site and reference locations along the Blackstone River. The USEPA provided oversight for a portion of the sampling. The sampling included eight locations spread across the landfill proximal to previous remedial investigation (RI) surface soil locations and eight reference locations (Figure 1). Reference locations were selected at random

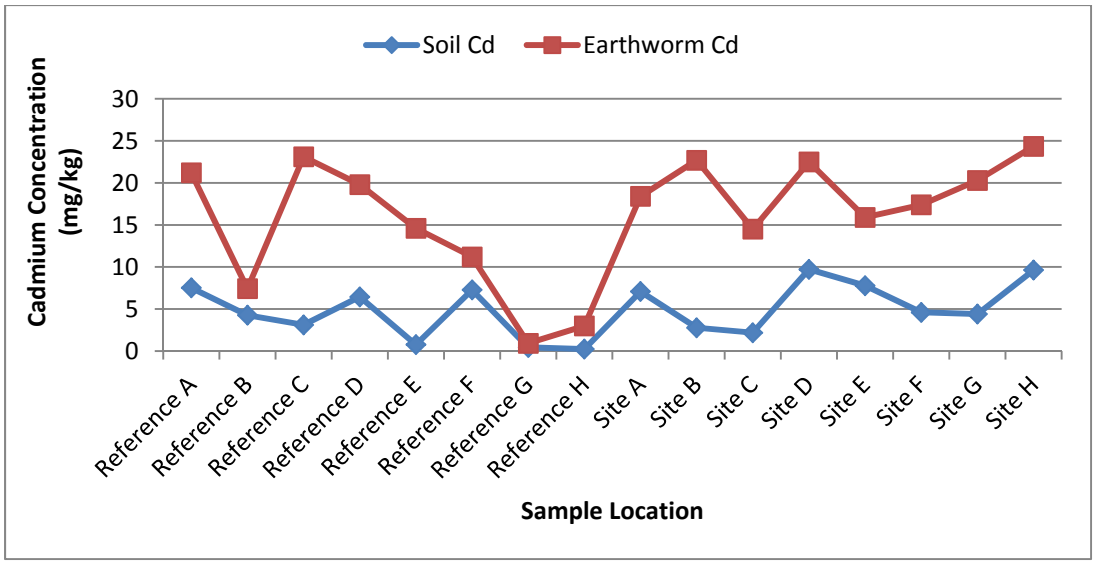
locations from approximately 1 mile upstream to approximately 5 miles upstream of OU2 where the floodplain soil settings were similar to those along the landfill's floodplain. At each of these locations, a rectangular soil pit was excavated to a depth of approximately 0 to 0.5 foot, and earthworms were hand-picked from the excavated soil until sufficient sample volume was obtained for processing and analysis. This media depth was dictated in the field based on the predominant depth of earthworm presence in the soil.

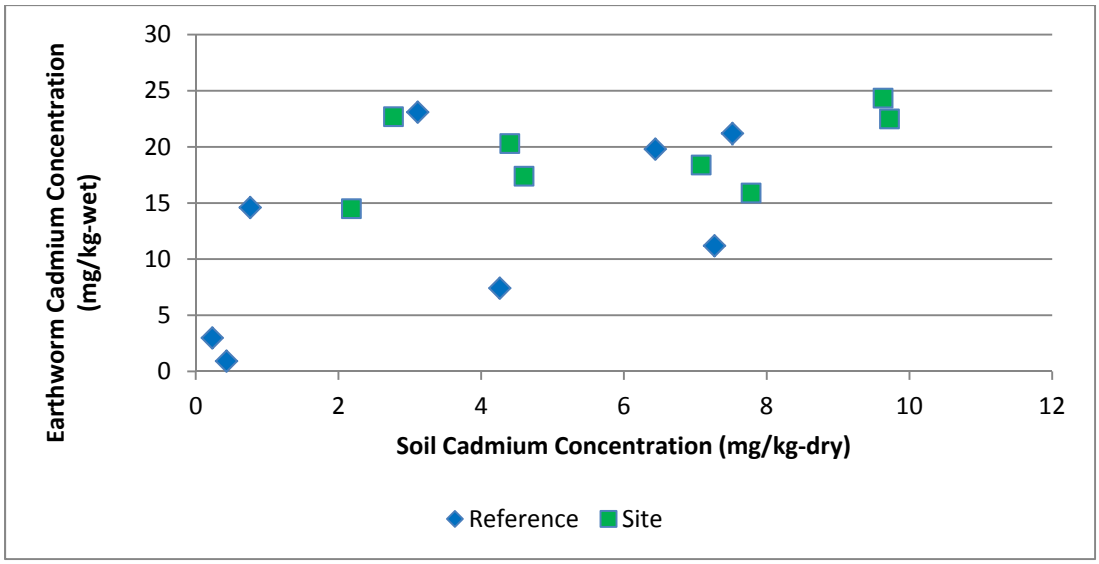
When enough earthworms were collected from a location, a single composite soil sample was collected from the excavated soil at the same depths. An additional 0 to 1 foot soil sample was collected from each location and held for analysis. The 0 to 0.5 foot soil and earthworm samples were analyzed for cadmium, and reported as dry-weight (for soil) and wet-weight (for earthworms). Analytical results for the site and reference soil samples are presented in Table 1, and analytical results of the earthworm tissue composite samples are presented in Table 2.

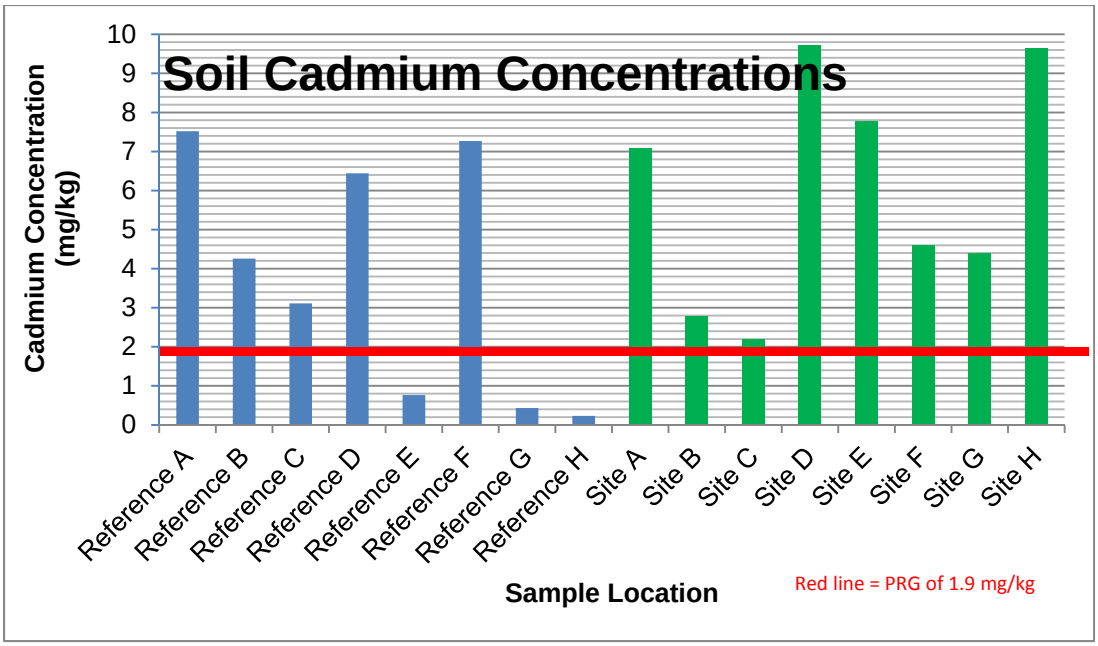
A graphical summary to indicate the relationships and findings of the 2012 soil and earthworm data analyzed for cadmium is provided in the four figures below. The first figure details the comparison of soil to co-located earthworm cadmium results for both reference and site areas. The soil cadmium concentrations range from 0.232 to 7.52 mg/kg in the reference samples, and 2.18 to 9.72 mg/kg in site samples. The earthworm cadmium concentrations range from 0.926 to 21.2 mg/kg in reference samples, and 14.5 to 24.4 mg/kg in site samples. The earthworm cadmium concentrations are greater than the soil cadmium concentrations at each location (including reference areas), indicating cadmium bioaccumulation is likely occurring in earthworm tissue. The second figure indicates the relationship of earthworm cadmium concentrations as soil cadmium concentrations increase. The relationship indicates a potential leveling off of earthworm bioaccumulation, as soil cadmium concentrations increase.

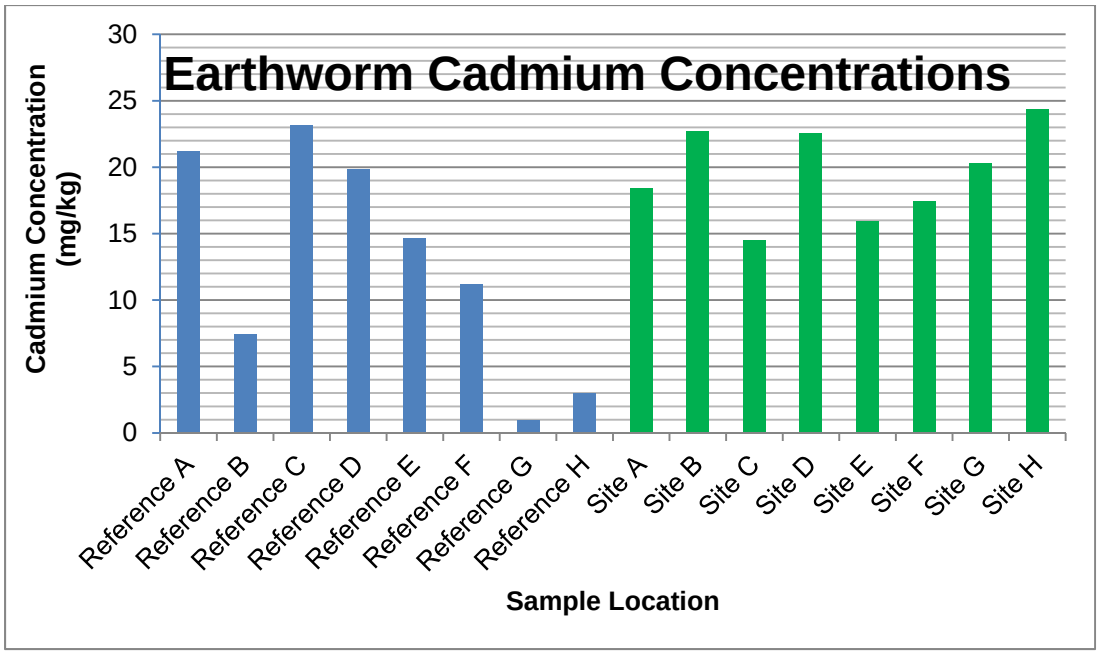
Memo Table 7 recommended an ecological soil Preliminary Remediation Goal (PRG) for cadmium for the landfill as 1.9 mg/kg. This value is based on the previous soil exposure point concentration (EPC) from the reference dataset. A reference concentration was recommended as the PRG because the risk-based value of 1.0 mg/kg is below background. The third figure below indicates the relationship of the new 2012 site-specific soil cadmium concentrations to this PRG. Each of the eight site samples from the landfill exceeded the PRG, as well as with five of the eight reference samples. Based on the new data, the use of the recommended soil PRG for cadmium of 1.9 mg/kg appears to be overly conservative and inappropriate for use.

Additionally, the earthworm cadmium concentrations (as shown in the fourth figure) from the landfill locations do not appear greatly elevated as compared to the background location earthworm cadmium concentrations.


Soil Cd
Earthworm Cd
Cadmium Concentration (mg/kg)
30
25
20
15
10
5
0
Reference A
Reference B
Reference C
Reference D
Reference E
Reference F
Reference G
Reference H
Site A
Site B
Site C
Site D
Site E
Site F
Site G
Site H
Sample Location


Earthworm Cadmium Concentration (mg/kg-wet)
30
25
20
15
10
5
0
0
2
4
6
8
10
12
Soil Cadmium Concentration (mg/kg-dry)
Reference
Site





Small Omnivorous Bird Risk Calculations

The risk calculations for small omnivorous birds from the revised BERA utilized both the historic landfill soil and the reference area soil data to calculate dose estimates for incidental soil ingestion and food intake through the use of a generic cadmium BSAF. Dose estimates were compared to Toxicity Reference Values (TRVs), including No Observed Adverse Effects Levels (NOAELs) and Lowest Observed Adverse Effects Levels (LOAELs), to calculate Hazard Quotients (HQs). The site HQs ranged from 1.3 (LOAEL-based CTE) to 17 (NOAEL-based RME). The reference HQs ranged from 0.22 (LOAEL-based CTE) to 2.8 (NOAEL-based RME).

The site-specific co-located soil and earthworm tissue data were used to update the previous risk calculations for small omnivorous birds. The risk estimates utilize the same exposure parameters and TRVs as before, but update the EPCs with the recent soil and earthworm data. Given the availability of actual earthworm concentrations, a BSAF was not used in the revised risk calculations. Details for the small omnivorous bird dietary modeling calculations for cadmium are presented in the attached Tables 3 and 4.

As shown in the table below, the revised site HQs range from 2.8 (LOAEL-based CTE) to 20 (NOAEL-based RME). The reference HQs range from 1.3 (LOAEL-based CTE) to 24 (NOAEL-based RME).

	No Effect HQ		Effect HQ	
	RME/NOAEL	CTE/NOAEL	RME/LOAEL	CTE/LOAEL
	RME	CTE	RME	CTE
Original Risk Calculations				
Site	17	3	8.1	1.3
Reference	2.8	0.46	1.3	0.22
Revised Risk Calculations				
Site	20	5.9	9.7	2.8
Reference	24	2.7	12	1.3

Conclusions

The revised risk calculations for small omnivorous birds indicate slightly higher onsite risk estimates (i.e., HQ values) using the 2012 dataset compared to the original risk estimates. However, the revised risk estimates also indicate that background risks from reference areas are equally elevated (and sometimes higher than site-related risks). Collectively, this information verifies the conservatism of the risk calculations presented in the BERA, and indicates that risks to small omnivorous birds are not uniquely elevated due to site-related conditions. Given this information, risks to small omnivorous birds from cadmium exposure should not be a risk driver for the landfill.

References

ARCADIS. 2009. REVISED DRAFT --- AGENCY REVISION performed for EPA Region 1 by the Environmental Services Assistance Team (ESAT), Baseline Ecological Risk Assessment, Peterson Puritan Superfund Site – Operable Unit 2 Cumberland and Lincoln, Rhode Island. May.

USEPA. 2012. Draft Memorandum from Bart Hoskins, EPA Ecological Risk Assessor to David Newton, EPA Remedial Project Manager, Peterson Puritan Site. “Additional Refinements to Terrestrial Ecological Risk Calculations, Peterson Puritan OU 2.” April 12, 2012. 143 pp.

TABLE 1

SURFACE SOIL SAMPLE RESULTS FOR BACKGROUND AND J.M. MILLS LANDFILL

PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

		Onsite Soil Correlated to Earthworm Locations							
Location ID:		**S-12-A-01**	**S-12-B-01**	**S-12-C-01**	**S-12-D-01**	**S-12-E-01**	**S-12-F-01**	**S-12-G-01**	**S-12-H-02**
Sample Depth (feet):		**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**
Date Collected:	**Units**	**11/26/12**	**11/26/12**	**11/26/12**	**11/26/12**	**11/26/12**	**11/26/12**	**11/27/12**	**11/27/12**
Metals									
Cadmium	mg/kg	7.08	2.77	2.18	9.72	7.78	4.60	4.40	9.63

		Background Soil Correlated to Earthworm Locations							
Location ID:		**S-12-RA-01**	**S-12-RB-01**	**S-12-RC-01**	**S-12-RD-01**	**S-12-RE-01**	**S-12-RF-01**	**S-12-RG-01**	**S-12-RH-01**
Sample Depth (feet):		**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**
Date Collected:	**Units**	**11/27/12**	**11/27/12**	**11/27/12**	**11/27/12**	**11/28/12**	**11/28/12**	**11/28/12**	**11/28/12**
Metals									
Cadmium	mg/kg	7.52	4.26	3.11	6.44	0.763	7.27	0.432	0.232

Notes:

1. Data is not validated.

mg/kg = milligrams per kilogram on a dry-weight basis

TABLE 2

EARTHWORM TISSUE COMPOSITE SAMPLE RESULTS FOR BACKGROUND AND J.M. MILLS LANDFILL

PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

		Onsite Earthworm Samples[1]							
Location ID:		**E-12-A01**	**E-12-B01**	**E-12-C01**	**E-12-D01**	**E-12-E01**	**E-12-F01**	**E-12-G01**	**E-12-H01[2]**
Date Collected:	**Units**	**11/28/12**	**11/28/12**	**11/27/12**	**11/28/12**	**11/27/12**	**11/28/12**	**11/28/12**	**11/28/12**
Metals									
Cadmium	mg/kg	18.4	22.7	14.5	22.5	15.9	17.4	20.3	25.1 [23.6]

		Background Earthworm Samples[1]							
Location ID:		**E-12-RA01**	**E-12-RB01**	**E-12-RC01**	**E-12-RD01**	**E-12-RE01**	**E-12-RF01**	**E-12-RG01**	**E-12-RH01**
Date Collected:	**Units**	**11/29/12**	**11/28/12**	**11/28/12**	**11/28/12**	**11/29/12**	**11/29/12**	**11/29/12**	**11/29/12**
Metals									
Cadmium	mg/kg	21.2	7.42	23.1	19.8	14.6	11.2	0.926	2.99

Notes:

[1]Data is not validated.

[2]For sample location E-12-H01, a composite tissue replicate was analyzed and the result is provided in brackets.

mg/kg = milligrams per kilogram on a wet-weight basis

TABLE 3
CALCULATED HAZARD QUOTIENTS FOR SMALL OMNIVOROUS BIRDS - J.M. MILLS LANDFILL

BASELINE ECOLOGICAL RISK ASSESSMENT
PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

Area	Chemical Group	COPEC	Statistics (mg/kg)								Cf		Exposure Rate (mg/kg bw/day)		Benchmark (mg/kg bw/day)		No Effect HQ		Effect HQ		Residual Risk			
			Soil (dw)				Food (ww)										RME/NOAEL	CTE/NOAEL	RME/LOAEL	CTE/LOAEL	No Effect RR		Effect RR	
			Geometric Mean	95% UCL	Maximum	N	BSoilAF (ww/dw)	Geometric Mean	95% UCL		CTE	RME	CTE	RME	NOAEL	LOAEL	RME	CTE	RME	CTE	RME	CTE	RME	CTE
landfill	Metals	Cadmium (Site)	6.77E-01	1.15E+01	2.35E+01	16	1.32E+00	8.97E-01	1.52E+01	1.19E+01	2.01E+01	3.99E-01	2.46E+01	1.45E-01	3.05E-01	1		7	3	8.1	1.3	14	2	7	1
		Cadmium (Reference)	1.14E-01	1.90E-01	1.90E-01	3	1.32E+00	1.51E-01	2.52E-01	2.00E-01	3.33E-01	6.72E-01	4.08E-01	1.45E-01	3.05E-01	2.8	0.46	1.3	0		.22	NA	NA	NA	NA

Notes:

NA = Residual risks are not applicable for reference
UCL = Upper Confidence Limit
BSoilAF = Biota-Soil Accumulation Factor (BSAF)
CTE = Central Tendency Exposure
RME = Reasonable Maximum Exposure
HQ = Hazard Quotient
COPEC = Constituent of Potential Concern

mg/kg = milligrams per kilogram
dw = dry weight
ww = wet weight
LOAEL = Lowest Observable Adverse Effects Level
NOAEL = No Observable Adverse Effects Level
N = number of samples
bw = body weight

Exposure Parameters - Small Omnivorous Birds

Variable	CTE	RME
Pf	0.5	1
IR	0.89	1.62
Ps	0.0166	0.0249
SIR	0.015	0.04
Cf	BSoilAFss	BSoilAFss
BSAF	1.32	1.32

Pf = Proportion of contaminated food (unitless)
IR = Food intake rate (kg food ww/kg bw/day)
Ps = Proportion of ingested food that is soil (wet weight basis,unitless)
SIR = Soil intake rate normalized to body weight (kg soil dw/kg bw-day)
Cf = Concentration in food (mg/kg food dw)
Cs = Concentration in soil (mg/kg soil dw)

TABLE 4
CALCULATED HAZARD QUOTIENTS FOR SMALL OMNIVOROUS BIRDS - J.M. MILLS LANDFILL

BASELINE ECOLOGICAL RISK ASSESSMENT
PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

Area	Chemical Group	COPEC	Statistics (mg/L or mg/kg)								Cf		Exposure Rate (mg/kg bw/day)		Benchmark (mg/kg bw/day)		No Effect HQ		Effect HQ		Residual Risk			
			Soil (dw)				Food (ww)										RME/NOAEL	CTE/NOAEL	RME/LOAEL	CTE/LOAEL	No Effect RR		Effect RR	
			Geometric Mean	95% UCL	Maximum	N	Geometric Mean	95% UCL	Maximum	N	CTE	RME	CTE	RME	NOAEL	LOAEL	RME	CTE	RME	CTE	RME	CTE	RME	CTE
Landfill	Metals	Cadmium (Site)	5.31E+00	8.00E+00	9.72E+00	8	1.92E+01	1.83E+01	2.51E+01	8	1.92E+01	1.83E+01	8.55E+00	2.97E+01	1.45E+00	3.05E+00	2	0	5.9	9.7	2.8	-4	3	-2	1.5
		Cadmium (Reference)	2.08E+00	5.82E+00	7.52E+00	8	8.69E+00	2.19E+01	2.31E+01	8	8.69E+00	2.19E+01	3.87E+00	3.55E+01	1.45E+00	3.05E+00	24	2.7	12	1.3	NA	NA	NA	NA	

Notes:

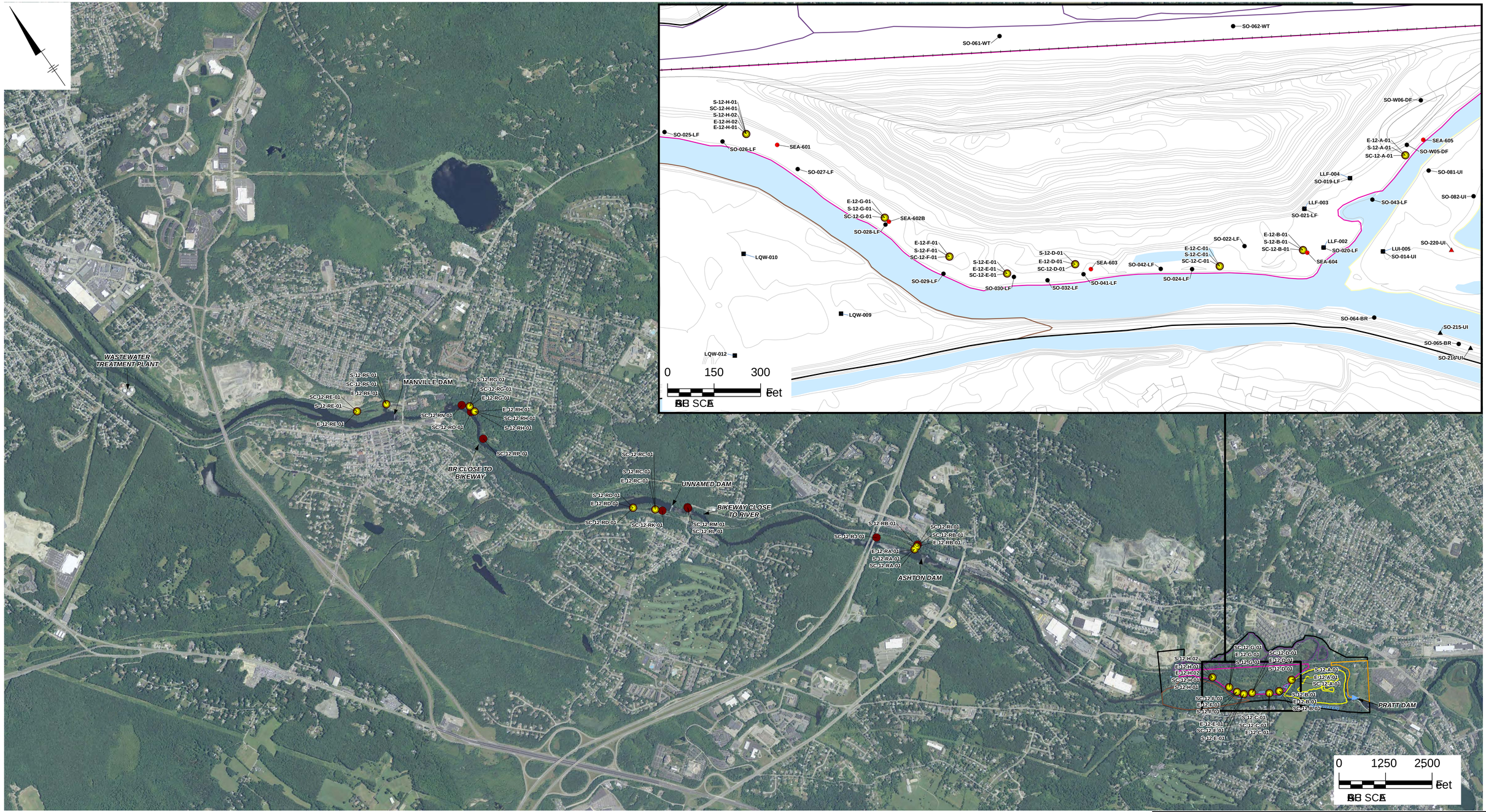
COPEC = Constituent of Potential Concern
NA = Residual risks are not applicable for reference
UCL = Upper Confidence Limit
BSAF = Biota-Soil Accumulation Factor (BSAF)
CTE = Central Tendency Exposure
RME = Reasonable Maximum Exposure
HQ = Hazard Quotient

mg/L = milligrams per liter
mg/kg = milligrams per kilogram
dw = dry weight
ww = wet weight
NOAEL = No Observable Adverse Effects Level
LOAEL = Lowest Observable Adverse Effects Level
N = Number of samples
bw = body weight

Exposure Parameters - Small Omnivorous Birds

Variable	CTE	RME
Pf	0.5	1
IR	0.89	1.62
Ps	0.0166	0.0249
SR	0.015	0.04
Cf	BSAF*Cs	BSAF*Cs
BSAF	1.32	1.32

Pf = Proportion of contaminated food (unitless)
IR = Food intake rate (kg food ww/kg bw/day)
Ps = Proportion of ingested food that is soil (wet weight basis,unitless)
SR = Soil intake rate normalized to body weight (kg soil dw/kg bw-day)
Cf = Concentration in food (mg/kg food dw)
Cs = Concentration in soil (mg/kg soil dw)



LEGEND:

SAMPLE TYPE

- [illegible]
- SD-5 [illegible]
- SC[illegible]-1 [illegible]

[illegible]

PREVIOUS SAMPLE LOCATIONS

- [illegible]

[illegible]:

1. [illegible]

2012 EARTHWORM AND SOIL SITE AND BACKGROUND SAMPLE LOCATIONS

ARCADIS

FIGURE 1

[illegible]

Peterson/Puritan, Inc. Superfund Site
Cumberland and Lincoln, Rhode Island

Background Screening Levels for Sediment and Soil
Supplemental Data Collection Efforts

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Peterson/Puritan, Inc. Superfund Site
Cumberland and Lincoln, Rhode Island

Background Screening Levels for Sediment and Soil
Supplemental Data Collection Efforts

1. Introduction

In November 2012, several background sediment and soil samples were collected to supplement the existing database available for determining background concentrations of select metals, polycyclic aromatic hydrocarbons (PAHs), and bis(2-ethylhexyl)phthalate for the Blackstone River upgradient of the Peterson/Puritan, Inc. Site (site). These new data were used (in combination with historic background data) to calculate background screening levels (BSLs) for sediments and soil.

This technical memorandum describes the background soil/sediment data available for the site, including a description of the previous historic background dataset collected during the remedial investigation (RI), and a description of the samples that were collected in November 2012. This memorandum also shows the locations of the historic and recent sample locations in relation to the site location and the presence of recognized waste sites and other possible point sources along the Blackstone River.

2. Description of Previous Background Dataset

The following is a description of the historic background dataset:

- Sediment – Data include 15 sediment samples, including eight samples from the 0 to 1 foot depth interval and seven samples from the 0 to 0.5 foot depth interval. These background sediment samples were collected during three time periods (September 2003, August to September 2004, and June 2005) (Table 1a) from immediately upstream of the Ashton Dam to the upstream reach of Operable Unit 2 (OU2).

- Soil – Data include three surface soil (0 to 1 foot) samples collected on September 10, 2004 (Table 2) from the Mackland Farm area approximately ½ mile upstream of OU2.

The chemical data from the historic background sampling are included in Table 1a (sediment) and Table 2 (soil). All soil and sediment background sample locations (and inset data boxes) are depicted on Figures 1 through 4. Figure 1 shows the entire reach of background samples collected as part of the RI of OU2. Figures 2 through 4 represent close-up portions of the reach shown on Figure 1, west to east along the Blackstone River upstream of OU2.

3. Description of New (2012) Background Dataset

From November 26 to 29, 2012, ARCADIS collected additional background sediment and soil samples. The objective of the background soil/sediment sampling was to supplement the existing database and provide additional information for evaluating non-site-related contributions to and from the Blackstone River. These data were collected as part of a fast-track investigation and, therefore, a formal Work Plan was not prepared for Agency review. Regardless, these data remain valid and usable for evaluating

conditions at the site. All background chemical data were validated by a third-party independent data validator following the United States Environmental Protection Agency- (EPA-) approved Quality Assurance Project Plan (ARCADIS, 2009).

The November 2012 dataset includes the results from the following samples:

- Sediment – Eight sediment samples (0 to 0.5 foot) were collected from upstream of the site (Figure 1), each corresponding to the approximate area and depth of earthworm and corresponding background soil locations.

- Soil – Twenty-four soil samples (0 to 0.5 and 0 to 1 foot depth intervals) were collected from upstream of the site (Figure 1) from approximately 1 mile to 5 miles upstream of OU2.

At eight of the sixteen 0 to 0.5 foot soil sample locations (locations S-12-RA-01 through S-12-RH-01), a single composite sample of earthworms was also collected and analyzed for cadmium. However, these earthworm data are described in a separate technical memorandum addressing potential cadmium risks to small omnivorous birds at the J.M. Mills Landfill and are not included in this technical memorandum.

The November 2012 background soil/sediment samples were collected from areas along the Blackstone River with apparent public access. Specific sample locations were selected in the field to be similar in setting and soil type as to the floodplain in front of the J.M. Mills Landfill, and purposely avoided areas of visual contamination or predominant presence of fill material. However, complete avoidance of areas absent of any anthropogenic material was not possible because so much of the river upstream of the site includes at least trace amounts of fill.

Subsequent to initial reporting of these background data, locations of hazardous waste sites and point source locations were identified using information from a Rhode Island Department of Environmental Management (RIDEM) geographic information system-based website (2012). Current and historic soil and sediment background locations collected for OU2 are shown on Figures 2 through 4. The background soil/sediment samples were not intentionally collected from immediately adjacent to or downstream of recognized hazardous waste sites or point sources.

Reference sample locations were selected from throughout the 5-mile stretch of the Blackstone River to allow for spatial variability based on accessibility, setting and soil conditions similar to the landfill floodplain, and those with the least visual anthropogenic impacts based on fill material present. Review of the spatial distribution of the constituent results in soils and sediments do not reveal hot spot correlations based on proximity to any of the waste sites or discharge points, but are reflective of variability often detected in a depositional/scouring riverine setting. For instance, some of the lowest cadmium results have been observed in locations immediately adjacent and downstream of the Manville Well Field Comprehensive Environmental Response, Compensation, and Liability Information

System site. Alternatively, while sample SC-12-RL-01 (0-1'), collected approximately ¼ mile downstream of the Cumberland Landfill, had the highest total PAH and lead concentrations, the four other soil and sediment samples collected between the Cumberland Landfill and this location analyzed for PAHs and lead had concentrations that fell in the middle of the distributional ranges for these constituents. It does not appear that definitive links exist correlating the location of the other waste sites and point discharges to the constituent concentrations measured in the reference sample locations.

Soil samples were collected using a hand-held trowel, and sediment samples were collected using Lexan® tubing. Samples were analyzed for select metals, PAHs, and bis(2-ethylhexyl)phthalate, except the 0 to 1 foot core samples, which were analyzed for cadmium only. Analytical results are presented in Table 1b (sediment) and Table 2 (soils). Sample locations are depicted on Figures 1 through 4. Soil core descriptions taken from the field notes are included in Table 3. Photographs of the soil sampling locations are included in Attachment 1.

As described in the field notes (Table 3), five of the eight sediment samples exhibited sheen and/or odor, indicative of possible wide-spread non-site-related impacts to sediment conditions upstream of the site. For soils, no sheens or odors were observed. However, trace fill material was observed in two of the 0 to 1 foot soil cores (SC-12-RL-01 and SC-12-RM-01). These two samples exhibited some of the highest concentrations of total PAHs, copper, lead, and zinc, but did not exhibit the highest concentrations of other constituents (i.e., cadmium and chromium). Fill material was not identified in any of the 0 to 0.5 foot soil samples, including the areas targeted for earthworm sampling.

Overall comparisons of onsite soil types and reference locations were that they were similar. The top few inches along the landfill floodplain and reference soil floodplain locations were most frequently described as a brown sandy or silty loam underlain by silty sand or sand and gravel.

4. Derivation of Background Screening Levels

BSLs were calculated using the combined 2012 and historic data. For sediment, the BSLs included a total of 15 samples (seven samples collected in June 2005 and eight samples in November 2012) from the 0 to 0.5 foot depth interval only, which best represents the biologically available zone. For soil, BSLs were separately derived for both the 0 to 0.5 foot depth interval and the 0 to 1 foot depth interval. The 0 to 0.5 foot depth interval dataset included eight background soil samples collected in November 2012 (analyzed for cadmium only). The 0 to 1 foot depth interval dataset included 19 background soil samples (16 samples collected in November 2012 and three samples collected in September 2004). Eight additional of the sixteen 0 to 1 foot background soil samples collected in 2012 were analyzed for cadmium only.

BSLs were calculated consistent with EPA (2002) guidelines, and included an evaluation of sample size, distributions, skewness, and degree of censoring (i.e., the percentage of non-detects). Upper tolerance

limits (UTLs), which represent upper confidence limits on upper percentiles, were calculated to estimate an upper-bound statistic. UTLs provide an interval within which at least a certain proportion of the population is "contained," with a specific probability that the stated interval does indeed "contain" that proportion of the population (EPA, 2002). EPA's ProUCL Version 4.1.00 software (EPA 2010) was used to assess the distributions and skewness and to calculate the UTLs.

Various methods can be used to calculate the UTL. Table 4 summarizes the process used to select the appropriate UTL calculation method for this analysis. Based on the sample size of each dataset and the frequency of detection, the maximum detection or UTL was selected to represent the BSL (Table 4). A tolerance limit with a 95% confidence level (α=0.05) and 95th percentile (95% coverage, q), or 95/95 UTL, was calculated for each constituent. BSLs for both sediment and soil were derived consistent with relevant statistical analysis protocols presented in EPA guidance (EPA 2002; 2006; 2010).

5. Background Screening Level Results

BSLs were developed for bis(2-ethylhexyl)phthalate, total PAHs, cadmium, chromium, copper, lead, and zinc for background sediment samples (Table 5). The BSL for cadmium in background soil (0 to 0.5 foot) is shown in Table 6. BSLs were also developed for bis(2-ethylhexyl)phthalate, total PAHs, cadmium, chromium, copper, lead, and zinc for background soil (0 to 1 foot) (Table 7).

6. Summary

The BSLs for the Blackstone River were developed using available soil and sediment data collected from upstream of the site, and were calculated consistent with EPA (2002) guidelines. The resulting BSLs reflect a combination of both natural conditions and widespread historic anthropogenic sources that have been documented throughout the Blackstone River. This information regarding background conditions (possibly supplemented with additional future background sampling) should be used to help refine the remedial approaches that are being developed as part of the feasibility study process.

7. References

ARCADIS. 2009. Quality Assurance Project Plan for the Peterson Puritan Operable Unit 2. Revision 6. Updates to Support Unnamed Island Supplemental Investigation. November, 2009.

EPA. 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. EPA 540-R-01-003.

EPA. 2006. Data Quality Assessment: Statistical Methods for Practitioners. EPA QA/G-9S. Office of Environmental Information. EPA/240/B-06/003. February.

EPA. 2010. ProUCL Version 4.1.00 Technical Guide (Draft). Office of Research and Development, Washington, DC. EPA/600-R-07-04. May.

RIDEM. 2013. Rhode Island Geographic Information System. Managed by University of Rhode Island. http://www.edc.uri.edu/RIGIS/DATA/

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Tables

TABLE 1A

SUMMARY OF HISTORIC SEDIMENT BACKGROUND SAMPLE RESULTS

PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

Location ID: / Sample Depth (feet): / Date Collected:	Units	SE-022-BR 0-1 09/05/03	SE-033-BR 0-1 09/10/03	SE-034-BR 0-1 09/10/03	SE-044-BR 0-1 08/30/04	SE-045-BR 0-1 08/30/04	SE-049-BR 0-1 08/30/04	SE-050-BR 0-1 08/31/04	SE-054-BR 0-1 09/01/04
SVOCs									
bis(2-ethylhexyl)phthalate	mg/kg	0.460 U	0.420 U	0.500 U	0.160 J	0.150 J	1.00	0.260 J	0.450 U
Total PAHs	mg/kg	0.110	1.69	8.86 J	3.13 J	8.94 J	0.489	4.72 J	0.441
Metals									
Cadmium	mg/kg	0.780 J	0.230 J	0.330 J	0.460 J	0.250 J	0.390 J	2.90	1.80 J
Chromium	mg/kg	19.1	7.80	10.4	6.30 J	9.30 J	17.3 J	29.0 J	37.0
Copper	mg/kg	22.7	11.0	132	11.8	10.5	11.9	37.6	22.4
Lead	mg/kg	9.50 J	12.5 J	18.9 J	12.3 J	25.1 J	26.1 J	46.2 J	19.8 J
Zinc	mg/kg	106 J	33.6	49.0	38.2 J	35.0 J	35.3 J	168 J	95.4 J

Location ID: / Sample Depth (feet): / Date Collected:	Units	T05BL-001 0-0.5 06/23/05	T05BL-002 0-0.5 06/23/05	T05BL-003 0-0.5 06/23/05	T05BL-004 0-0.5 06/23/05	T05BL-005 0-0.5 06/23/05	T05BL-006 0-0.5 06/23/05	T05BL-007 0-0.5 06/23/05
SVOCs								
bis(2-ethylhexyl)phthalate	mg/kg	0.700	0.110	5.90	1.90	1.10	2.70	1.10
Total PAHs	mg/kg	25.9 J	9.47 J	20.2	18.0	23.2 J	30.6	18.2 J
Metals								
Cadmium	mg/kg	2.00	0.200	9.90	9.80	11.0	12.0	3.10
Chromium	mg/kg	19.0	10.0	110	120	86.0	110	21.0
Copper	mg/kg	38.0	13.0	170	160	140	180	47.0
Lead	mg/kg	34.0	18.0	450	300	160	160	48.0
Zinc	mg/kg	96.0	24.0	680 J	490 J	410	380 J	120

Notes:
mg/kg = milligrams per kilogram on a dry-weight basis
U = The compound was not detected above the reported sample quantitation limit shown.
J = The compound was positively identified; however, the associated numerical value is an estimated concentration only.

TABLE 1B

SUMMARY OF 2012 SEDIMENT BACKGROUND SAMPLE RESULTS

PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

Location ID: Sample Depth (feet): Date Collected:	Units	SED-12-RA-01 0-0.5 11/29/12	SED-12-RB-01 0-0.5 11/29/12	SED-12-RC-01 0-0.5 11/29/12	SED-12-RD-01 0-0.5 11/29/12	SED-12-RE-01 0-0.5 11/28/12	SED-12-RF-01 0-0.5 11/28/12	SED-12-RG-01 0-0.5 11/28/12	SED-12-RH-01 0-0.5 11/28/12
SVOCs									
bis(2-ethylhexyl)phthalate	mg/kg	3.60 UJ	4.07 UJ [0.784 UJ]	3.28 UJ	2.51 UJ	0.630 UJ	1.18 UJ	2.97 UJ	0.134 J
Total PAHs	mg/kg	26.3	13.3 [8.9]	22.2	18.8	8.82	26.0	46.7	8.23
Metals									
Cadmium	mg/kg	14.0	4.04 [3.57]	6.74	6.96	8.63	16.8 J	6.99	1.76
Chromium	mg/kg	153	124 [119]	70.2	46.4	91.9	139 J	202	20.2
Copper	mg/kg	219	156 [160]	132	96.2	103	200 J	218	32.0
Lead	mg/kg	207	231 [254]	127	82.6	108	187 J	521	40.7
Zinc	mg/kg	400	234 [230]	258	196	334	597 J	692	83.3

Notes:

1. Data is validated nad table reflect validation updates.

mg/kg = milligrams per kilogram on a dry-weight basis

U = The compound was not detected above the reported sample quantitation limit shown.

J = The compound was positively identified; however, the associated numerical value is an estimated concentration only.

TABLE 2

SUMMARY OF BACKGROUND SOIL SAMPLE RESULTS USED FOR BACKGROUND SCREENING LEVELS

PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

Location ID:		SC-12-RI-01	SC-12-RJ-01	SC-12-RK-01	SC-12-RL-01	SC-12-RM-01	SC-12-RN-01	SC-12-RO-01	SC-12-RP-01	SO-072-MF	SO-073-MF	SO-074-MF
Sample Depth (feet):		0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1
Date Collected:	Units	11/29/12	11/29/12	11/29/12	11/29/12	11/29/12	11/29/12	11/29/12	11/29/12	9/10/2004	9/10/2004	9/10/2004
SVOCs												
bis(2-ethylhexyl)phthalate	mg/kg	0.649 UJ	1.78 UJ	2.73 UJ	1.55 UJ	1.60 UJ	1.62 UJ	1.47 UJ	1.04 JEB	0.480 U	0.390 U	0.370 U
Total PAHs	mg/kg	14.4	17.8	24.0	152	30.9	92.4	36.0	14.9	24.6	100	14.2
Metals												
Cadmium	mg/kg	8.91	0.609 J	6.38	1.78	1.18	2.27	0.33	1.86	1.90	1.40	1.10 U
Chromium	mg/kg	170	44 J	106	37.3	18.8	27.6	8.98	120	89.6	44.2	31.1
Copper	mg/kg	236	38.5 J	158	190	94.6	62.5	16.1	159	75.1	40.7	34.0
Lead	mg/kg	289	86 J	175	1640	326	562	193	209	161	82.6	60.0
Zinc	mg/kg	362	40.7 J	209	1010	260	314	91.7	86.4	51.7	43.5	29.3

Location ID:		S-12-RA-01	S-12-RB-01	S-12-RC-01	S-12-RD-01	S-12-RE-01	S-12-RF-01	S-12-RG-01	S-12-RH-01
Sample Depth (feet):		0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Date Collected:	Units	11/27/12	11/27/12	11/27/12	11/27/12	11/28/12	11/28/12	11/28/12	11/28/12
SVOCs									
bis(2-ethylhexyl)phthalate	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA
Metals									
Cadmium	mg/kg	7.52	4.26	3.11	6.44	0.763	7.27	0.432	0.232
Chromium	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA
Copper	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA

Location ID:		S-12-RA-01	S-12-RB-01	S-12-RC-01	S-12-RD-01	S-12-RE-01	S-12-RF-01	S-12-RG-01	S-12-RH-01
Sample Depth (feet):		0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1
Date Collected:	Units	11/27/12	11/27/12	11/27/12	11/27/12	11/28/12	11/28/12	11/28/12	11/28/12
SVOCs									
bis(2-ethylhexyl)phthalate	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA
Metals									
Cadmium	mg/kg	5.36	1.41 [1.69]	4.9 [3.86]	6.52	0.358	7.58	0.338	0.189
Chromium	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA
Copper	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

1. Data collected in 2012 are validated. The table reflects validation updates.

mg/kg = milligrams per kilogram on a dry-weight basis

NA = not analyzed

U = The compound was not detected above the reported sample quantitation limit shown.

J = The compound was positively identified; however, the associated numerical value is an estimated concentration only.

EB = Compound was detected in an associated equipment blank, but not high enough to qualify the result as nondetected.

TABLE 3
BACKGROUND SOIL AND SEDIMENT SAMPLE DESCRIPTIONS

PETERSON PURITAN SUPERFUND SITE - 0U2
CUMBERLAND AND LINCOLN, RHODE ISLAND

Sample ID	Sample Type	Description
S-12-A-01	Soil	Dark brown loam
S-12-B-01	Soil	Brown sandy loam
S-12-C-01	Soil	Sandy loam
S-12-D-01	Soil	Brown loam
S-12-E-01	Soil	Brown sandy loam
S-12-F-01	Soil	Brown sandy loam
S-12-G-01	Soil	Sandy loam with organics
S-12-H-01/02	Soil	Brown loam
S-12-RA-01	Soil	Loamy with heavy roots
S-12-RB-01	Soil	Dark brown loam with heavy roots
S-12-RC-01	Soil	Dark brown sandy loam
S-12-RD-01	Soil	Brown loam with heavy organics, leaf, and root matter
S-12-RE-01	Soil	Brown loam with heavy root mass
S-12-RF-01	Soil	Moist brown silty loam with heavy root mass
S-12-RG-01	Soil	Brown silty loam
S-12-RH-01	Soil	Brown silty loam
SED-12-RA-01	Sediment	Dark gray brown silt with trace organics and slight sheen
SED-12-RB-01	Sediment	Dark gray brown silt with trace organics
SED-12-RC-01	Sediment	Dark gray brown silt with trace organics
SED-12-RD-01	Sediment	Dark gray brown sandy silt with trace organics
SED-12-RE-01	Sediment	Brown silt with trace organics and slight odor
SED-12-RF-01	Sediment	Brown silty with trace organics and sheen
SED-12-RG-01	Sediment	Dark gray brown silt with trace organics and slight sheen
SED-12-RH-01	Sediment	Brown silt upper layer and gray clay and sand lower layer, with slight sheen
SC-12-A-01	Soil Core	0 - 2": Dark organics and sandy loam, 2 - 6": Brown sandy loam, 6 - 12": Sand and gravel
SC-12-B-01	Soil Core	0 - 1": Roots and till, 1 - 6": Brown sandy loam, 6 - 7": Sand, 7 - 12": Dark brown sandy silt
SC-12-C-01	Soil Core	0 - 2": Organics, 2 - 12": Light brown sand
SC-12-D-01	Soil Core	0 - 2": Loam with roots and organics, 2 - 12": Sandy brown loam
SC-12-E-01	Soil Core	0 - 1": Sandy loam and organics, 1 - 12": Sandy brown loam with roots
SC-12-F-01	Soil Core	0 - 1": Sandy loam and organics, 1 - 12": Sandy brown loam, 0 - 8": Roots
SC-12-G-01	Soil Core	0 - 1": Roots and organics, 1 - 11": Sandy loam with organics, 11 - 12": Sand
SC-12-H-01/02	Soil Core	0 - 12": Brown loam
SC-12-RA-01	Soil Core	0 - 7": Brown sandy loam with silt and fine roots, 7 - 12": Brown silty sand
SC-12-RB-01	Soil Core	0 - 8": Dark brown silty loam with fine roots, 8 - 12": Brown silty sand with some fine gravel
SC-12-RC-01	Soil Core	0 - 12": Moist dark brown very fine sand and silt, 0 - 7": Root masses
SC-12-RD-01	Soil Core	0 - 3": Dark brown loam with fine roots, 3 - 12": Brown to tan very fine sand and silt
SC-12-RE-01	Soil Core	0 - 6": Brown silty loam with roots, 6 - 12": Light brown silty sand and gravel
SC-12-RF-01	Soil Core	0 - 12": Moist dark brown silty loam, 0 - 6": Roots
SC-12-RG-01	Soil Core	0 - 4": Dark brown silty loam with trace roots, 4 - 12": Brown fine sand with gravel
SC-12-RH-01	Soil Core	0 - 3": Dark brown silt loam with some roots, 3 - 12": Brown fine to coarse sand and gravel
SC-12-RI-01	Soil Core	0 - 3": Dark brown silt loam with trace clay and organics, 3 - 12": Dark brown silt, fine sand with clay and trace roots
SC-12-RJ-01	Soil Core	0 - 12": Brown fine sand and silt, 0 - 7": Root masses
SC-12-RK-01	Soil Core	0 - 10": Dark brown silty loam with heavy roots, 10 - 12": Dark brown silty loam with few roots
SC-12-RL-01	Soil Core	0 - 4": Brown to tan fine to medium sand with roots, 4 - 12": fine to coarse sand with trace fill
SC-12-RM-01	Soil Core	0 - 12": Tan to brown fine sand with silt, 0 - 7": Root masses with trace fill
SC-12-RN-01	Soil Core	0 - 12": Brown sandy loam with very fine sand and silt, 0 - 6": Roots
SC-12-RO-01	Soil Core	0 - 4": Light brown fine to coarse sand with some gravel, 4 - 12": brown fine silty sand and gravel
SC-12-RP-01	Soil Core	0 - 5": Brown silty fine sand with roots, 5 - 12": Tan very fine sand with some silt and roots

Notes:

Soil samples S-12-A-01 through S-12-RH-01 are 0-6" depth grab soil samples colocated and correlated depths to earthworm sample locations. These are the same locations as the sample identifications beginning with "SC", but were collected separately, so both descriptions are presented.

Samples S-12-A-01 through S-12-H-01 and SC-12-A-01 though SC-12-H-02 represent the 0-0.5' and corresponding 0-1' (SC) samples collected onsite. Their soil descriptions are included for comparative purposes to background (reference) sample locations.

Samples S-12-H-01/02 and SC-12-RH-01/02 are colocated replicate locations immediately adjacent to other.

TABLE 4

DECISION TREE FOR 95/95 UPPER TOLERANCE LIMITS

PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

Sample Size	Censoring	Distribution[1]	Skewness[2]	Statistic Used for UTL[3,5]
All	Detects < 5	NA	NA	NA
n < 8	All	NA	NA	NA
n ≥ 8	Detects ≥ 5 FOD = 100%	N N and LN N, LN, and G	NA	Normal 95/95 UTL
		LN	NA	Lognormal 95/95 UTL
		G LN and G	NA	Gamma 95/95 UTL
		not N, LN, or G	NA	Nonparametric 95/95 UTL[4]
	Detects ≥ 5 FOD < 100%	N, LN, or G	NA	Kaplan-Meier 95/95 UTL
		not N, LN, or G (i.e., nonparametric)	Mild	Kaplan-Meier 95/95 UTL
			Moderate to High	Nonparametric 95/95 UTL[4]

Abbreviations:

95/95 UTL = one-sided upper 95 percent confidence limit for the 95th percentile
FOD = frequency of detection
n = sample size
NA = not applicable

Notes:

[1] Distribution assessed by goodness-of-fit tests based on detected values only conducted using ProUCL 4.1 at a 95% confidence level (α = 0.05).

Distributions:

Normal (N): dataset follows a normal distribution, according to the Shapiro-Wilk test.

Gamma (G): dataset follows a gamma distribution, according to the Kolmogorov-Smirnov test.

Lognormal (LN): dataset follows a lognormal distribution, according to the Shapiro-Wilk test.

Nonparametric (NP): dataset does not follow any of the three distributions noted above.

[2] Skewness estimated using the standard deviation of the log-transformed data (detects only) (σ). Datasets with σ≤1.0 are considered mildly skewed; σ>1.0 is considered moderately to highly skewed (USEPA 2010).

[3] Statistics calculated with ProUCL Version 4.1.

[4] Nonparametric UTL is based on a rank-ordered value (e.g., maximum detect or second highest detect) that achieves the coverage and confidence coefficient for a given sample size. The ranks are unlikely to match these parameters exactly. Values presented are based on ranks from Table A-5 of Conover (1999), which correspond to minimum sample sizes needed to achieve the specified parameters. ProUCL selects the rank-ordered value that most closely matches the parameters, even if the rank yields a lower coverage or confidence coefficient.

[5] Group A: n ≥ 8 and detects ≥ 5, BSL is based on 95/95 UTL; Group B: n ≥ 8 but detects < 5, BSL is based on max detect or "--" if all nondetect; Group C: n < 8, BSL is based on max detect or "--" if all nondetect.

References:

Conover, W.J. 1999. Practical Nonparametric Statistics. Third Edition. John Wiley & Sons.

USEPA. 2010. ProUCL Version 4.1.00 Technical Guide. Office of Research and Development. EPA/600/R-07/041. May.

TABLE 5

BACKGROUND SCREENING LEVELS - SEDIMENT (0 TO 0.5 FOOT DEPTH)

PETERSON PURITAN SUPERFUND SITE - CUMBERLAND AND LINCOLN, RHODE ISLAND

Parameter Group	Analyte	n	FOD %	Distribution[1]	Skewness[2]	Maximum Detect	95/95 UTL[3]	UTL Method[3]	Final BSL[4] Value
PAHs[5]	bis(2-ethylhexyl)phthalate	15	53%	G/LN	1.39	5.90	5.04	KM 95/95UTL	5.04 (A)
	Total PAHs	15	100%	N/G/LN	0.498	46.7	46.6	Normal 95/95 UTL	46.6 (A)
Metals[5]	Cadmium	15	100%	N/G	1.13	16.8	19.9	Normal 95/95 UTL	19.9 (A)
	Chromium	15	100%	N/G	0.922	202	233	Normal 95/95 UTL	233 (A)
	Copper	15	100%	N/G	0.842	219	304	Normal 95/95 UTL	304 (A)
	Lead	15	100%	G/LN	0.972	521	802 (WH)	Gamma 95/95 UTL	802 (A)
	Zinc	15	100%	N/G/LN	0.933	692	886	Normal 95/95 UTL	886 (A)

Abbreviations:

PAHs = polycyclic aromatic hydrocarbons

95/95 UTL = one-sided upper 95 percent confidence limit for the 95 th percentile

BSL = background screening level

FOD = frequency of detection

KM = Kaplan-Meier

n = sample size

NA = not applicable for datasets with nondetects

WH = Wilson-Hilferty

Notes:

1 Distribution assessed by goodness-of-fit tests based on detected values only conducted using ProUCL 4.1 at a 95% confidence level (α = 0.05). Distribution for BSL selected according to the following hierarchy: (N) normal > (G) gamma > (LN) lognormal > (NP) nonparametric.

2 Skewness estimated using the standard deviation of the log-transformed data (detects only) (σ). Datasets with σ≤ 1.0 are considered mildly skewed, whereas datasets with σ>1.0 are moderately to highly skewed (USEPA 2010). See Table 4 for how skewness informs the choice of UTL methods.

3 UTLs only calculated for analytes with at least 8 total observations and 5 detected observations (USEPA 2010). Calculation method selected in accordance with Table 4.

4 Final BSL selected in accordance with decision tree presented in Table 4. Notes indicate basis for BSL: A = 95/95 UTL; B = maximum detected concentration; C = BSL not defined because FOD=0%.

5 Concentrations presented in units of milligrams per kilogram (mg/kg).

References:

USEPA. 2010. ProUCL Version 4.1.00 Technical Guide. Office of Research and Development. EPA/600/R-07/041. May.

TABLE 6

BACKGROUND SCREENING LEVELS - SOIL (0 TO 0.5 FOOT DEPTH)

PETERSON PURITAN SUPERFUND SITE - CUMBERLAND AND LINCOLN, RHODE ISLAND

Parameter Group	Analyte	n	FOD %	Distribution[1]	Skewness[2]	Maximum Detect	95/95 UTL[3]	UTL Method[3]	Final BSL[4] Value
Metals[5]	Cadmium	8	100%	N/G/LN	1.39	7.52	13.6	Normal 95/95 UTL	13.6 (A)

Abbreviations:

95/95 UTL = one-sided upper 95 percent confidence limit for the 95th percentile
BSL = background screening level
FOD = frequency of detection
n = sample size

Notes:

1 Distribution assessed by goodness-of-fit tests based on detected values only conducted using ProUCL 4.1 at a 95% confidence level (α = 0.05). Distribution for BSL selected according to the following hierarchy: (N) normal > (G) gamma > (LN) lognormal > (NP) nonparametric.

2 Skewness estimated using the standard deviation of the log-transformed data (detects only) (σ). Datasets with σ≤ 1.0 are considered mildly skewed, whereas datasets with σ>1.0 are moderately to highly skewed (USEPA 2010). See Table 4 for how skewness informs the choice of UTL methods.

3 UTLs only calculated for analytes with at least eight total observations and five detected observations (USEPA 2010). Calculation method selected in accordance with Table 4.

4 Final BSL selected in accordance with decision tree presented in Table 4. Notes indicate basis for BSL: A = 95/95 UTL; B = maximum detected concentration; C = BSL not defined because FOD=0%.

5 Concentrations presented in units of milligrams per kilogram (mg/kg).

References:

USEPA. 2010. ProUCL Version 4.1.00 Technical Guide. Office of Research and Development. EPA/600/R-07/041. May.

TABLE 7

BACKGROUND SCREENING LEVELS - SOIL (0 TO 1 FOOT DEPTH)

PETERSON PURITAN SUPERFUND SITE - CUMBERLAND AND LINCOLN, RHODE ISLAND

Parameter Group	Analyte	n	FOD %	Distribution[1]	Skewness[2]	Maximum Detect	95/95 UTL[3]	UTL Method[3]	Final BSL[4] Value
PAHs[5]	bis(2-ethylhexyl)phthalate	11	9%	NA	NA	1.04	NA	NA	1.04 (B)
	Total PAHs	11	100%	G/LN	0.851	152	240 (WH)	Gamma 95/95 UTL	240 (A)
Metals[5]	Cadmium	19	95%	G/LN	1.20	8.91	9.40	KM 95/95UTL	9.40 (A)
	Chromium	11	100%	N/G/LN	0.878	170	206	Normal 95/95 UTL	206 (A)
	Copper	11	100%	N/G/LN	0.848	236	308	Normal 95/95 UTL	308 (A)
	Lead	11	100%	G/LN	0.940	1,640	1,956 (WH)	Gamma 95/95 UTL	1,956 (A)
	Zinc	11	100%	G/LN	1.12	1,010	1,454 (WH)	Gamma 95/95 UTL	1,454 (A)

Abbreviations:

PAHs = polycyclic aromatic hydrocarbons

95/95 UTL = one-sided upper 95 percent confidence limit for the 95 th percentile

BSL = background screening level

FOD = frequency of detection

KM = Kaplan-Meier

n = sample size

NA = not applicable for datasets with nondetects

WH = Wilson-Hilferty

Notes:

1 Distribution assessed by goodness-of-fit tests based on detected values only conducted using ProUCL 4.1 at a 95% confidence level (α = 0.05). Distribution for BSL selected according to the following hierarchy: (N) normal > (G) gamma > (LN) lognormal > (NP) nonparametric.

2 Skewness estimated using the standard deviation of the log-transformed data (detects only) (σ). Datasets with σ≤ 1.0 are considered mildly skewed, whereas datasets with σ>1.0 are moderately to highly skewed (USEPA 2010). See Table 4 for how skewness informs the choice of UTL methods.

3 UTLs only calculated for analytes with at least eight total observations and five detected observations (USEPA 2010). Calculation method selected in accordance with Table 4.

4 Final BSL selected in accordance with decision tree presented in Table 4. Notes indicate basis for BSL: A = 95/95 UTL; B = maximum detected concentration; C = BSL not defined because FOD=0%.

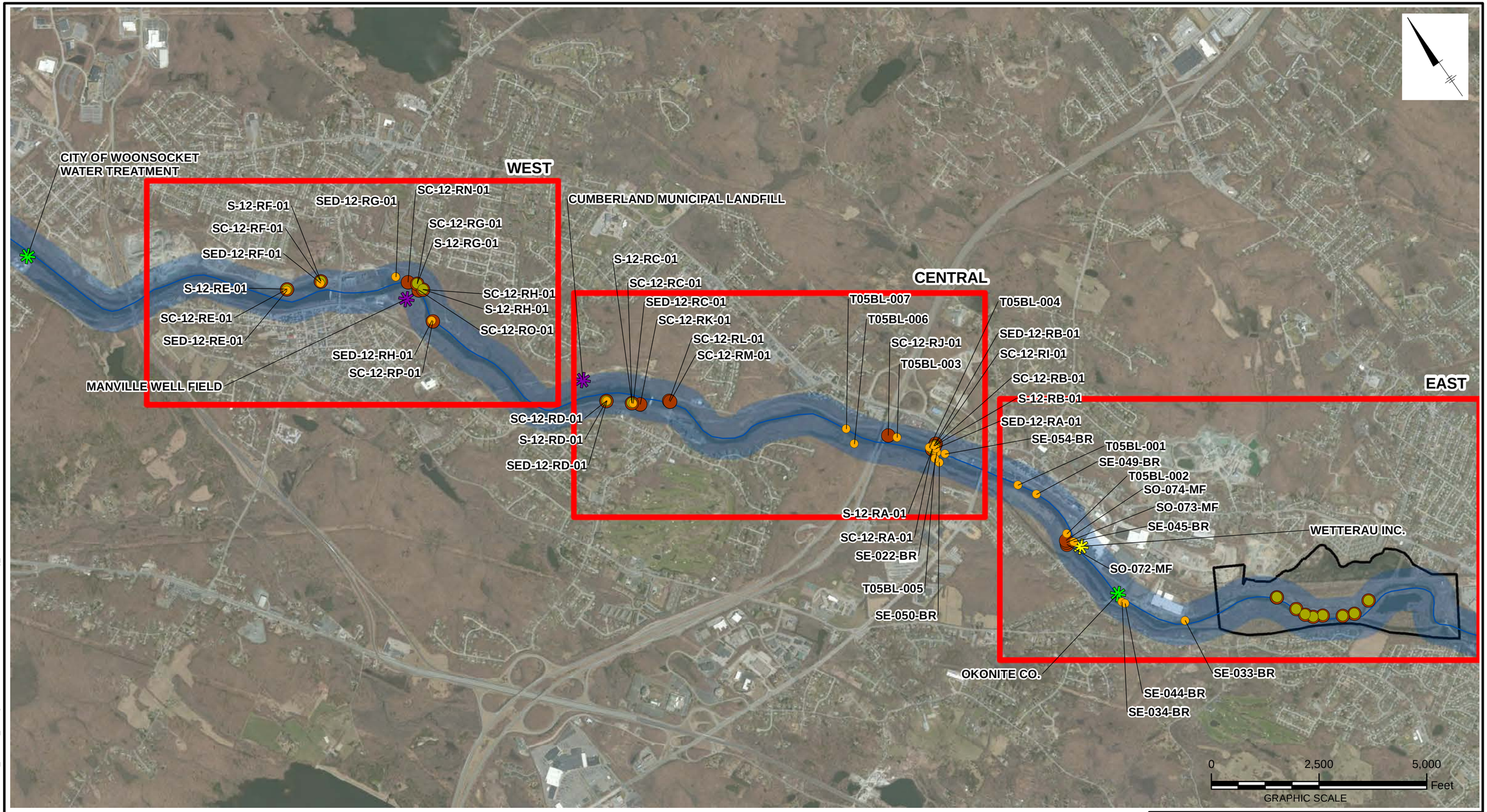
5 Concentrations presented in units of milligrams per kilogram (mg/kg).

References:

USEPA. 2010. ProUCL Version 4.1.00 Technical Guide. Office of Research and Development. EPA/600/R-07/041. May.

ARCADIS

Figures



LEGEND:

- PERMITTED POINT DISCHARGE ELIMINATION SYSTEM SANITARY WASTE SITES WITHIN 500' OF BLACKSTONE RIVER
- LEAKING UNDERGROUND STORAGE TANKS (LUSTS) WITHIN 500 FEET OF BLACKSTONE RIVER
- KNOWN HAZARDOUS WASTE SITES (CERCLIS) WITHIN 500 FEET OF BLACKSTONE RIVER
- SEDIMENT
- SOIL 0-0.5 FT
- SOIL CORE 0-1 FT
- BLACKSTONE RIVER
- 500' STREAM BUFFER
- OU2 BOUNDARY

NOTES:

1. SAMPLE LOCATIONS AND BASEMAPPING ARE IN THE COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD 83 FEET. LOCATIONS RECORDED IN THE FIELD USING GPS.
2. SANITARY WASTE SITE, LEAKING UNDERGROUND STORAGE TANK, AND KNOWN HAZARDOUS WASTE SITE POINT LOCATIONS OBTAINED FROM THE RHODE ISLAND GEOSPATIAL DATA CATALOG AT HTTP://WWW.EDC.URI.EDU/RIGIS/DATA/

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

BACKGROUND SEDIMENT AND SOIL LOCATIONS

ARCADIS

FIGURE 1

CITY:(CLEVELAND) DIV/GROUP:(ENV/GIS) DB:L.GREENE LD: PIC: PM: TM:
PROJECT: B0037902.0001.00500
Path: G:\env\roCommon\GIS\Peterson_PuritanCumberland_RI\2013_EcologicalRA\mxd\2012SoilandSedimentWorking_new.mxd Date Saved: 3/20/2013 1:47:47 PM

Location ID:		SED-12-RE-01	S-12-RE-01	SC-12-RE-01	S-12-RF-01	SC-12-RF-01	SED-12-RF-01
Sample Depth (feet):		0-0.5	0 - 0.5	0 - 1	0 - 0.5	0 - 1	0-0.5
Date Collected:	Units	11/28/12	11/28/12	11/28/12	11/28/12	11/28/12	11/28/12
SVOCs							
bis(2-ethylhexyl)phthalate	mg/kg	0.630 UJ	NA	NA	NA	NA	1.18 UJ
Total PAHs	mg/kg	8.82	NA	NA	NA	NA	26.0
Metals							
Cadmium	mg/kg	8.63	0.763	0.358	7.27	7.58	16.8 J
Chromium	mg/kg	91.9	NA	NA	NA	NA	139 J
Copper	mg/kg	103	NA	NA	NA	NA	200 J
Lead	mg/kg	108	NA	NA	NA	NA	187 J
Zinc	mg/kg	334	NA	NA	NA	NA	597 J

Location ID:		SED-12-RG-01	SC-12-RN-01	S-12-RG-01	SC-12-RG-01	S-12-RH-01	SC-12-RH-01
Sample Depth (feet):		0-0.5	0 - 1	0 - 0.5	0 - 1	0 - 0.5	0 - 1
Date Collected:	Units	11/28/12	11/29/12	11/28/12	11/28/12	11/28/12	11/28/12
SVOCs							
bis(2-ethylhexyl)phthalate	mg/kg	2.97 UJ	1.62 UJ	NA	NA	NA	NA
Total PAHs	mg/kg	46.7	92.4	NA	NA	NA	NA
Metals							
Cadmium	mg/kg	6.99	2.27	0.432	0.338	0.232	0.189
Chromium	mg/kg	202	27.6	NA	NA	NA	NA
Copper	mg/kg	218	62.5	NA	NA	NA	NA
Lead	mg/kg	521	562	NA	NA	NA	NA
Zinc	mg/kg	692	314	NA	NA	NA	NA

MANVILLE WELL FIELD

Location ID:		SC-12-RO-01	SED-12-RH-01	SC-12-RP-01
Sample Depth (feet):		0 - 1	0-0.5	0 - 1
Date Collected:	Units	11/29/12	11/28/12	11/29/12
SVOCs				
bis(2-ethylhexyl)phthalate	mg/kg	1.47 UJ	0.134 J	1.04 JEB
Total PAHs	mg/kg	36.0	8.23	14.9
Metals				
Cadmium	mg/kg	0.329	1.76	1.860
Chromium	mg/kg	8.98	20.2	120.0
Copper	mg/kg	16.1	32.0	159.0
Lead	mg/kg	193	41	209.0
Zinc	mg/kg	91.7	83	86.4

0 600 1,200 Feet

GRAPHIC SCALE

LEGEND:

- SEDIMENT
- SOIL CORE 0-1 FT
- SOIL 0-0.5 FT
- PERMITTED POINT DISCHARGE ELIMINATION SYSTEM SANITARY WASTE SITES WITHIN 500' OF BLACKSTONE RIVER
- LEAKING UNDERGROUND STORAGE TANKS (LUSTS) WITHIN 500 FEET OF BLACKSTONE RIVER
- KNOWN HAZARDOUS WASTE SITES (CERCLIS) WITHIN 500 FEET OF BLACKSTONE RIVER
- BLACKSTONE RIVER
- 500' STREAM BUFFER
- OU2 BOUNDARY

KEY:

U - REPORTED AS NON-DETECTED
J - ESTIMATED
EB - QUALIFIED AS NON-DETECTED DUE TO ASSOCIATED BLANK CONTAMINATION
NA - NOT ANALYZED

NOTES:

1. SAMPLE LOCATIONS AND BASEMAPPING ARE IN THE COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD 83 FEET. LOCATIONS RECORDED IN THE FIELD USING GPS.
2. SANITARY WASTE SITE, LEAKING UNDERGROUND STORAGE TANK, AND KNOWN HAZARDOUS WASTE SITE POINT LOCATIONS OBTAINED FROM THE RHODE ISLAND GEOSPATIAL DATA CATALOG AT HTTP://WWW.EDC.URI.EDU/RIGIS/DATA/

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

BACKGROUND SEDIMENT AND SOIL DATA - WEST

ARCADIS

FIGURE 2

CITY:(CLEVELAND) DIV/GROUP:(ENV/GIS) DB:L.GREENE LD: PIC: PM: TM:
PROJECT: B0037902.0001.00500
Path: G:\env\Common\GIS\Peterson_Puritan\Cumberland_RI\2013_EcologicalRA\mxd\2012SoilandSedimentAnalyticalWest.mxd Date Saved: 3/20/2013 2:45:05 PM

Location ID:		S-12-RD-01	SC-12-RD-01	SED-12-RD-01	S-12-RC-01	SC-12-RC-01	SED-12-RC-01
Sample Depth (feet):		0 - 0.5	0 - 1	0-0.5	0 - 0.5	0 - 1	0-0.5
Date Collected:	Units	11/27/12	11/27/12	11/29/12	11/27/12	11/27/12	11/29/12
SVOCs							
bis(2-ethylhexyl)phthalate	mg/kg	NA	NA	2.51 UJ	NA	NA	3.28 UJ
Total PAHs	mg/kg	NA	NA	18.8	NA	NA	22.2
Metals							
Cadmium	mg/kg	6.44	6.52	6.96	3.11	4.9 [3.86]	6.74
Chromium	mg/kg	NA	NA	46.4	NA	NA	70.2
Copper	mg/kg	NA	NA	96.2	NA	NA	132
Lead	mg/kg	NA	NA	82.6	NA	NA	127
Zinc	mg/kg	NA	NA	196	NA	NA	258

Location ID:		S-12-RA-01	SC-12-RA-01	S-12-RB-01	SC-12-RB-01	SED-12-RA-01	SED-12-RB-01	SC-12-RI-01	SE-022-BR	SE-054-BR
Sample Depth (feet):		0 - 0.5	0 - 1	0 - 0.5	0 - 1	0-0.5	0-0.5	0 - 1	0-1	0-1
Date Collected:	Units	11/27/12	11/27/12	11/27/12	11/27/12	11/29/12	11/29/12	11/29/12	09/05/03	09/01/04
SVOCs										
bis(2-ethylhexyl)phthalate	mg/kg	NA	NA	NA	NA	3.60 UJ	4.07 UJ [0.784 UJ]	0.649 UJ	0.460 U	0.450 U
Total PAHs	mg/kg	NA	NA	NA	NA	26.3	13.3 [8.9]	14.4	0.1	0.441
Metals										
Cadmium	mg/kg	7.52	5.36	4.3	1.41 [1.69]	14.00	4.04 [3.57]	8.9	0.780 J	1.80 J
Chromium	mg/kg	NA	NA	NA	NA	153	124 [119]	170.0	19.1	37.0
Copper	mg/kg	NA	NA	NA	NA	219	156 [160]	236	22.7	22.4
Lead	mg/kg	NA	NA	NA	NA	207	231 [254]	289	9.50 J	19.8 J
Zinc	mg/kg	NA	NA	NA	NA	400	234 [230]	362	106 J	95.4 J

Location ID:		SC-12-RK-01	SC-12-RL-01	SC-12-RM-01
Sample Depth (feet):		0 - 1	0 - 1	0 - 1
Date Collected:	Units	11/29/12	11/29/12	11/29/12
SVOCs				
bis(2-ethylhexyl)phthalate	mg/kg	2.73 UJ	1.55 UJ	1.60 UJ
Total PAHs	mg/kg	24.0	152	30.9
Metals				
Cadmium	mg/kg	6.38	1.78	1.18
Chromium	mg/kg	106	37.3	18.8
Copper	mg/kg	158	190	94.6
Lead	mg/kg	175	1640	326
Zinc	mg/kg	209	1010	260

Location ID:		T05BL-007	T05BL-006	SC-12-RJ-01	T05BL-003	T05BL-004	T05BL-005	SE-050-BR
Sample Depth (feet):		0-0.5	0-0.5	0 - 1	0-0.5	0-0.5	0-0.5	0-1
Date Collected:	Units	06/23/05	06/23/05	11/29/12	06/23/05	06/23/05	06/23/05	08/31/04
SVOCs								
bis(2-ethylhexyl)phthalate	mg/kg	1.100	2.700	1.78 UJ	5.90	1.90	1.10	0.260 J
Total PAHs	mg/kg	18.2 J	30.6	17.8	20.2	18	23.2 J	4.72 J
Metals								
Cadmium	mg/kg	3.10	12.000	0.609 J	9.90	9.8	11.0	2.90
Chromium	mg/kg	21.0	110.0	44 J	110	120.0	86	29.0 J
Copper	mg/kg	47.0	180.0	38.5 J	170	160	140	37.6
Lead	mg/kg	48.0	160.0	86 J	450	300	160	46.2 J
Zinc	mg/kg	120.0	380 J	40.7 J	680 J	490 J	410	168 J

CUMBERLAND MUNICIPAL LANDFILL

0 600 1,200 Feet

GRAPHIC SCALE

LEGEND:

- SEDIMENT
- SOIL 0-0.5 FT
- SOIL CORE 0-1 FT
- PERMITTED POINT DISCHARGE ELIMINATION SYSTEM SANITARY WASTE SITES WITHIN 500' OF BLACKSTONE RIVER
- LEAKING UNDERGROUND STORAGE TANKS (LUSTS) WITHIN 500 FEET OF BLACKSTONE RIVER
- KNOWN HAZARDOUS WASTE SITES (CERCLIS) WITHIN 500 FEET OF BLACKSTONE RIVER
- BLACKSTONE RIVER
- 500' STREAM BUFFER
- OU2 BOUNDARY

KEY:

U - REPORTED AS NON-DETECTED
J - ESTIMATED
NA - NOT ANALYZED

NOTES:

1. SAMPLE LOCATIONS AND BASEMAPPING ARE IN THE COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD 83 FEET. LOCATIONS RECORDED IN THE FIELD USING GPS.
2. SANITARY WASTE SITE, LEAKING UNDERGROUND STORAGE TANK, AND KNOWN HAZARDOUS WASTE SITE POINT LOCATIONS OBTAINED FROM THE RHODE ISLAND GEOSPATIAL DATA CATALOG AT HTTP://WWW.EDC.URI.EDU/RIGIS/DATA/
3. RESULTS IN BRACKETS REPRESENT FIELD DUPLICATE RESULTS.

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

BACKGROUND SEDIMENT AND SOIL DATA - CENTRAL

ARCADIS

FIGURE 3

CITY:(CLEVELAND) DIV/GROUP:(ENV/GIS) DB:L.GREENE LD: PIC: PM: TM:
PROJECT: B0037902.0001.00500
Path: G:\enviro\Common\GIS\Peterson_Puritan\Cumberland_RI\2013_EcologicalRA\mxd\2012SolandSedimentAnalyticalCenter.mxd Date Saved: 3/20/2013 2:42:28 PM

Location ID:		T05BL-001	SE-049-BR	T05BL-002	SO-074-MF	SO-073-MF	SO-072-MF	SE-045-BR
Sample Depth (feet):		0-0.5	0-1	0-0.5	0 - 1	0 - 1	0 - 1	0-1
Date Collected:	Units	06/23/05	08/30/04	06/23/05	9/10/2004	9/10/2004	9/10/2004	08/30/04
SVOCs								
bis(2-ethylhexyl)phthalate	mg/kg	0.700	1.00	0.110	0.370 U	0.390 U	0.480 U	0.150 J
Total PAHs	mg/kg	25.9 J	0.489	9.47 J	14.2	100	24.6	8.94 J
Metals								
Cadmium	mg/kg	2.00	0.390 J	0.200	1.10 U	1.40	1.90	0.250 J
Chromium	mg/kg	19.0	17.3 J	10.0	31.1	44.2	89.6	9.30 J
Copper	mg/kg	38.0	11.9	13.0	34.0	40.7	75.1	10.5
Lead	mg/kg	34.0	26.1 J	18.0	60.0	82.6	161	25.1 J
Zinc	mg/kg	96.0	35.3 J	24.0	29.3	43.5	51.7	35.0 J

Location ID:		SE-034-BR	SE-044-BR	SE-033-BR
Sample Depth (feet):		0-1	0-1	0-1
Date Collected:	Units	09/10/03	08/30/04	09/10/03
SVOCs				
bis(2-ethylhexyl)phthalate	mg/kg	0.500 U	0.160 J	0.420 U
Total PAHs	mg/kg	8.86 J	3.13 J	1.69
Metals				
Cadmium	mg/kg	0.330 J	0.460 J	0.230 J
Chromium	mg/kg	10.4	6.30 J	7.80
Copper	mg/kg	132	11.8	11.0
Lead	mg/kg	18.9 J	12.3 J	12.5 J
Zinc	mg/kg	49.0	38.2 J	33.6

WETTERAU INC.

OKONITE CO.

0 700 1,400 Feet

GRAPHIC SCALE

LEGEND:

- SEDIMENT
- SOIL 0-0.5 FT
- SOIL CORE 0-1 FT
- PERMITTED POINT DISCHARGE ELIMINATION SYSTEM SANITARY WASTE SITES WITHIN 500' OF BLACKSTONE RIVER
- LEAKING UNDERGROUND STORAGE TANKS (LUSTS) WITHIN 500 FEET OF BLACKSTONE RIVER
- KNOWN HAZARDOUS WASTE SITES (CERCLIS) WITHIN 500 FEET OF BLACKSTONE RIVER
- BLACKSTONE RIVER
- 500' STREAM BUFFER
- OU2 BOUNDARY

KEY:

U - REPORTED AS NON-DETECTED
J - ESTIMATED

NOTES:

1. SAMPLE LOCATIONS AND BASEMAPPING ARE IN THE COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD 83 FEET. LOCATIONS RECORDED IN THE FIELD USING GPS.
2. SANITARY WASTE SITE, LEAKING UNDERGROUND STORAGE TANK, AND KNOWN HAZARDOUS WASTE SITE POINT LOCATIONS OBTAINED FROM THE RHODE ISLAND GEOSPATIAL DATA CATALOG AT HTTP://WWW.EDC.URI.EDU/RIGIS/DATA/

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

BACKGROUND SEDIMENT AND SOIL DATA - EAST

ARCADIS

FIGURE 4

CITY:(CLEVELAND) DIV/GROUP:(ENV/GIS) DB:L.GREENE LD: PIC: PM: TM:
PROJECT: B0037902.0001.00500
Path: G:\env\o\Common\GIS\Peterson_Puritan\Cumberland_RI\2013_EcologicalRA\mxd\2012SoilandSedimentAnalyticaleast.mxd Date Saved: 3/20/2013 2:47:42 PM

Attachment 1

Background Soil Sampling –
Sample Photos

1



Soil core sample SC-12-RA-01

2



Soil core sample SC-12-RB-01

PETERSON/PURITAN, INC. SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

Background Soil Sampling - Sample Photos

ARCADIS

Attachment
1

3



Soil core sample SC-12-RC-01

4



Soil core sample SC-12-RD-01

PETERSON/PURITAN, INC. SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

Background Soil Sampling - Sample Photos

ARCADIS

Attachment
1

5



Soil core sample SC-12-RE-01

6



Soil core sample SC-12-RF-01

PETERSON/PURITAN, INC. SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

Background Soil Sampling - Sample Photos

ARCADIS

Attachment
1

7



Soil core sample SC-12-RG-01

8



Soil core sample SC-12-RH-01

PETERSON/PURITAN, INC. SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

Background Soil Sampling - Sample Photos

ARCADIS

Attachment
1

9



Soil core sample SC-12-RI-01

10



Soil core sample SC-12-RJ-01

PETERSON/PURITAN, INC. SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

Background Soil Sampling - Sample Photos

ARCADIS

Attachment
1

11



Soil core sample SC-12-RK-01

12



Soil core sample SC-12-RL-01

PETERSON/PURITAN, INC. SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

Background Soil Sampling - Sample Photos

ARCADIS

Attachment
1

13



Soil core sample SC-12-RM-01

14



Soil core sample SC-12-RN-01

PETERSON/PURITAN, INC. SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

Background Soil Sampling - Sample Photos

ARCADIS

Attachment
1

15



Soil core sample SC-12-RO-01

16



Soil core sample SC-12-RP-01

PETERSON/PURITAN, INC. SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

Background Soil Sampling - Sample Photos

ARCADIS

Attachment
1

APPENDIX F

PAL REPORT

TECHNICAL REPORT

PHASE I CULTURAL RESOURCES RECONNAISSANCE SURVEY PETERSON/PURITAN, INC. SUPERFUND SITE – OPERABLE UNIT 2

Cumberland and Lincoln, Rhode Island

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April 2012
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PAL Publications

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MANAGEMENT ABSTRACT

PAL has completed a Phase I reconnaissance survey for the Peterson/Puritan, Inc. Superfund Site–Operable Unit 2 (OU2) (United States Environmental Protection Agency [EPA] ID #RID055176283) in Cumberland and Lincoln, Rhode Island. The objective of the Phase I reconnaissance survey was to locate and identify any previously recorded and visible historic and archaeological resources and sensitive areas within the OU2 project area, and make recommendations for further studies that may be needed in advance of site remediation activities. Archival research including local informant interviews, a review of available environmental site investigation (geotechnical) data, Native American consultation, and a visual field walkover of the project area was conducted.

The survey resulted in the identification of two historic properties listed in the National Register of Historic Places within the OU2 project area: the Lonsdale Historic District "Old Village" and the Blackstone Canal. Two contributing elements within these districts, the Pratt/Lonsdale Dam and Railroad Bridge and the earthen ramp and stone abutment (Blackstone Canal Feature 1A) are also located within the OU2 project area. Three historic aboveground resource areas older than 50 years are also present in the project area; however, they are assessed as not eligible for listing in the National Register: Lenox Street Well, Quinnville Well Field, and the Nunes Parcel Transfer Station. No additional historic aboveground survey is recommended for these three resource areas.

Archaeologically sensitive areas for pre- and post-contact period Native American and EuroAmerican resources are identified within the OU2 project area on the basis of regional/local site predictive models that take into account the project area land use histories, historic map reconstructions, and a review of available environmental geotechnical data. The potential sensitive strata for Native American sites consist of natural alluvium identified at varying depths within the Project APE. For the J.M. Mills Landfill, the natural alluvium would be present below the waste in the 100-feet (ft) thick delineated landfill mass and below 9-15 ft around the perimeter of the landfill mass up to and along the river's edge (riparian buffer). For the Unnamed Island the natural alluvium extend below 6-16 ft in the delineated waste and fill materials, but could be present beginning at the ground surface along the river and pond edges outside of the waste materials. On the Nunes Parcel the natural alluvium extend below 1.5-13.5 ft in the areas of delineated waste and fill materials, but could be present beginning at the ground surface along the railroad easement and the pond/river edges. The remaining river/pond/wetland areas could contain sensitive natural alluvial strata that begin at the river/pond/wetland bottoms. The upper 20 ft of natural alluvial deposits would have the highest potential for Native American cultural deposits. The age and precise horizontal/vertical location of the natural alluvial deposits below and adjacent to waste and fill materials is currently unknown without radiocarbon dating of any organic remains (e.g., wood charcoal, shell, peat) that may be present in these natural strata. The types of expected Native American cultural deposits in alluvial floodplain deposits dating to the pre-contact, contact, and early historic periods include habitation/resource procurement sites (e.g., fishing and hunting stations), dugout canoes in river and pond sediments, and possible burials in areas of naturally higher ground away from inundated, flood prone landforms. Post-contact period EuroAmerican archaeological resource areas are identified on the Nunes Parcel and on the north and east sides of Pond F. These resources include the documented gatehouse/power trench beneath and adjacent to the existing transfer station building in the eastern part of the Nunes Parcel and the Hunt Dam remains that extend along the north side of Pond F. Both of these resource areas are associated with the historical operations of the Lonsdale Mills, but are outside of the Lonsdale Historic District boundaries as currently mapped.

EPA is currently studying a proposed cleanup plan for the OU2 portion of the Peterson-Puritan, Inc. Superfund Site, which is expected to be released within the next year. PAL therefore recommends that the EPA and its remediation design team continue to consult with the RIHPHC and Native American tribes and other interested parties including the Cumberland and Lincoln historical associations to avoid, minimize, and/or mitigate direct impacts to historic properties and archaeologically sensitive areas.

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CHAPTER ONE

INTRODUCTION

This technical report presents the results of a Phase I reconnaissance survey for the Peterson/Puritan, Inc. Superfund Site–Operable Unit 2 (OU2) (United States Environmental Protection Agency [EPA] ID #RID055176283) in Cumberland and Lincoln, Rhode Island (Figure 1-1). PAL conducted the Phase I reconnaissance survey under contract with Ground Water Consultants, Inc. of Beverly, Massachusetts, which is assisting the potentially responsible parties (PRPs) in conducting a Remedial Investigation and Feasibility Study (RIFS) in the site remediation work with oversight from the U.S. Environmental Protection Agency Region 1 (EPA).

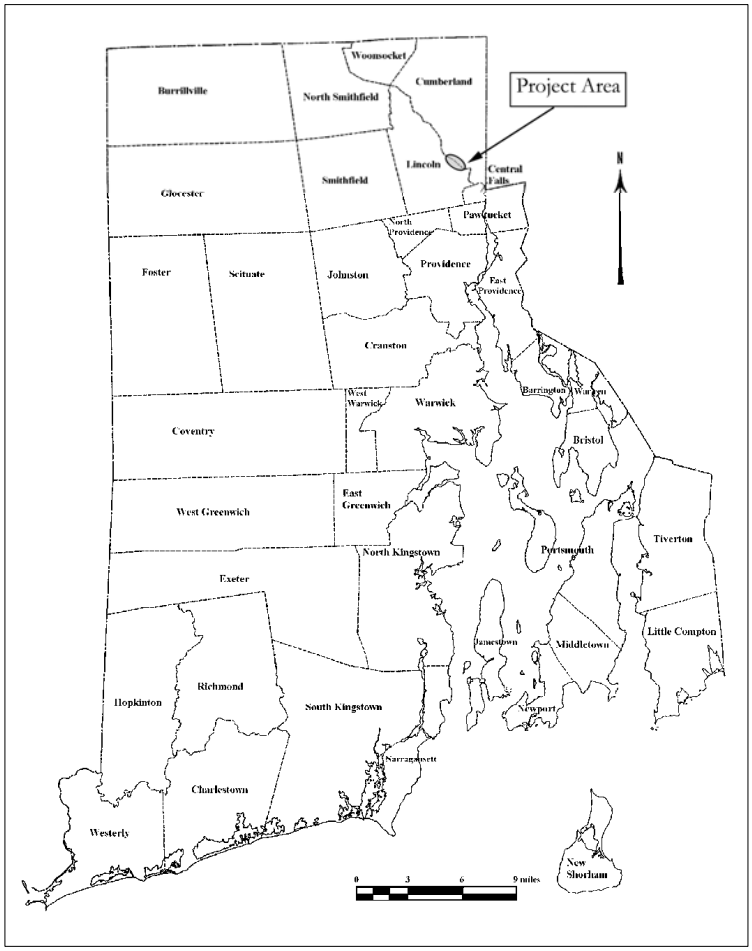


Figure 1-1. Location of the Towns of Cumberland and Lincoln in the State of Rhode Island.

Project Description

The Peterson/Puritan, Inc. Superfund Site occupies 500 acres, is approximately two miles long on the Blackstone River in Cumberland and Lincoln, and extends 2,000 feet (ft) to the east and west of the river. The site is divided into two operable units known as Operable Unit 1 (OU1) and Operable Unit 2 (OU2) (Figure 1-2). OU1 encompasses an industrial park containing the (former) Peterson/Puritan Facility (CCL) and the Pacific Anchor Chemical Facility (PAC) as well as the (former) Martin Street Municipal Well. OU2, the focus of the current investigations, is downstream of OU1 and encompasses an approximately one mile-long, 200-acre section of the river valley (Figure 1-3). OU2 is comprised of several private properties that include: the 38-acre J.M. Mills Landfill, the Nunes Property (inactive) solid waste transfer station, the Lenox Street Municipal Well on the east (Cumberland) side of the river; a 30-acre unnamed island in the Blackstone River and the 24-acre Quinnville Municipal Wellfield on the west (Lincoln) side of the Blackstone River[1]. The Providence and Worcester Railroad line runs through the northern portion of OU2 and forms the eastern extent of the landfill slope. It borders undeveloped floodplain and wetlands to the north associated with the Blackstone River. The Blackstone River adjacent to the tow path

[1] In keeping with EPA conventions, throughout this report the Blackstone River is assumed to run north to south with Cumberland to the east and Lincoln to the west).

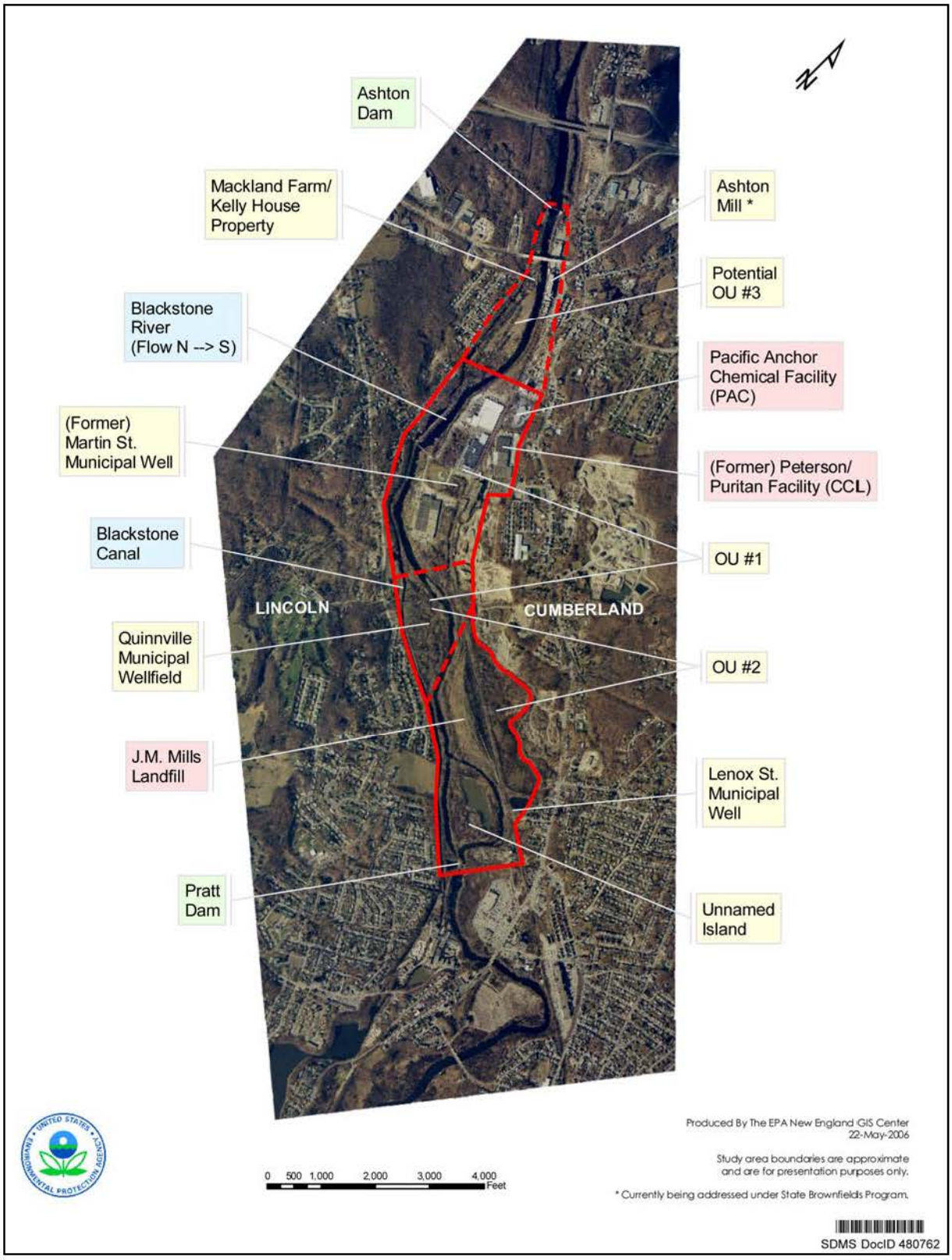


Figure 1-2. Peterson/Puritan, Inc. Superfund Site Study Area including Operable Unit 1 (OU1) and Operable Unit 2 (OU2) (source: EPA 2003).

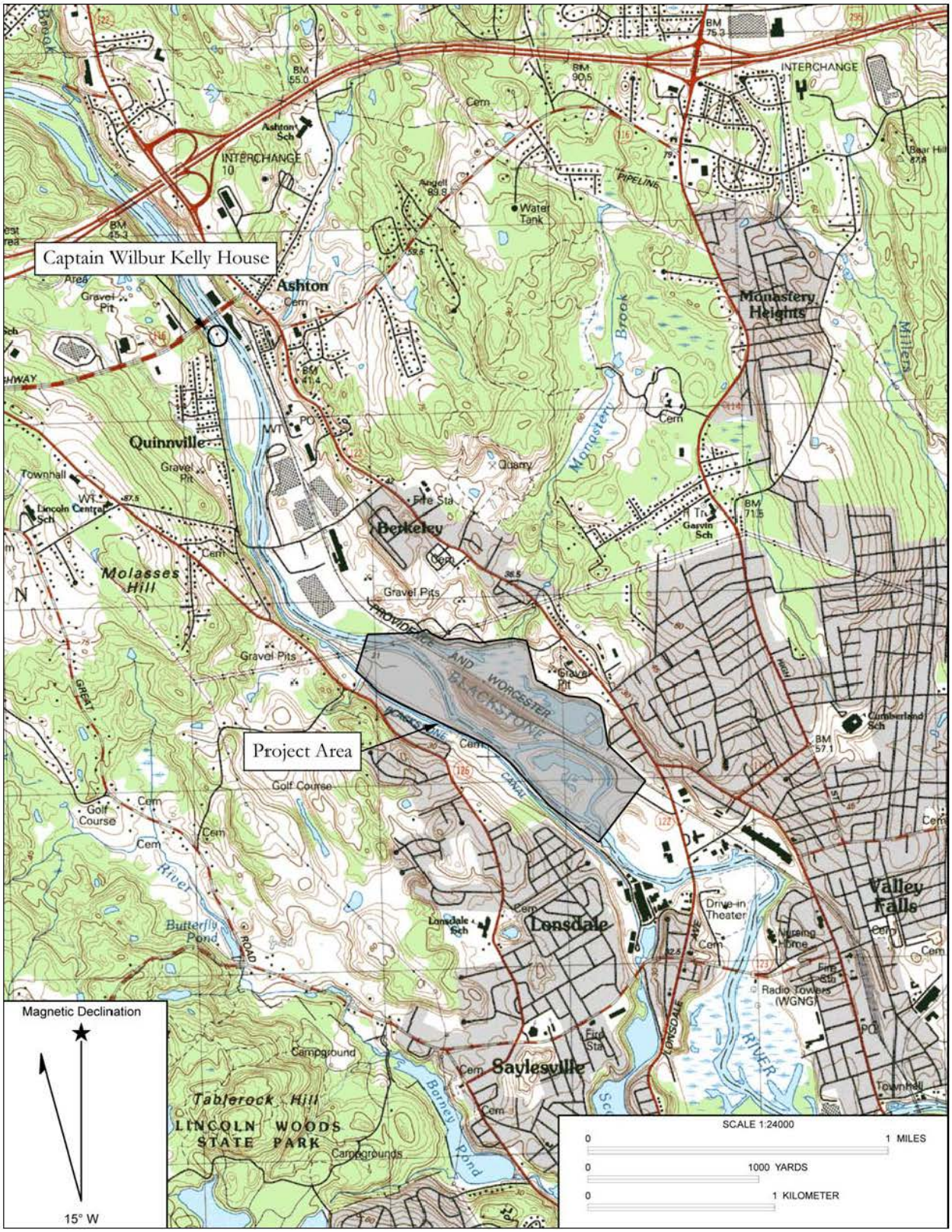


Figure 1-3. Location of the OU2 project area on the Pawtucket, RI USGS topographic quadrangle, 7.5 minute series.

embankment (current bike path) of the Blackstone Canal runs along the western boundary. The Pratt Dam forms the southern boundary of the OU2 project area.

EPA indicates that the most contaminated parcel in the OU2 project area is the J.M. Mills Landfill, which accepted mixed municipal and industrial waste from 1954 through 1986. The Unnamed Island adjacent to the landfill also contains solid waste and EPA believes the island's soils were used to provide daily cover for the landfill and perhaps served as an additional disposal location during landfill operations. The Quinnville Wellfield in Lincoln and the Cumberland Lenox Street municipal well were used as water supply wells until 1979, when they were closed by the Rhode Island Department of Health due to the presence of volatile organics (VOCs) in the water. EPA listed the Peterson/Puritan, Inc. Site on the Superfund National Priorities List on September 8, 1993. EPA is currently studying a proposed cleanup plan for the site, which is expected to be released within the next year. The cleanup will likely include the placement of a synthetic cap covering the entire area of waste for the landfill and transfer station parcel and possible removal of contaminated soils in the wellfield and the unnamed island.

Scope

In November 2010, EPA contacted the Rhode Island Historical Preservation & Heritage Commission (RIHPHC) regarding the site remediation for the Peterson/Puritan Superfund Site. The EPA requested information about cultural resources that may be present in the immediate area of the site. In a letter dated December 3, 2010 the RIHPHC responded to the EPA that the "protection of the historic resources in the cleanup area is of significant concern" to their office (see AppendixA). RIHPHC provided a map that showed the approximate boundaries of historic resources in the area of the site. According to the RIHPHC map, eight historic resources listed or determined eligible for the National Register of Historic Places are near the OU2 project area (Figure 1-4). These resources include: 1) Ashton Historic District (NR listed); 2) Old Ashton Historic District (NR listed); 3) St. Joseph's Church Complex (NR listed); 4) Berkeley Historic District (NR listed); 5) Blackstone Canal Historic District (NR listed); 6) Lonsdale Mill Village Historic District-Cumberland node (NR listed); 7) Lonsdale Mill Village Historic District-Lincoln node NR listed); and 8) Church Street Railroad Bridge (determined NR eligible). The RIHPHC letter and map did not identify any recorded archaeological sites within or near the OU2 project area.

In compliance with Section 106 of the National Historic Preservation Act (NHPA) of 1966 as amended, the EPA, as the lead federal agency for the superfund site, in response to the RIHPHC concerns, requested that a Phase I reconnaissance survey be conducted of the OU2 project area. The objective of the Phase I reconnaissance survey was to locate and identify any previously recorded and visible historic and archaeological resources and sensitive areas within the OU2 project area, and make recommendations for further studies that may be needed in advance of site remediation activities.

Area of Potential Effect (APE)

The APE of a project is defined as the "geographic area or areas within which an undertaking may directly or indirectly cause changes in the character of or use of historic properties, if any such properties exist" (36 CFR 800.1(d)). The establishment of an APE is based on the potential for effect, which will differ for aboveground historic properties (historic districts, buildings, objects, and structures) and belowground historic properties (archaeological sites). The APE for historic resources considers the area where the project's construction and/or operation has the potential to result in a direct physical effect on historic properties or where indirect effects, such as noise, vibration, visual (setting), traffic, atmospheric, construction, and cumulative may change the characteristics of significance or integrity of a property. For archaeological resources the primary impacts will be associated with construction impacts. Construction impacts are physical changes caused during and by project construction, as opposed to project operation, with the potential to damage all or part of a historic property or its setting.

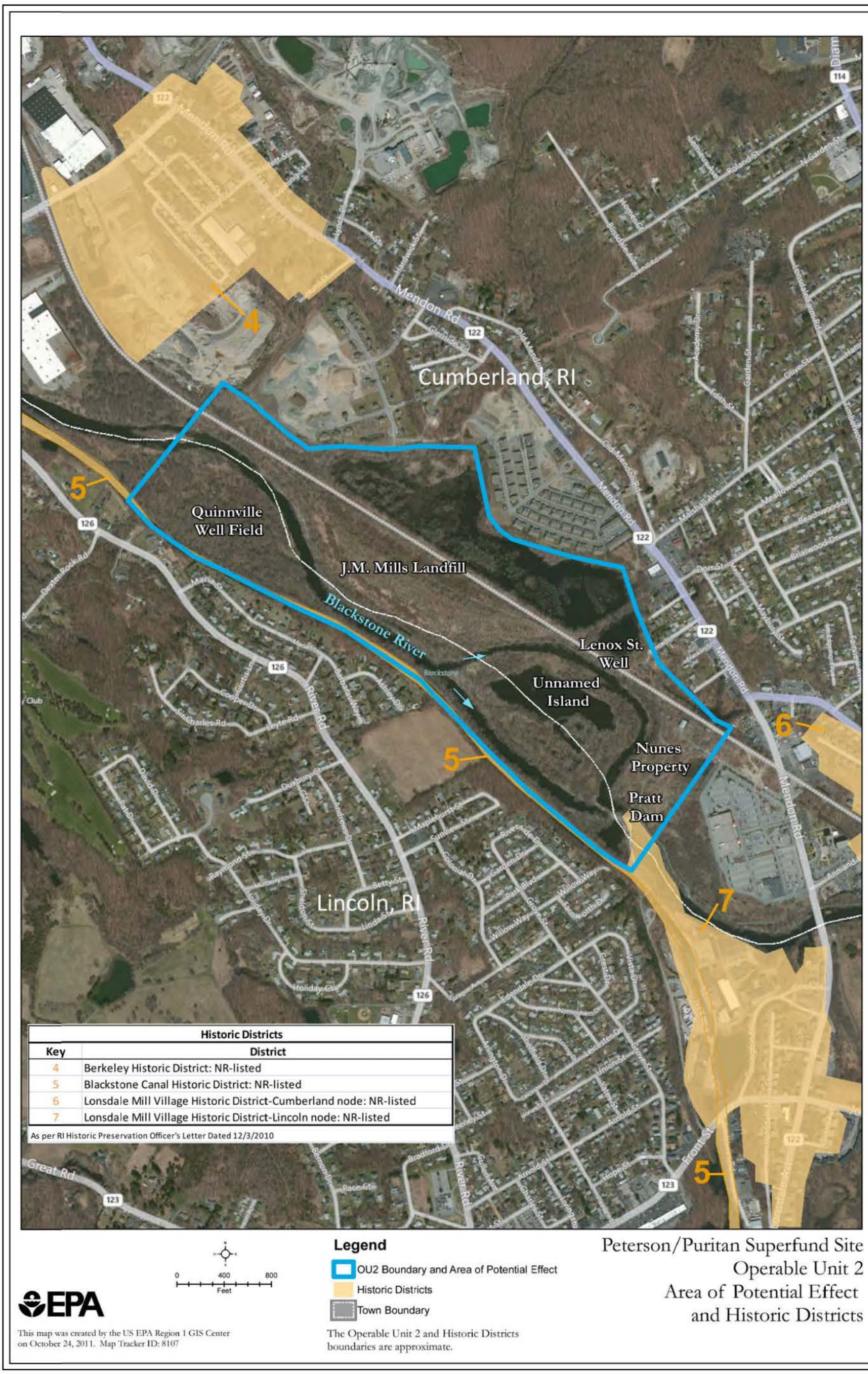


Figure 1-4. Historic resources listed or determined eligible for the National Register of Historic Places near the OU2 project area (source: RIHPHC 2010).

As noted above, EPA is currently studying a proposed cleanup plan for the site, which is expected to be released within the next year. No specific work plans identifying direct project impact areas such as construction staging, access, and remediation areas, however, have yet been developed. For purposes of this Phase I reconnaissance survey, PAL therefore recommends a combined, preliminary APE for archaeological sites and aboveground historic properties that conforms to the current boundaries of the OU2 project area as shown on Figure 1-2 and described above. The physically isolated location of the OU2 project area and the nature of the planned remediation activities (earth moving/capping, surface cleanup) will limit impacts resulting from the project to historic properties outside of the project area. Therefore, no additional APE for potential indirect effects is recommended at this time.

Authority

The Phase I reconnaissance survey will assist the EPA in fulfilling their Section 106 responsibilities, as outlined in the regulations at 36 CFR 800.4 to 800.6, including consultation with the RIHPHC and other potential parties including Native American tribes. The survey was conducted under state archaeological permit number 11-27, issued on December 20, 2011 by the RIHPHC (see Appendix A). The permit included special conditions for consultation with the Narragansett Indian Tribal Historic Preservation Officer.

Project Personnel

Archival research and field investigations were conducted from December 2011 to March 2012. PAL personnel involved in the project include Suzanne Cherau (project manager/principal investigator), John Daly (industrial historian), and Kate Johnson (researcher).

Disposition of Project Materials

All project information (i.e., field recording forms, maps, cultural materials, photographs) is currently on file at PAL, 210 Lonsdale Avenue, Pawtucket, Rhode Island. PAL serves as a temporary curation facility until such time as the State of Rhode Island designates a permanent state repository.

CHAPTER TWO

METHODOLOGY

The goals of the Phase I reconnaissance survey was to recommend a preliminary APE for direct and indirect project impacts to aboveground historic and belowground archaeological resources, to identify historic resources more than 50 years of age within the preliminary APE; and to identify the presence of any inventoried archaeological sites and potentially significant belowground resources within the preliminary APE. To accomplish these objectives, two research strategies were used:

- archival research, including a review of literature and maps; and
- field investigations, consisting of a "walkover" visual survey of the OU 2 project area as currently defined by EPA.

The archival research and walkover survey provided the information needed to make recommendations concerning the preliminary project APE, and to develop environmental and historic contexts and a predictive model for archaeological sensitivity. Archaeological sensitivity is defined as the likelihood for belowground cultural resources to be present and is based on various categories of information:

- locational, functional, and temporal characteristics of previously identified cultural resources in the project area or vicinity; and
- local and regional environmental data reviewed in conjunction with existing project area conditions documented during the walkover survey, and archival research about the project area's land use history.

The archival research was correlated with the field survey data, and the resulting information was interpreted within the environmental and historic contexts developed for the project area. The result was an inventory of previously recorded cultural resources and sensitive areas within and adjacent to the OU2 project area and an assessment of their potential significance and eligibility for listing in the National Register of Historic Places (National Register).

Evaluating Significance and Historic Contexts

The different phases of investigations (reconnaissance/identification survey, evaluation, and data recovery) reflect preservation planning standards for the identification, evaluation, registration, and treatment of cultural resources (National Park Service [NPS] 1983). An essential component of this planning structure is the identification of historic properties that are eligible for inclusion in the National Register, the official federal list of properties that have been studied and found worthy of preservation. Historic properties can be a district, site, building, structure, or object.

An archaeological property may be pre-contact, post-contact, or contain components from both periods. Pre-contact (or what is often termed "prehistoric") archaeology focuses on the remains of indigenous American societies as they existed before substantial contact with Europeans and resulting written records (Little et al. 2000). In accordance with the NPS guidelines, the term "pre-contact" instead of "prehistoric" is used unless directly quoting materials that use the term "prehistoric." The date of contact

varies across the country and in the New England region. There is no single year that marks the transition from pre-contact to post-contact. Post-contact (or what is often termed "historical") archaeology is the archaeology of sites and structures dating from time periods since significant contact between Native Americans and Europeans. Documentary records as well as oral traditions can be used to better understand these properties and their inhabitants (Little et al. 2000). Again, for reasons of consistency with the NPS guidelines, the term "post-contact" instead of "historical" is used when referring to archaeology unless directly quoting materials that use the term "historical."

The NPS has established four criteria for listing significant historic properties in the National Register (36 CFR 60). The criteria are broadly defined to include the wide range of properties that are significant in American history, architecture, archaeology, engineering, and culture. The quality of significance may be present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association. The criteria allow for the listing of properties:

A. that are associated with events that have made a significant contribution to the broad patterns of our history; or

B. that are associated with the lives of persons significant in our past; or

C. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. that have yielded, or may be likely to yield, information important to prehistory or history.

Historic properties are determined eligible for listing in the National Register under the first three criteria, while archaeological properties can be determined eligible for listing in the National Register under all four criteria (Little et al. 2000; Parker and King 1998). Significance under any of these criteria is determined by the kind of data contained in the property, the relative importance of research topics that could be addressed by the data, whether these data are unique or redundant, and the current state of knowledge relating to the research topic(s). A defensible argument must establish that a property "has important legitimate associations and/or information value based upon existing knowledge and interpretations that have been made, evaluated, and accepted" (McManamon 1990:15).

The criteria are applied in relation to the historic contexts of the resources. A historic context is defined as follows:

> A historic context is a body of thematically, geographically, and temporally linked information. For an archaeological property, the historic context is the analytical framework within which the property's importance can be understood and to which an archaeological study is likely to contribute important information (Little et al. 2000).

The formulation of historic contexts is a logical first step in the design of an archaeological investigation and is crucial to the evaluation of archaeological properties in the absence of a comprehensive survey of a region (NPS 1983:9). Historic contexts provide an organizational framework that groups information about related historic properties based on a theme, geographic limits, and chronological periods. A historic context should identify gaps in data and knowledge to help determine what significant information may be obtained from the resource. Each historic context is related to the developmental history of an area, region, or theme (e.g., agriculture, transportation, waterpower), and identifies the significant patterns of which a particular resource may be an element. Only those contexts important to understanding and justifying the significance of the property must be discussed.

Historic contexts are developed by:

- identifying the concept, time period, and geographic limits for the context;
- collecting and assessing existing information within these limits;
- identifying locational patterns and current conditions of the associated property types;
- synthesizing the information in a written narrative; and
- identifying information needs.

"Property types" are groupings of individual sites or properties based on common physical and associative characteristics. They serve to link the concepts presented in the historic contexts with properties illustrating those ideas (NPS 1983, 48 FR 44719).

The following historic research contexts have been developed to organize the data relating to the cultural resources identified within the OU2 project area:

- Native American (pre-contact and contact period) land use and settlement patterns in the Blackstone River drainage, circa (ca.) 12,500 to 300 years before present (B.P.); and
- EuroAmerican (post-contact period) land use and settlement patterns of Cumberland and Lincoln, and particularly the Lonsdale Village area, ca. A.D. 1650 to present.

These historical contexts, along with expected property types and locational patterns, are discussed in detail in Chapter 4. The potential research value of the known and expected historic and archaeological resources identified within the OU2 project area is evaluated in terms of these historic contexts. This evaluation, along with management recommendations, are presented in Chapters 5 and 6.

Archival Research

The development of a historic context and a predictive model of expected property types and densities within the project area began with archival research, consisting of an examination of primary and secondary documentary sources. These sources include written and cartographic documents relating both to past and present environmental conditions as well as documented/recorded sites in the general project area. The information contained in archival sources formed the basis of the predictive models developed for the project area, and were an integral part of the archaeological survey.

Specific sources reviewed as part of the archival research for the OU2 project area include:

State Site Files and Town Reconnaissance Survey

The state site files at the RIHPHC were reviewed to locate any recorded historic districts, buildings, and structures, and archaeological sites in or close to the OU2 project area. These files also contain National Register forms for recorded resources. Specifically, the Blackstone Canal Historic District, Lonsdale Historic District, and Berkely Mill Village National Register forms were reviewed. The town survey reports prepared by the RIHPHC for Cumberland (1988) and Lincoln (1982) were also consulted for information relating to physical settings, cultural contexts, and inventoried historic and architectural resources.

Cultural Resource Management Reports

Reports documenting cultural resource management (CRM) investigations conducted in the project vicinity were reviewed. These reports and accompanying state inventory forms result from studies conducted in Cumberland and Lincoln for the Blackstone Canal and proposed bikepath. These reports include the Phase I archaeological survey of the Blackstone River Bikeway (Morenon and Raber 1989) and Phase II intensive archaeological testing of the Blackstone Canal Towpath (Freedman and Morenon 1991), both of which included the portion of the Blackstone Canal and towpath that run along the west boundary of the OU2 project area.

PAL also identified and reviewed additional historic resources identification and planning reports pertinent to the project area, including: *Blackstone Canal Assessment Study* (Kierstead 2003), the *Blackstone Canal Reservation Study, Rhode Island* (VHB 2010) and *Rhode Island: An Inventory of Historic Engineering and Industrial Sites* (Kulik and Bonham 1978).

Histories, Maps, and Local Informants

Primary and secondary histories and historical maps and atlases were examined to assess changes in land use, to locate any documented structures, and to trace the development of transportation networks, an important variable in the location of post-contact period archaeological sites. State and local repositories were consulted for relevant information: Rhode Island State Archives - dam commissioner reports; Rhode Island Department of Environmental Management - dam inspection report files; Rhode Island Historical Society Library - Lonsdale Company papers; the Blackstone Valley Historical Society; the John H. Chafee Blackstone River Valley National Heritage Corridor Commission (JHCBRVNHCC); the Cumberland Historic District Commission; and the Lincoln Town Water Commission.

Interviews with local persons knowledgeable about the prehistory and history of the area were also conducted. Specifically, PAL contacted Mr. Albert Klyberg, local historian and ranger at the Wilbur Kelly House Museum in Lincoln; his son, Kevin Klyberg, park ranger at the JHCBRVNHCC; Joanna Doherty, community planner at the JHCBRVNHCC; David Balfour, chair of the Cumberland Historic District Commission; and John Faile, manager of the Lincoln Water Commission.

Environmental Studies

Bedrock and surficial geological studies such as Hermes et al. (1994) Bedrock Geologic Map of Rhode Island provide information about the region's physical structure and about geological resources in and near the project area. The United States Department of Agriculture (USDA) Soil Conservation Service soil survey dating from 1981 and the web soil survey (2012) provided information about soil types and surficial deposits within the OU2 project area and the general categories of flora and fauna that these soil types support. Studies of past environmental and geological settings were also consulted, primarily form historic USGS topographical maps available online through the University of New Hampshire-Dimond Library.

Supplemental data about localized topography, environment, and drainage was obtained from the University of Rhode Island's online Geographic Information System (RIGIS). This information specifically included a series of aerial photographs of the site and surrounding area dating from 1939 to 1992. PAL also reviewed the recently completed study of wetland boundaries and waterways for the Peterson/Puritan, Inc. Superfund Site (Arcadis 2011). PAL also reviewed the pending *Final Remediation Investigation Report, Peterson Puritan Superfund Site – Operable Unit 2, Cumberland and Lincoln, Rhode Island*, which includes a detailed discussion of the geotechnical investigations conducted to date in

the OU2 project area as well as the test pit, test trench, soil sample, and monitoring well logs and location maps (Arcadis 2012).

Native American Consultation

Under Section 106, federally recognized Native American tribes and other interested parties must be consulted regarding their concerns for cultural resources in the project area. The project proponent's environmental consultant had previously contacted the following tribes who may have an interest in the remediation project lands: John Brown, Narragansett Indian Tribal Historic Preservation Officer (NITHPO); Nipmuc Tribe; and Chief Wilfred Greene, Seaconke Wampanoag Tribe. Of these tribes, only the Narragansetts are federal recognized at this time. PAL's state archaeological permit from the RIHPHC includes special conditions by which PAL and the EPA are required to notify the NITHPO of the survey findings. To this end, a meeting was held on February 29, 2012 at the Cumberland Town Library attended by NITHPO representatives. The NITHPO asked that available soil borings be reviewed and included in the PAL reconnaissance survey report to inform on the nature of the soil stratigraphy within the OU2 project area. PAL also provided a copy of the technical proposal for the Phase I reconnaissance survey to the NITHPO (see Appendix A).

The results of the previous and current consultation outreach to Native American tribes are summarized in Chapter 6 of the report.

Archaeological and Historic Above-ground Reconnaissance Fieldwork

Walkover Survey

A walkover survey was conducted to examine the existing conditions of the OU2 project area. The walkover survey included a close ground surface inspection to locate and record any recorded and visible historic and archaeological resources within the project area. Previously identified historic resources including the Pratt Dam, P&W Railroad, and stone walls and wooden structures at Pond F were included in the survey. Notes were taken on the physical attributes of these and any other identified resources along with digital photographs. The results of the walkover/existing conditions survey was analyzed in the context of the historical research to provide an assessment of the current condition of identified historic resources as well as the archaeological sensitivity of the project area and potential for unrecorded cultural deposits.

No subsurface testing was conducted and no artifacts were collected during the walkover survey. Any artifacts observed on the ground surface or in association with buildings and structural remains were photographed, described, and indicated on project maps.

For historic aboveground resources, the Phase I reconnaissance survey consisted of a walkover to become familiar with the project area and surrounding environment, establish a recommended project APE, confirm the presence of previously inventoried resources, and identify all previously undocumented resources more than 50 years of age in the project APE. High-resolution digital photographs were taken; basic notes about the style, condition, and integrity of the resources were recorded; and the resources were located on project maps.

Archaeological Sensitivity Assessment

Information collected during the archival research and walkover survey was used to develop a predictive model of potential site types and their cultural and temporal affiliation. The development of predictive

models for locating archaeological resources has become an increasingly important aspect of CRM planning.

The predictive model considers various criteria to rank the potential for the Project APE to contain archaeological sites. The criteria are proximity of recorded and documented sites, local land use history, environmental data, and existing conditions (Table 2-1). The project APE was stratified into zones of expected archaeological sensitivity where further survey may be needed. The results of the sensitivity assessment are presented in Chapter 6 of the report.

Table 2-1 Archaeological Sensitivity Rankings Used for the OU2 Project Area/APE.

Presence of Sites		Proximity to Favorable Cultural/Environmental Characteristics			Degree of Disturbance			Sensitivity Ranking
Known	Unknown	< 150 m	≥ 150 ≤ 500 m	> 500 m	None/Minimal	Moderate	Extensive	
•		•			•			High
•		•				•		High
•		•					•	Low
•			•		•			High
•			•			•		High
•			•				•	Low
•				•	•			High
•				•		•		High
•				•			•	Low
	•	•			•			High
	•	•				•		Moderate
	•	•					•	Low
	•		•		•			Moderate
	•		•			•		Moderate
	•		•				•	Low
	•			•	•			Moderate
	•			•		•		Low
	•			•			•	Low

Pre-Contact Period Archaeological Sensitivity

Archaeologists have documented 12,000 years of pre-contact Native American occupation of the region, and oral traditions of some contemporary tribes tell of a 50,000-year cultural legacy. Prior to 7,000 years ago, peoples focused primarily on inland-based resources, hunting and collecting along the Northeast's waterways. After 7,000 years ago, settlement became more concentrated within the region's major river drainages. By 3,000 years ago, concurrent with a focus on coastal and riverine settlement, large

populations were living in nucleated settlements and developing complex social ties, with language, kinship, ideology, and trade linking peoples across the Northeast. During the centuries prior to European contact, these groups began to coalesce into the peoples known as Pocumtucks, Nipmucks, Massachusetts, Wampanoags, Pokanokets, Mohegans, Pequots, and Narragansetts. The chronology of the pre-contact period is presented in detail in Chapter 4. Assessing the pre-contact archaeological sensitivity of any given project area depends on a consideration of past and present geographical and ecological characteristics, known site location databases, and knowledge of distinctive temporal and cultural patterns.

The choices that pre-contact Native Americans made about where they settled, how they organized themselves, and their technologies were all results of the dynamic relationship between culture and environment. Predictive modeling for larger-scale site location in southern New England has its roots in academic research including Dincauze's (1974) study of reported sites in the Boston Basin and Mullholland's (1984) dissertation research about regional patterns of change in pre-contact southern New England. Peter Thorbahn applied ecological modeling and quantitative spatial analysis, synthesizing data from several hundred sites in southeastern New England (Thorbahn et al. 1980), demonstrating that the highest concentration of pre-contact sites occurred within 300 meters (m) of low-ranking streams and large wetlands. The distribution of sites found along a 14-mile I-495 highway corridor in the same area reinforced the strong correlations between proximity to water and site locations (Thorbahn 1982). These and other large-scale projects provided data toward developing models of Native American locational and temporal land use (MHC 1982a, 1982b, 1984; RIHPC 1982) that became the foundation for site predictive modeling employed during CRM surveys through the next two decades.

Today, assessment of archaeological sensitivity within a given project area, and the sampling strategy applied to it, continues to take existing physiographic conditions into consideration but at multiple scales, from bedrock geology, to river drainages, to microenvironmental characteristics. These categories of data are used to establish the diversity of possible resources through time, the land use patterns of particular cultures, and the degree to which the landscape has been altered since being occupied (Leveillee 1999). Increasingly, social and cultural perspectives, as reflected in both the archaeological and historical records (Johnson 1999), and as expressed by representatives of existing Native American communities (Kerber 2006), are being taken into consideration when assessing archaeological sensitivity. Archaeological sampling strategies have also been evaluated and refined through applications of quantitative analyses (Kintigh 1992).

Geologic data provide information about lithic resources and current and past environmental settings and climates. Bedrock geology helps to identify where pre-contact Native Americans obtained raw materials for stone tools and gives indications of how far from their origin lithic materials may have been transported or traded. The variety and amount of available natural resources are dependent on soil composition and drainage, which also play a significant role in determining wildlife habitats, and forest and plant communities.

Geomorphology assists in reconstructing the paleoenvironment of an area and is particularly useful for early Holocene (PaleoIndian and Early Archaic Period) sites in areas that are different physically from 10,000 years ago (Simon 1991). Recent landscape changes such as drainage impoundments for highways and railroads, the creation of artificial wetlands to replace wetlands affected by construction, or wetlands drained for agricultural use can make it difficult to assess an area's original configuration and current archaeological potential (Hasenstab 1991:57).

Beyond predicting where sites are located, archaeologists attempt to associate cultural and temporal groups with changes in the environmental settings of sites. Changes in the way pre-contact Native Americans used the landscape can be investigated through formal multivariates such as site location,

intensity of land use, and specificity of land use (Nicholas 1991:76). However, distinguishing the difference between repeated short-term, roughly contemporaneous occupations and long-term settlements is difficult, and can make interpreting land use patterns and their evolution problematic (Nicholas 1991:86).

Contact Period Archaeological Sensitivity

The contact period in New England roughly dates from AD 1500 to 1650, and predates most of the permanent Euro-American settlements in the region. This period encompasses a time when Native and non-Native groups interacted with one another through trade, exploration of the coastal region, and sometimes conflict. While contact period sites are usually associated with Native American activity during this period, they can also include sites utilized by Native and non-Native groups such as trading posts.

Native settlement patterns during the contact period are generally thought to follow Late Woodland traditions, but with an increased tendency toward the fortification of village settlements. Larger village settlements are frequently expected along coastal and riverine settings, often at confluences. Inland villages are known to occur near swamp systems, which were exploited both as resource areas and as places of refuge in the event of attack. Such sites would likely contain material remnants reflecting the dynamics of daily life, trade, and a preparedness for defense.

The identification of contact period deposits is most frequently tied to the types of artifacts located within archaeological sites. Unfortunately, the majority of the archaeological data for this period in southern New England comes from the analysis of grave goods within identified Native American burial grounds, rather than from habitation sites and/or activity areas (Gibson 1980; Robinson et al. 1985; Simmons 1970). The available data suggest that sites dating to this period often contain traditionally pre-contact features and artifacts (e.g., storage pits, chipped-stone tools) as well as non-Native trade goods and objects (e.g., glass beads, iron kettles and hoes) (Bragdon 1996). The earliest contact period sites are often located at or near the coast and estuarine margin, since European visits to New England occurred via ship. Non-Native artifacts passed from the coastal region to the interior through trade and/or seasonal travel.

Post-Contact Period Archaeological Sensitivity

The landscape of a project area is used to predict the types of post-contact period archaeological sites likely to be present. Major locational attributes differ according to site type. Domestic and agrarian sites (houses and farms) are characteristically located near water sources, arable lands, and transportation networks. Industrial sites (e.g., mills, tanneries, forges, and blacksmith shops) established before the late nineteenth century are typically located close to waterpower sources and transportation networks. Commercial, public, and institutional sites (e.g., stores, taverns, inns, schools, and churches) are usually situated near settlement concentrations with access to local and regional road systems (Ritchie et al. 1988).

Written and cartographic documents aid in determining post-contact period archaeological sensitivity. Historical maps are particularly useful for locating sites in a given area, determining a period of occupation, establishing the names of past owners, and providing indications of past use(s) of the property. Town histories often provide information, including previous functions, ownership, local socioeconomic conditions, and political evolution, which is used in the development of a historic context and to assess the relative significance of a post-contact period site.

The written historic record, however, tends to be biased toward the representation of Euro-American cultural practices and resources, particularly those of prominent individuals and families. Archival materials generally are less sensitive to the depiction of cultural resources and activities associated with socioeconomically or politically "marginalized" communities (MacGuire and Paynter 1991; Scott 1994). These communities may include, but are not limited to, Native Americans, African-Americans, and "middling" farming or working-class Euro-Americans.

Several archaeological studies conducted throughout New England have demonstrated the methodological pitfalls of relying exclusively on documentary or cartographic materials as a means to identify potential site locations associated with these types of communities. A large-scale archaeological study by King (1988) showed that in rural areas only 63 percent of the sites discovered were identifiable through documentary research. This suggests that approximately one-third of New England's rural Euro-American archaeological sites may not appear on historical maps or in town and regional histories.

More recent archaeological and ethnohistoric studies in the region have focused on the identification of other historically "invisible" communities, notably post-contact Native American communities. Several townwide surveys in southeastern Massachusetts have compiled archaeological and historical data about eighteenth- and nineteenth-century Native and African-American communities that are poorly represented or are altogether absent in written town histories (Herbster and Cox 2002; Herbster and Heitert 2004). In central Massachusetts, active and influential Native Americans have been identified through archival research despite the recorded "disappearance" of this group in the early eighteenth century (Doughton 1997, 1999). The cultural continuity of groups such as the Aquinnah Wampanoag is more thoroughly documented in archival sources, but until recently archaeologists focused their attention on pre-contact archaeological deposits. Current studies include predictive models for distinctly Native American post-contact sites, as well as interpretations of eighteenth- through twentieth-century archaeological sites (Cherau 2001; Herbster and Cherau 2002).

Other archaeological investigations have focused on worker housing and landscape organization within mixed-cultural mining communities in northern New England (Cherau et al. 2003); the social and spatial organization of a mixed racial community in western Connecticut (Feder 1994); and material culture and architectural patterns among nineteenth-century mixed African-American and Native American households in central Massachusetts (Baron et al. 1996).

Information about post-contact period land use within a project area can also be collected through written and oral histories passed through family members and descendant communities. These types of information sources can often fill in gaps in the documentary record and provide details that are not available through more conventional archival sources. While informants and other oral sources are subject to contradictory interpretations just like the documentary record, this type of information can also provide important data for the identification and interpretation of archaeological sites. The sole use of and reliance on the written and oral historical records during archival research, however, can lead to an underestimation of the full range of post-contact period sites in any given region. Therefore, walkover surveys and subsurface testing, in conjunction with the critical evaluation of available documentary and cartographic resources, are required to locate and identify underdocumented post-contact sites.

CHAPTER THREE

ENVIRONMENTAL CONTEXT

The environmental context of a given area, including its geology, topography, hydrology, and natural resources, plays a significant role in determining the nature of human activity that took place within it over time. This chapter presents an overview of the environmental history of the general OU2 project area, focusing on macro-level considerations, such as the effects of glacial activity on the regional landscape. Project area-specific conditions are described more fully in Chapter 5.

Rhode Island Physiography

Combined archaeological and ethnohistorical data for the region prompted the Rhode Island Historical Preservation Commission (RIHPC) to demarcate six distinct physiographic zones within Rhode Island's geographical borders (RIHPC 1986). These distinctions were based on seventeenth-century Narragansett Indian land use patterns described by Roger Williams (1973). Williams' observations serve as a model by which archaeologists formulate predictive statements regarding expected site types in the different environs of Rhode Island. The combined physiographic contexts for the state include:

1. The Salt Pond Region
2. The Bay Area
3. The Near Interior
4. The Upland Interior
5. The Islands
6. Pre-5000 B.P. Context (RIHPC 1986)

The operating ecological and geographic land use model projects that certain site types are expected to occur within each of these distinctive physiographic zones. The coastal area contexts include the Salt Pond Region, the Bay Area, and offshore islands. The Salt Pond region is a group of low-lying estuaries along the southern margin of the state. The Bay Area refers to an area of land less than 3 miles from the Narragansett Bay shoreline and an elevation of up to 100 feet (ft), and roughly approximates the boundary between the mixed oak forest and the hemlock-northern hardwoods transition to the Near Interior. The islands' context is similar to both the Bay Area and Salt Pond Region physiographical contexts but pertains to landforms physically separated from the mainland and includes the Narragansett Bay islands (Aquidneck, Conanicut, Prudence, etc.) and Block Island.

The Near Interior physiographic zone is situated adjacent to the coastal zone and is analogous to the "thicke woodie bottomes" and valleys recorded by Roger Williams (RIHPC 1986). The Near Interior does not exceed the 300-ft elevation around the coastal contexts and represents a transition zone between the coastal plain to the hemlock northern hardwoods forest supporting a high diversity of plant and animal species (RIHPC 1986). The Upland Interior physiographic context is a line of the northern hardwood forests above the 300-ft contour elevation around the Near Interior context (RIHPC 1986). The Upland Interior is modeled to coincide with the area of hunting camps described by Roger Williams. The OU2 project area is situated in the Near Interior, near the transition with the Bay Area (Figure 3-1). The overall landscape is characterized by rolling hills hilly marked by rocky, uneven terrain. Elevations range from 180 ft above sea level in river and lake valleys at the southern end of the towns of Cumberland and Lincoln and rise to 556 ft at Beacon Pole Hill in the northern part of Cumberland (RIHPC 1998).

Surficial Geology

The topography of southern New England is the result of glacial, fluvial, and coastal dynamics. Although the timing of the late Wisconsin glacial maximum in southern New England is difficult to accurately determine, it is likely that the Laurentide ice sheet reached its maximum between 25,000 and 21,000 years ago covering all of Rhode Island and extending south to the Ronkonkoma-Block Island-Martha's Vineyard Moraine complex (Lawson 1995). Following 21,000 years ago, glacial ice began its slow retreat inland with a period of increased glacial thaw around 16,000 years ago. This resulted in the complete deglaciation of Rhode Island by approximately 15,000 years ago (Lawson 1995). The glacial advance and subsequent retreat eroded bedrock, realigned drainages, and deposited till, boulder erratics, and other material along its course. Flowing meltwaters and stationary blocks of ice created various landforms including remnant glacial swamps, kames, eskers, terraces, moraines, and outwash plains. Many of these features are discernible across today's regional landscape.

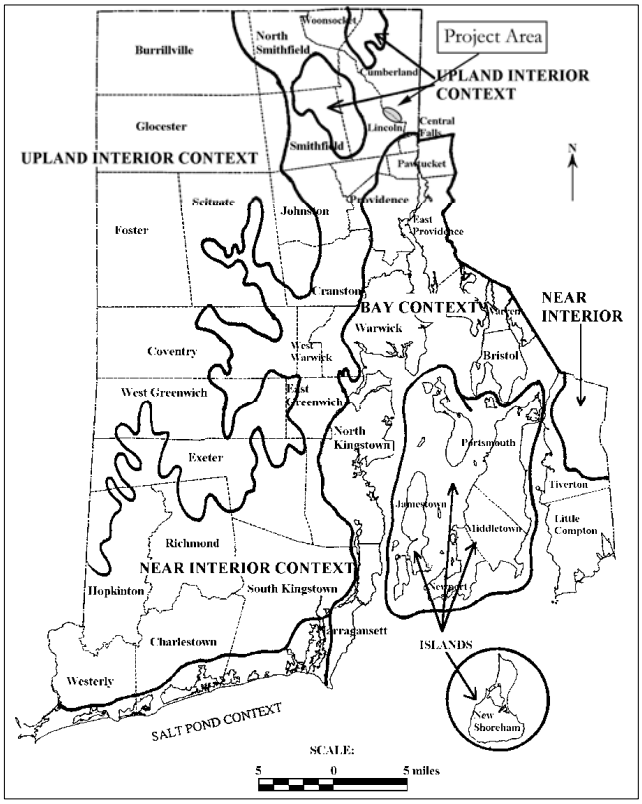


Figure 3-1. Rhode Island physiographic zones showing the location of the OU2 project area (source: RIHPC 1986).

As the glaciers continued their retreat northward, the erosional forces of wind, water, and glacial deposition continued to scour and transform the southern New England surface. The periodically advancing and receding ice sheet carried a dense assortment of silt, sand, gravel, and stone, known as glacial till. Ridges of this material were left when the ice retreated for the last time, forming the terminal moraine ridge of Charlestown along the southern coastline of Rhode Island, between 21,000 and 16,000 years ago (Lawson 1995).

Glacial activity across southern New England resulted in four discrete topographic zones within Rhode Island, which include:

1) Upland till plains, composed predominately of granite, schist, and gneiss rocks that characterize the western portions of the state, away from the coast;

2) Narragansett till plains, composed of glacial till from sedimentary rock, shale, sandstone, conglomerates, and coal, located predominately in Newport and the Narragansett Bay islands;

3) Charlestown and Block Island moraines, along southern Rhode Island, where dense glacial buildup developed at the glacier's terminal extent of southern advancement; and

4) Outwash deposits of broad level plains of gravel, sand, silt, and clay along the western edge of Narragansett Bay (Rector 1981).

The OU2 project area is situated within the zone of outwash deposits (Figure 3-2).

Bedrock Geology and Soils

The OU2 project vicinity is situated west of the Narragansett Basin Border Fault. At the fault's contact are outcrops of Esmond Igneous Suite granite and Blackstone greenstone, amphibolite, and serpentine (Quinn 1971). The Cumberland and Lincoln areas are situated on a Late Proterozoic or older formation of fine-grained granite known as the Esmond Igneous Suite (Hermes et al. 1994). It is an area surrounded by Pennsylvanian sedimentary rocks and younger granite rocks (Figure 3-3). The bedrock is mostly variable granitic rock with small amounts of greenstone and marble. To the west of the project area is a formation known as the Blackstone Group. The largest area of the Blackstone Series rocks is located along the valley of the Blackstone River in the Pawtucket USGS topographic quadrangle. It consists of four different metamorphic rock types, of which only the Hunting Hill Greenstone and the Quinville Quartzite can be readily distinguished. No definite age can be assigned for the Blackstone series, but known evidence favors a Precambrian age (Quinn 1971).

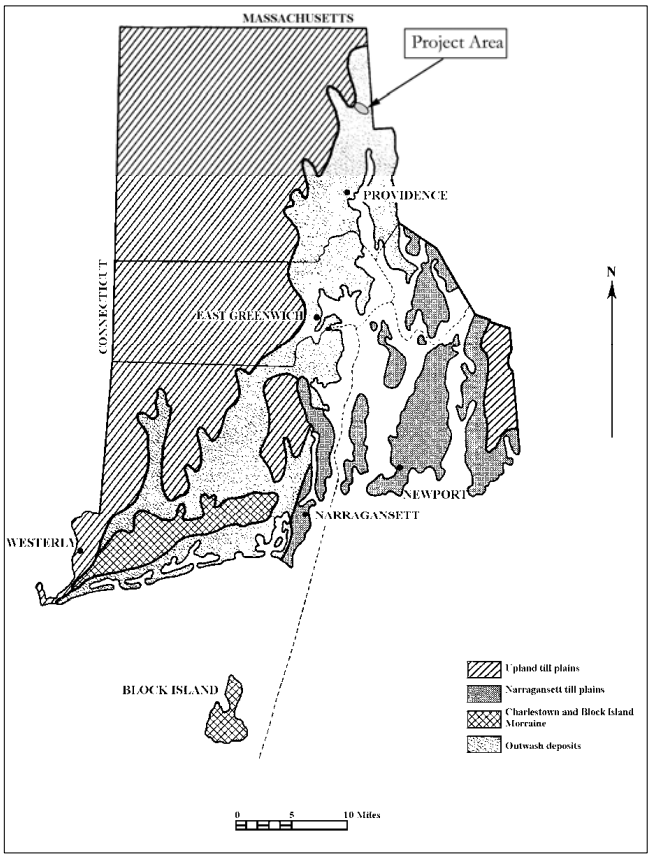


Figure 3-2. Glacial features of greater Rhode Island with the location of the OU2 project area (source: Rector 1981).

Soils are the product of "physical and chemical processes acting upon geological material" (Rector 1981:57). Glacial ice picked up and ground bedrock, which was then transported and deposited as a mixture of unweathered rock particles of various sizes. These sediments were separated and sorted by glacial meltwater. Strong winds distributed fine eolian particles over the landscape. Vegetation became established, chemical processes of weathering increased, and rock sediments developed into soils. Differences in regional soils are primarily attributed to the interaction of the five factors of soil formation: the parent material, climate, living organisms, relief, and time. The soils in the region, including the project area, have developed since the retreat of the glaciers (Rector 1981).

The bedrock in the project vicinity is overlain by a thin mantle of till consisting of poorly sorted sand, silt, gravel, cobbles, and boulders, ranging from very dense sandy silt to comparatively loose silty sand. In the river valley, thick sand and gravel deposits overlie the till. These surficial river valley deposits are mapped as floodplain alluvium, river terrace alluvium, and kame terraces (along the valley walls) (Chute 1949). The deeper sand deposits within the OU2 project area are generally characterized as undifferentiated glaciofluvial deposits (Shield 2004a in Arcadis 2012). A series of soil borings (41 locations) completed by EPA consultants indicate that the OU2 project area contains the above-described till over bedrock, although the exact thickness of the buried till is not well defined since many of the deep borings were drilled to refusal. Extensive glaciofluvial deposits overly the till in the OU2 project area. These deposits range from poorly to well-graded sands and gravels found everywhere in the project area except for the northern portion of the Unnamed Island east across Wetland B and west across the Blackstone River. In this area there is a relatively thick (15 ft) lens of laminated silt and clay (Arcadis 2012).

The glaciofluvial deposits are overlain by alluvial deposits in approximately the upper 20 ft across the entire project area. The alluvial deposits contain a greater percentage of organic matter and thin silt layers. This interlayering of silt and organic layers is typical of the meandering river environment. The significant reworking and mixing of the natural surficial deposits has occurred in the past 100 years. This reworking/remixing has been caused by draining of the historic mill pond and scouring of the Blackstone River bottom by subsequent spring floods, by filling and sand and gravel extraction, and by the regrading of the river valley in the area of the J.M. Mills Landfill and the Unnamed Island. Wetlands have become established in some of the formerly flooded and/or excavated areas. The Blackstone River, Ponds A thru F, the Blackstone River inlet near the Nunes Parcel transfer station (called Nunes Inlet), and the wetland areas all contain sandy, silt, and clay sediments (Arcadis 2012).

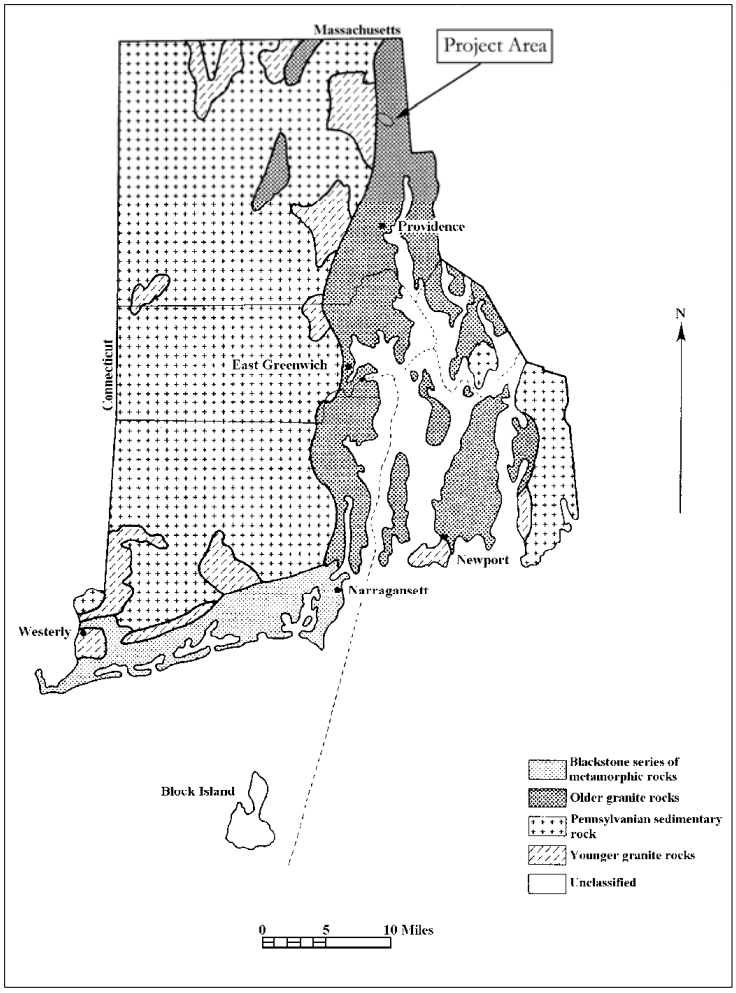


Figure 3-3. General geologic map of Rhode Island with the location of the OU2 project area (source: Rector 1981).

The OU2 project area is comprised of five mapped soil units including water (Figure 3-4). The Unnamed Island and the J.M. Landfill are both characterized as Dumps (Du), containing human transported materials. The Nunes Property is characterized as Udorthents-Urban land complex (UD), consisting of moderately to excessively drained soils that have been disturbed by cutting or filling, and areas that are covered by buildings and pavement. The complex is about 70 percent Udorthents, 20 percent Urban land, and 10 percent other soils. The soils surrounding the Lenox Street Well Site are characterized as Merrimack sandy loam (MmB), consisting of nearly level somewhat excessively drained soil on outwash plans and terraces. The Quinnville Well Field is characterized as Podunk fine sandy loam (Pp), consisting of nearly level, moderately well drained soil on flood plains. Water (W) is depicted for the Blackstone River, Blackstone Canal, ponds, and mapped wetlands (USDA 1981, 2012).

Soils information specific to each of these individual project units obtained from previous geotechnical investigations provided by Arcadis (2012) are included in Chapter 5 of the report.

Drainage Patterns

The OU2 project area is directly drained by the Blackstone River and in fact, lies mostly in river floodplain. The Blackstone River watershed is part of the Narragansett Bay drainage basin. The river itself is a major topographic feature, with its steep banks and broad channel. Smaller streams, such as

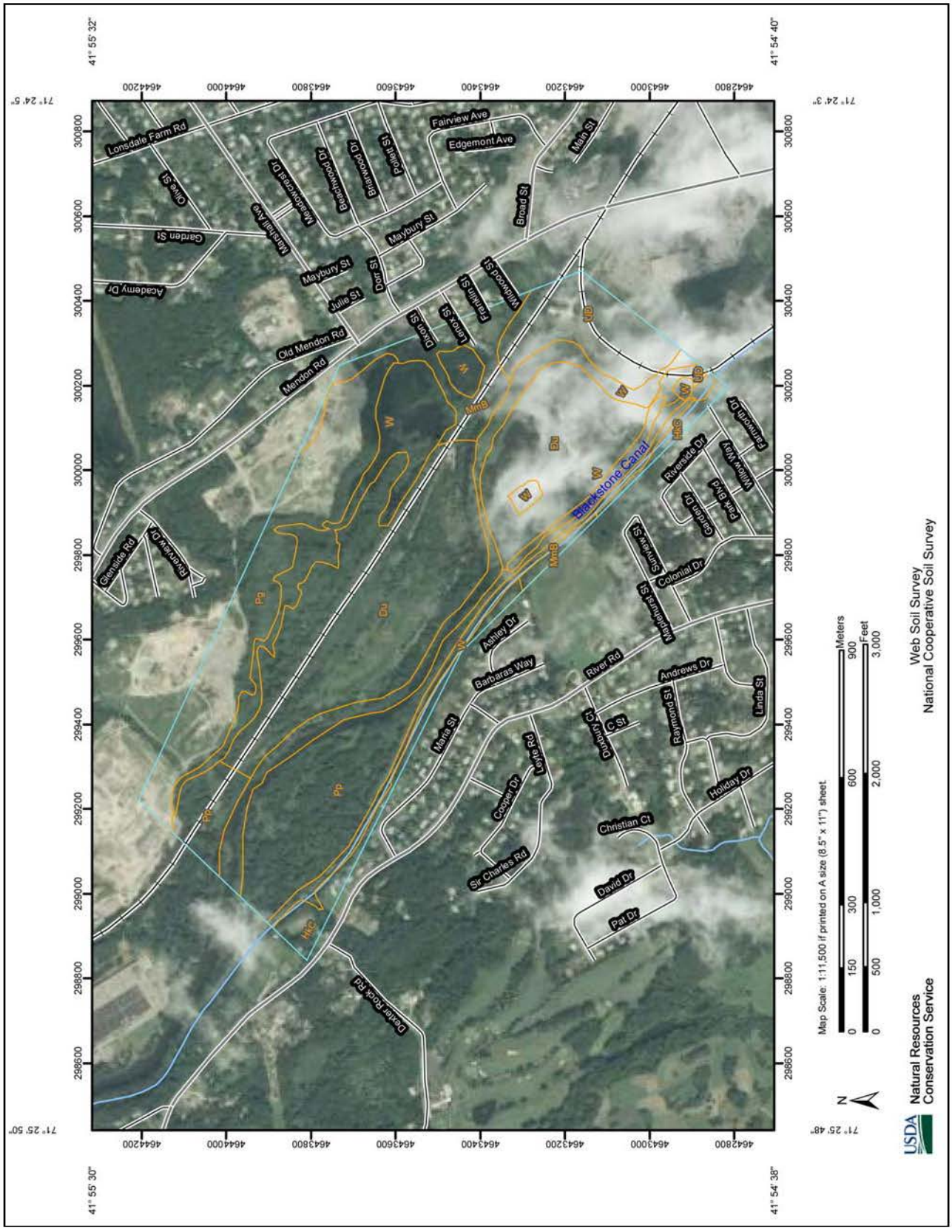


Figure 3-4. USDA mapped soil units within the OU2 project area (source: USDA 2012).

Abbott Run, Monastery Brook, Scott Brook, and Sneech Brook in Cumberland all drain into the Blackstone. Wooded wetlands and swamps are associated with these streams. The course of the Blackstone River in the OU2 project area between Martin Street and Pratt Dam has been substantially modified over the last two centuries. These modifications began with the construction of the Blackstone Canal in the early 1800s and included the first dam in the area of Pratt Dam around that same time. The Blackstone River and floodplain was flooded in the area of what became known as "New Pond" in the late 1800s with the construction of the Pratt Dam and remained flooded for the next 80+ years when the pond was drained for the creation of a landfill. Subsequent filling in the area of the J.M. Mills Landfill as well as the excavation and filling activities on the Nunes Parcel transfer station and the Unnamed Island to the south led to additional alterations to the flow channel (Arcadis 2012).

The Unnamed Island, which was created by the draining of the historic "New" millpond in the mid-late 1900s (see further discussion in Chapter 4), contains four recently delineated ponds (A, D, E, and P) in its center and along its northwestern side as well as associated freshwater wetlands (Figure 3-5). A potential vernal pool has also been identified to the southwest of Pond D near the southwest corner of the island. The ponds and wetlands are frequently inundated especially during high flow events associated with the Blackstone River (Arcadis 2011:5).

The Nunes Parcel is adjacent to Pond I along the shoreline of the Blackstone River. The pond appears to be a permanent backwater that is perennially connected to the river. The Quinnville Well Field contains three mapped wetland areas as well as evidence of flooding (e.g., drift lines, sediment deposits) along the access road that traverses the parcel. The riverbank along the well field parcel drops off to the west and creates a depression or bowl where water tends to accumulate and settled after the river stage begins to decrease. This bowl area has likely accumulated trapped sediments from the Blackstone River flood flows (Arcadis 2011:6-7).

The J.M. Landfill contains Ponds B and C located along the southwest toe of the landfill slope (see Figure 3-5). The ponds contain saturated soils and appear to be seasonally connected to the Blackstone River. The remaining water feature is named Pond F, situated along the southern bank of the Blackstone River in the OU2 project area, just west of the Pratt Dam (see Figure 3-5). This pond contains standing water, although the depths of the water appear to seasonally fluctuate and are affected by storm events. The Providence and Worcester Railroad property on the east side of the tracks, also included in the OU2 project area, consists primarily of delineated wetlands designated as Wetlands A, B, and C (see Figure 3-5). Wetland D is also present to the west of Wetland C along the railroad tracks.

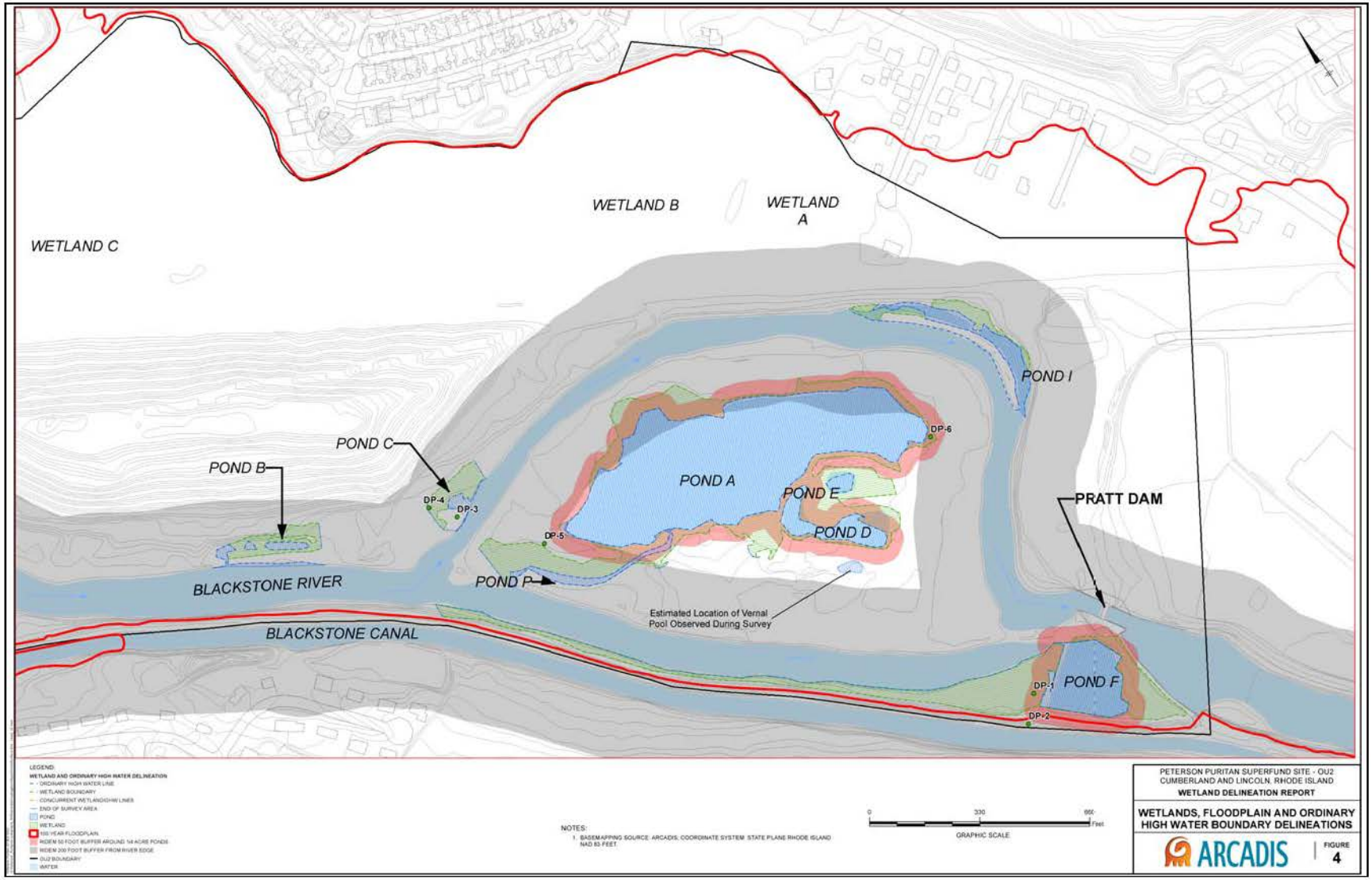


Figure 3-5. Wetlands, floodplain, and ordinary high water boundary delineations for the OU2 project area (source: Arcadis 2011).

CHAPTER FOUR

CULTURAL CONTEXT

A regional understanding of long-term human settlement and subsistence practices is critical to understanding those same issues within a given project area. This chapter provides an overview of the pre- and post-contact period history of the Lower Blackstone River drainage and the towns of Cumberland and Lincoln. This review is by no means exhaustive, but provides a framework with which to predict and interpret historic and archeological resources identified within the project area. The information for this context has been drawn from the results of professional CRM surveys, through a review of state site files at the RIHPHC, general pre-contact and post-contact culture histories for the region, and the National Register nomination form for the Blackstone Canal (Fitch 1988).

Pre-contact and Contact Periods

The earliest evidence for human occupation of the Blackstone River drainage dates from the **PaleoIndian Period (12,000–10,000 B.P.)**. Following the retreat of the Wisconsin glacier, the environment changed from tundra to open spruce woodland dominated by scrub birch and alder (Funk 1972). Small highly mobile bands of hunter-gatherers moved into the Northeast at this time, covering large territories and exploiting post Pleistocene megafauna, as well as smaller game, marine resources, and seasonally available plant foods (Dragoo 1976). Artifacts associated with the PaleoIndian tradition include Clovis fluted points, scraping tools, gravers, and drills. A single fluted projectile point was recovered from the Twin Rivers Site in Lincoln, Rhode Island (Fowler 1952).

The **Early Archaic Period (10,000–7500 B.P.)** was characterized by a warmer and drier climate, dominated by a mixed pine-hardwood forest. This type of paleoenvironment would have made seasonally available natural food resources more predictable and abundant, allowing pre-contact populations to exploit a wide range of territories. Populations increased during this period and a multisite settlement system had been established by this period, with different locations focused on the exploitation of different resources (Johnson 1984; Ritchie 1983). Specialized hunting strategies appear to have broadened to include a more generalized hunting and gathering subsistence system, probably due in part to the changing environmental conditions. Projectile points diagnostic of this period include the Dalton type and a variety of bifurcate base point types (Kirk, Kanawha-like). Evidence of Early Archaic activity in the Blackstone drainage includes the Mill River Site, which produced a single bifurcate base projectile point (Roop 1963). Archaeological sites examined at Olney Pond in Lincoln Woods State Park indicated that pre-contact activity there spanned 9,000 years (Thorbahn and Strauss 1980).

Middle Archaic Period (7500–5000 B.P.) activity in the Blackstone River drainage is greater than preceding periods and is documented at several sites. The Mill River Site in Hopedale, Massachusetts, an unnamed site on a small pond near the floodplain of the Blackstone River in Uxbridge, the Cracked Rock Rockshelter in Millbury (19-WR-111), and an unknown location in Sutton all contained diagnostic Neville, Stark or both types of projectile points. The distribution and higher density of Middle Archaic sites indicates that the multisite seasonal settlement system had been firmly established in southern New England at this time. A preference for regionally and locally available lithic raw materials is also recognized at many area sites. Sites from this period appear to cluster around falls and rapids along major river drainages, where the harvesting of anadromous fish and various plant resources was combined with generalized hunting practices. Also, Middle Archaic components on larger, complex multicomponent

sites located on ponds, tributary streams, or in swamp settings are known from the Beaver Pond core in the upper Charles River in Massachusetts and from the headwaters of the West River (Twin Rivers Site) in Lincoln, Rhode Island.

Late Archaic and Transitional Archaic Periods (5000–3000 B.P.) settlement in the Blackstone River drainage is well documented. Sites represent all three Late Archaic cultural traditions (Laurentian, Small Stemmed, Susquehanna), as well as the Orient phase of the Transitional Archaic Period (3600–2500 B.P.). Site distributions from this tradition also appear to be oriented to the uplands region, which has been interpreted as suggesting an interior or riverine adaptation by Laurentian groups (Dincauze 1974; Ritchie 1971). The Laurentian tradition is the earliest phase of Late Archaic activity in the area. Several varieties of Brewerton and Otter Creek-like projectile points represent the predominant form of Laurentian point types found at sites in central Massachusetts and northern Rhode Island. These points are manufactured primarily from locally available materials such as quartzite.

Despite recent revisions concerning the diagnostic value of Small Stemmed projectile point types, the Small Stemmed tradition continues to be an accepted Late Archaic cultural affiliation. Both artifact collections and excavated sites are quantitatively dominated by both Small Stemmed and Small Triangular point types usually manufactured from quartz. These point types have been identified at many of the previously mentioned sites in both Massachusetts and Rhode Island. The Crookfall Brook No. 1 Site in Lincoln, Rhode Island, in an area of upland swamps along the upper part of the brook, is located just west of the Blackstone River. The Sassafras Site (RI-55), located near the Blackstone River in Albion, Rhode Island, is a small quartz extraction/lithic workshop area where quarried material was reduced to preforms for bifacially chipped-stone tools. Three additional sites in Woonsocket where quartz projectile points and chipping debris were collected by avocational archaeologists appear to contain Late Archaic Period components.

Although the Susquehanna tradition of the Late Archaic has been often associated with mortuary practices or ceremonial sites in the coastal zone of southern New England (Dincauze 1968), some recent evidence of upland area land use by Susquehanna groups has been recorded in the Blackstone drainage. The Fisherville Pond Site (19-WR-442) in Grafton, Massachusetts contained the Basal section of a felsite Mansion Inn blade (Elia et al. 1986). Subsurface testing at this site did not recover any additional cultural materials suggesting this felsite blade was an isolated surface find. This site area is situated on a low-lying terrace projecting from the west bank of Fisherville Pond, a former riverine habitat of the Quinsigamond River. In 1990 an intact Susquehanna cremation complex was discovered in an upland environmental setting on an elevated terrace overlooking the Blackstone River in Millbury, Massachusetts. Analysis of the site and cultural materials recovered during data recovery investigations are now in progress (Leveillee 1999).

The Orient Phase of the Transitional Archaic Period is also represented at both quarry sites and rockshelters recorded in the Blackstone drainage. The quarrying and utilization of steatite or soapstone was a regionally important activity associated with this cultural tradition. The presence of steatite outcrops in Millbury, Massachusetts and Johnston, Rhode Island attracted pre-contact groups practicing steatite bowl manufacturing to those general areas. All three of the steatite quarries in Millbury (Horne Hill, Torrey Lane, Dolly Bond) contained Orient projectile point types (Bullen 1940; Fowler 1966). Rockshelters identified in the area also contained Orient phase materials. One Wayland Notched and two Orient Fishtail projectile points were collected from the Hartford Avenue Rockshelter (Ritchie 1985).

Pre-contact cultural deposits representing the **Early Woodland Period (3000–1600 B.P.)** are poorly documented and not completely understood in southern New England. This could be due to the artifactual overlap and possible cultural unity of both the Small Stemmed and Susquehanna traditions, as well as Transitional Archaic Period materials generally attributed to these earlier Archaic Period temporal

divisions. Investigations in the Blackstone drainage have explored the possibility that steatite quarries were exploited by pre-contact groups during the Transitional and Early Woodland periods (Ritchie 1985).

Early Woodland site locations have generally relied on the identification of Meadowood and Rossville point types as well as Vinette I ceramic styles. Based solely on these artifact distributions, Early Woodland activity is sparsely represented in the Blackstone drainage. With the exception of a surface find consisting of a black chert Meadowood point in Grafton, Massachusetts (19-WR-448), no evidence of Early Woodland occupations in the drainage has been firmly documented. However, many of the previously identified steatite quarries, rockshelters, and temporary campsites associated with the Late Archaic/Transitional Archaic Period may have been used by Early Woodland groups as well.

The Middle Woodland Period (1600–1000 B.P.) is not well documented in the Blackstone drainage. Few sites in the Cumberland area contain evidence of Woodland Period occupation. Ceramic shards from a rockshelter (WO-4) near Elder Ballou Road in Woonsocket indicate that sites of this type continued in use as temporary upland zone camps during this period. The Crookfall Pottery Site on the lower portion of Crookfall Brook appears to be the remains of a small temporary camp occupied during the Middle to Late Woodland Period.

Pre-contact sites containing **Late Woodland Period (1000–450 B.P.)** depositions are not highly visible in the Blackstone drainage, but are better documented than the preceding Woodland periods. The Late Woodland Period is marked by the introduction of horticulture into the traditional hunting and gathering subsistence practices of pre-contact groups in the Northeast. Coastal resources are also evidenced by the high frequency of known Late Woodland Period coastal sites in southern New England. Ceramic production and technology increased and improved throughout the Woodland Period.

With the formation of the tidal estuaries ca. 3,000 years ago, Native American occupation in Rhode Island became focused along the coastal margins of southern Rhode Island where there was a reliable subsistence base. Early ***Contact Period*** Native American settlements continued to be focused in coastal tribal territories that developed prior to and during the Late Woodland Period. Indigenous materials, such as pottery vessels and lithic artifacts, continued to be manufactured. Native American settlement and subsistence patterns established during the Late Woodland Period in southern New England were disrupted beginning in the early sixteenth century with initial and later sustained contact with Europeans.

At the time of initial contact between European explorers and Native American groups inhabiting Narragansett Bay, a group of southern New England Algonquian speakers known as the Narragansett inhabited all of western Narragansett Bay and held influence over the entire region. Narragansett country was bordered to the north and west by the Nipmuck, to the north and east by the Massachusetts, to the east by the Pokanoket (or Wampanoag), and to the west by the Pequots and Mohegans. Smaller tribes tributary to Narragansett influence also were settled within Narragansett territory during the early seventeenth century.

Early Contact Period settlement and subsistence strategies were focused on an annual round whereby small groups would leave main base camps or villages to exploit various resources based on seasonal availability. The rich coastal estuaries of Narragansett Bay served as important fishing and shellfishing localities. Other important Narragansett Indian subsistence activities included the planting of corn fields in the spring and summer with supplemental hunting and gathering activities in the peripheral zones around core settlement areas. The subsistence economy of the resident Native American tribes eventually changed as a result of the increasing influence and partial adaptations of the European commodity-based economic system (Robinson et al. 1985; Rubertone 1989, 2001). The local Natives began to sell off the land as they became increasingly reliant on items of European origin and were involuntarily coerced into a “life of enforced dependency” (Bourne 1990:135).

Blackstone River Valley Sites

A review of the RIHPHC archaeological site files indicates that there are over 50 pre-contact period Native American sites recorded within the Blackstone River Valley between Providence and the Rhode Island-Massachusetts state line. The majority of these sites are within one half mile of the river itself, or are within a two-mile radius on tributary streams and associated wetlands and ponds. These sites include a cluster of small encampments around the shoreline of Olney Pond and nearby Butterfly Pond in Lincoln where lithic materials including projectile points, bifaces, scrapers, and chipping debris (quartz, quartzite, felsite, argillite, chert) have been recovered. Several of these deposits are dated to the Late Archaic and Transitional Archaic periods based on diagnostic stone tools. Olney Pond is located approximately 1.5 miles southwest of the OU2 project area and the Blackstone River.

A second, more important cluster of sites within 1.5 miles of the OU2 project area and the Blackstone River is located along Monastery Brook in Cumberland. These sites include RI-1250, RI-1720, and RI-2316 thru 2321, which were identified and/or investigated during a recent Phase I(c) archaeological survey conducted for the Monument Loop Trail Project (Jones et al. 2008). RI-1720 and RI-2316 thru 2321 were all determined to be potentially eligible to the National Register of Historic Places based on artifact density, the presence of soil features, and good physical integrity. Diagnostic stone tools indicate occupation during the Middle Archaic, Late Archaic, and Woodland periods. The sites range from small, short-term resource procurement and lithic workshops to more dense camps where a wide variety of subsistence activities may have occurred. RI-1250 is the reported site of buried King Philip's War soldiers around the Nine Men's Misery Monument; however, the site is not confirmed and no human remains were recovered in this area during trail construction (Jones et al. 2008).

Further to the north in Cumberland three sites have been recorded in the Albion section of the Blackstone River floodplain. RI-55 (the Sassafras Site) was identified during a survey conducted for the Albion bridge replacement project. The site consisted of a Late Archaic lithic workshop that focused on a quartz outcrop on the banks of the river. RI-2009 (Sassafras 2) was identified just to the south and yielded felsite and quartz chipping debris of unknown temporal/cultural affiliation (Davin and Miller 1995). RI-1223 (Sneech Brook Site) is situated about one-quarter mile to the south of these two sites at the confluence of the Blackstone with Sneech Brook. The site yielded numerous quartz projectile points and chipping debris indicative of a Late Archaic Period occupation. Continuing north on the Blackstone River, RI-1985, also located on the Cumberland side of the river, was identified on the basis of quartz chipping debris eroding out of the river bank.

These sites and others attest to the importance of the Blackstone River drainage in Native American land use and settlement systems from the Archaic through Woodland periods. Ethnohistorical studies also support the supposition that Native American land use was concentrated along regional drainage systems and related landforms. The local populations were flexible in their subsistence and settlement strategies and evidence of Native American occupations have been recovered from a variety of environmental settings in the Blackstone River Valley and larger Narragansett Bay drainage system. The most common types of recorded archaeological sites in the Blackstone River Valley appear to be small, low to moderate densities of lithic tools and debitage. These sites represent specialized camps where resource procurement (e.g., hunting, fishing) was conducted, possibly in conjunction with food processing, storage, and refuse disposal. The numerous tributary streams, wetlands, and ponds that form the Blackstone River valley provided an abundance of seasonally available floral and faunal resources.

Post-Contact Period

Town of Cumberland

The area around present-day Cumberland was traditionally the tribal homeland of a Narragansett subtribe known as the Pawtuckets. At the time of European contact, Native American settlement and subsistence strategies focused on an annual round of hunting, gathering, and farming. Corn was planted in the spring and summer months and small groups or individuals left base camps to exploit targeted resources (e.g., fish, shellfish, nuts) depending on seasonal availability or need. Concentrated food resources enabled some of these groups to maintain year-round settlements in the region.

English colonists settled in northern Rhode Island in the early seventeenth century and found much of the best land already cleared by the Indian farmers. William Blackstone was one of the first European settlers in the region. By 1635, he and his family established themselves in the present-day Lonsdale section, near the river that now bears his name. Wampanoags shortly thereafter began to sell off lands in the Cumberland area to European settlers. In 1661, Captain Thomas Willett purchased a large tract of land, the Rehoboth North Purchase, which included Cumberland and parts of Woonsocket (Adams et al. 1998). In 1694 this tract became part of the newly incorporated town of Attleborough and was known as the "Attleborough Gore." In 1747 the area was annexed to Rhode Island and renamed after William, the Duke of Cumberland. In 1867 the northwest corner of the town was set off to form part of Woonsocket (Adams et al. 1998).

Settlement in Cumberland was slow. Dispersed agrarian settlements typified the settlement pattern and lifestyle in the mid-seventeenth to early eighteenth centuries. The first road through the town may have followed a Native American trail along the east side of the Blackstone River from Valley Falls to Mendon (Mendon Road).

Few isolated farmsteads survived the hostilities of King Philip's War (1675–1676). Following the cessation of hostilities, settlement in Cumberland accelerated as many families returned to the area to rebuild and new settlers moved in. By the turn of the eighteenth century, Cumberland's population had witnessed strong growth. Agriculture remained the mainstay of the local economy though the first ventures into industry were made. Sawmills and gristmills were established to support the local farmers. Iron manufacturing was an important development with three furnaces established in the Cumberland area, Unity Furnace at Manville, Furnace Carolina at Abbott Run, and a furnace at Happy Hollow. Iron ore came from Iron Mine Hill and deposits of magnetite near Cumberland Hill (Adams et al. 1998). A number of small hamlets began to emerge in close proximity to these furnaces as well as several other locations near waterpower supplies (Valley Falls, Woonsocket Falls).

As industry and transportation improved, the population of Cumberland became more concentrated in discrete villages situated along the Blackstone River. In 1828, the Blackstone Canal was completed, opening up the interior sections of the valley (Figure 4-1). In 1847, the Providence and Worcester Railroad supplanted the canal as the major means of transporting goods and people up and down the valley (Figure 4-2). In addition to the introduction of the railroad, many roadways were built or improved. The early mills established along the river served as the core of a number of later mills. By the second half of the eighteenth century the Industrial Revolution was in full force. After 1860, the Lonsdale Company built three mills (and villages) along the river at Lonsdale, Ashton, and Berkeley (Adams et al. 1998) (Figure 4-3). Each village was designed to be a self-contained community.

Increased population required improved services. During the later half of the nineteenth century the Cumberland Street Railway Company operated a horse car route from Valley Falls to Mendon. This was

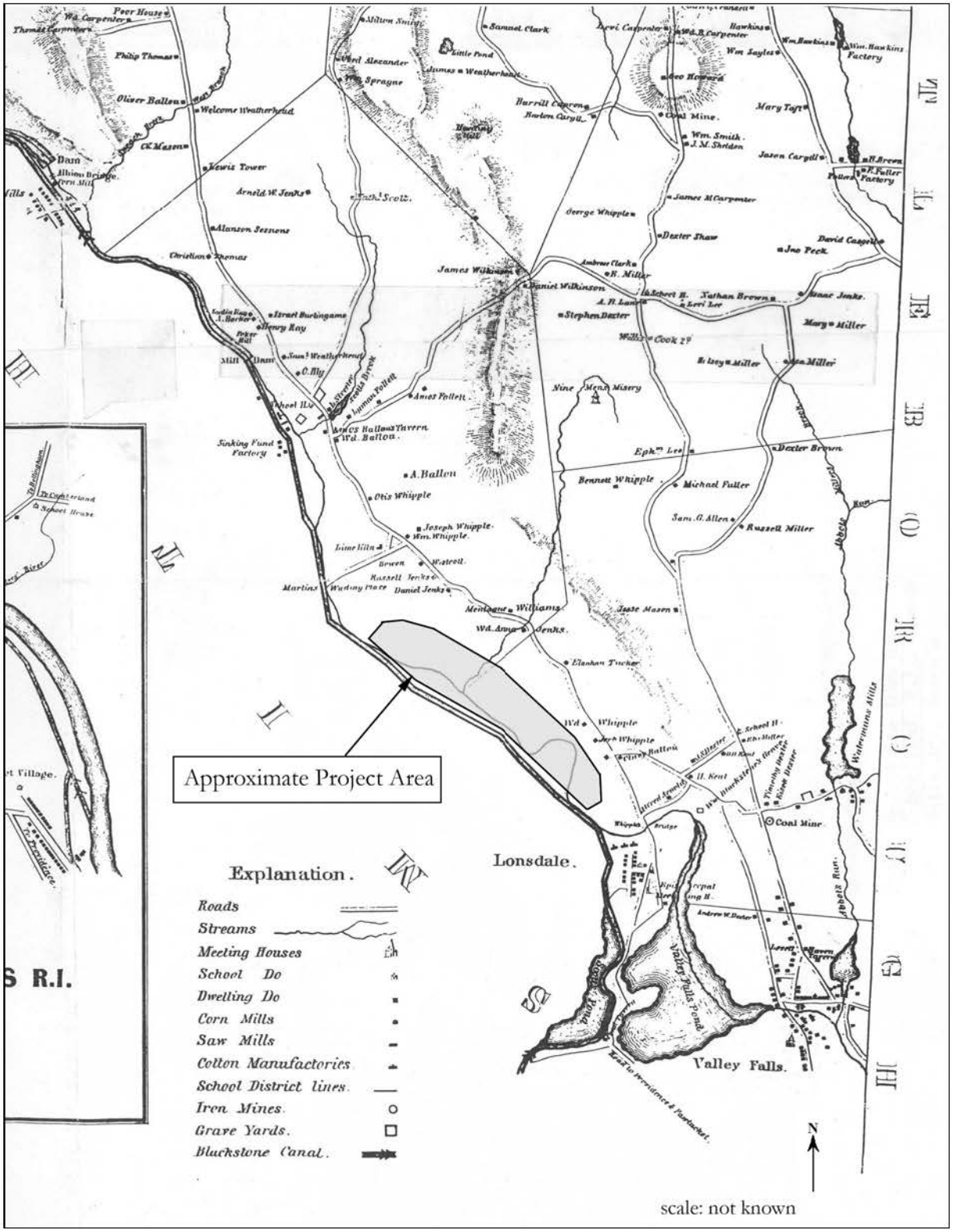


Figure 4-1. 1838 map of Cumberland, showing the approximate location of the OU2 project area (source: Nelson 1838).

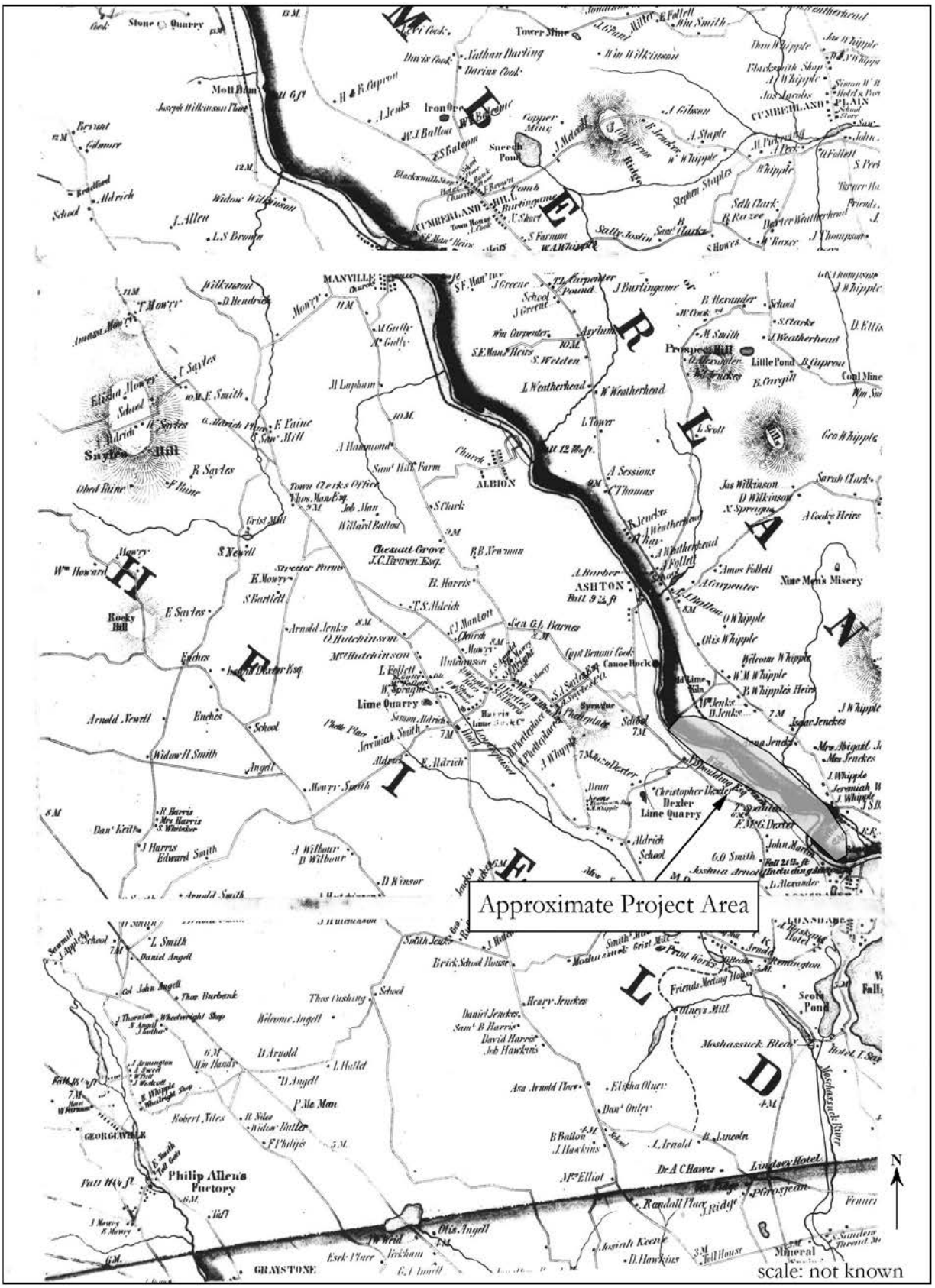


Figure 4-2. 1851 map of Providence County, RI, showing the approximate location of the OU2 project area (source: Walling 1851).

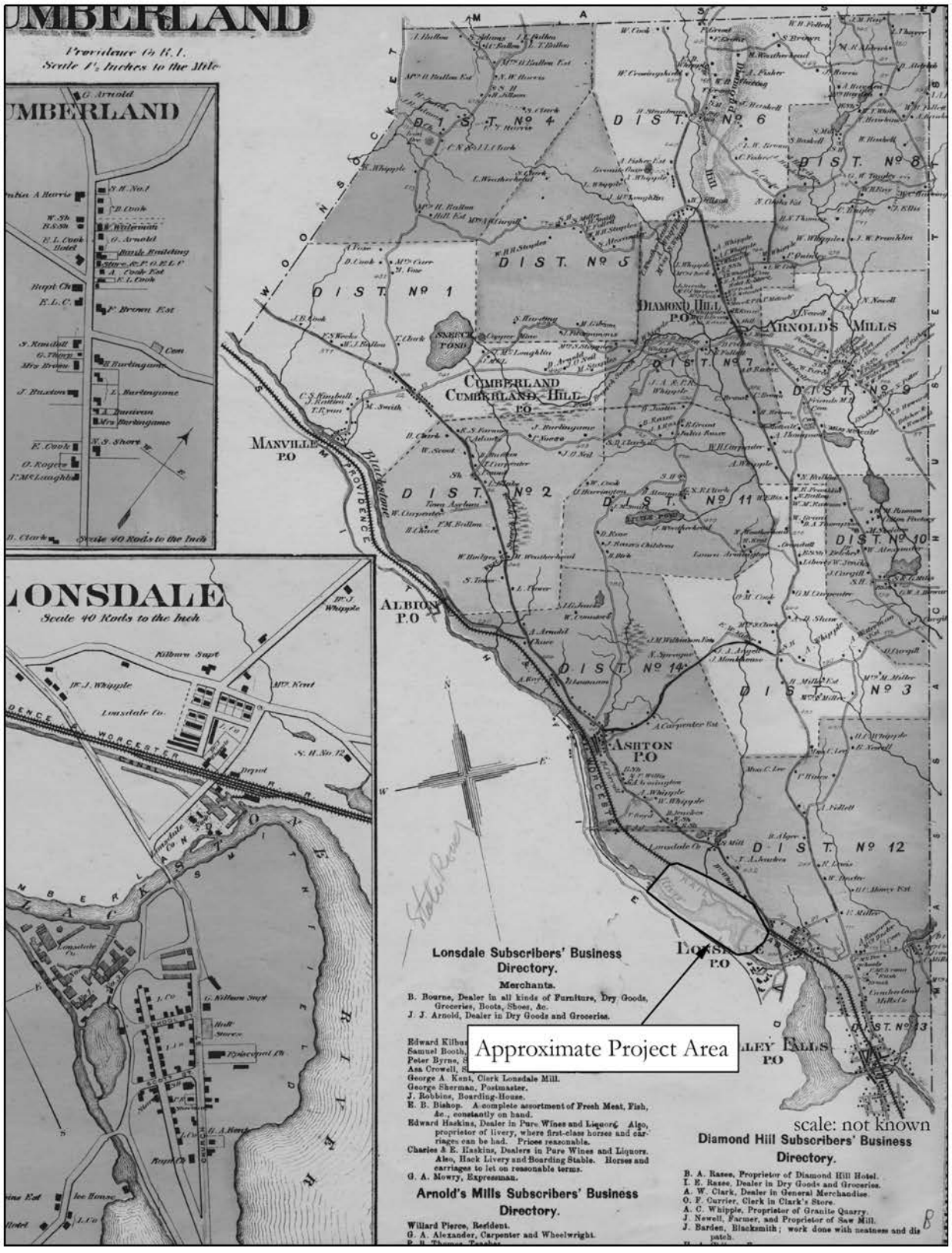


Figure 4-3. 1870 map of Cumberland, showing the approximate location of the OU2 project area (source: Beers 1870).

later replaced by an electric street railroad operated by the Rhode Island Company and later by the United Electric Railways Company and United Transit Company.

The character of Cumberland remained essentially unchanged during the first decades of the twentieth century. Although industry was an important economic mainstay, the majority of the town remained rural in character. After World War II, this dichotomy gradually diminished as a result of the automobile. Improved mobility enabled the population centers of Providence and Woonsocket to expand into previously rural areas, including Cumberland. The twentieth century also saw increased pressure on the industrial sector. The Albion Company Mill at Valley Falls was demolished in 1934. Manville Mills was destroyed by fire in the 1950s. The Lonsdale Company closed each of its mills, Ashton in the 1930s, Berkeley shortly thereafter, and Lonsdale by mid-century.

Other developments in Cumberland during the twentieth century included the construction of two reservoirs to meet increased demands for water. Diamond Hill State Park was acquired in the 1930s as a recreation area. Several religious orders established retreats in town, including the Monastery of Our Lady of the Valley established by the Order of Cistercians of the Strict Observance (Trappists) and Mount St. Rita by the Sisters of Mercy.

Town of Lincoln

The area that presently encompasses the town of Lincoln was included in Roger Williams' original purchase from the Narragansetts around 1636. A year later this land transaction was confirmed by deed, and the English settlers held the land between the Blackstone and Pawtuxet rivers. William Blackstone preceded Roger Williams as the first European settler in Rhode Island. By 1635, he and his family had established themselves in Lincoln near the river which now bears his name. The Lincoln area was described at this time as "upland from the water, most of it rocky and barren without meadow" (RIHPC 1982). When the English colonists first settled in northern Rhode Island during the early seventeenth century, they found that Native American farmers had already cleared much of the best land. The early European settlers did not initially displace the Native Americans. Records note that a group continued to live on the Moshassuck River, just north of Saylesville. King Philip's War in 1676, however, resulted in the decimation of the native populations. By 1748, only 20 Native Americans were recorded as living in Smithfield, which then included Lincoln.

Lincoln legally remained a part of Providence until 1730. The colonial legislature at that time divided the northern section into Scituate, Glocester, and Smithfield. The town of Smithfield then included all or parts of Woonsocket, Smithfield, North Smithfield, and Lincoln. Settlement of the upland areas was slow, beginning with intermittent use that included hunting, fishing, and the harvesting of marsh hay from riverbanks for cattle feed. The number of settlers increased following King Philip's War, but no community was established until the eighteenth century (RIHPC 1982:6). Individual families applied for land grants or purchased property and then established farmsteads.

The Arnold family was among the first to settle in the Lincoln area. Thomas Arnold, a member of Roger Williams's original party, bought a tract of land in southern Lincoln, near the present day Lincoln Woods in 1661. However, the first one to settle in the area was his son Eleazer, who moved to Lincoln in the early 1680s. By 1683 the Great Road was laid out through the Arnold land. Succeeding generations of Arnolds built homes and operated farms adjacent to it, and a small community developed. The economic mainstay of the area was farming. In 1710 Eleazer Arnold was granted a license to sell liquor and operate a tavern along the Great Road.

The lime deposits at the head of the Moshassuck River in Lime Rock constituted the most important mineral resource in the area. The mining and processing of lime for use in mortar was begun in the late

1660s by Gregory Dexter at Dexter's Ledge, and represents one of the earliest industries in the United States. Thomas Harris also opened a quarry at Lime Rock in the late seventeenth century, where the stone was mined and burned. By 1750 his son, David Harris, had turned this into a major industry with a substantial village associated with it (RIHPC 1982). In 1823 and 1854, respectively, the Harris Lime Rock Company and the Dexter Lime Rock Company were incorporated. These two companies later merged and continued to process lime well into the twentieth century. While the demand for lime decreased in the mid-nineteenth century, there remained a slow but steady market for the product.

Agriculture was the primary occupation of many Lincoln residents and served as a direct complement to the lime industry. Many of the early farms were largely self-sufficient economic units where crops were grown and animals raised. Settlement at this time was dispersed, with family farms being spread out across the landscape. With the advent of industrialism in the nineteenth century the nature of farming changed, with an increasing number of farmers becoming involved in cash crops. During this period, Lincoln farmers produced fruits and vegetables for local sale, but dairying became their economic mainstay. By the end of the nineteenth century, competition from western states in terms of cheaper cattle and grain led the Lincoln farmers to specialize in perishable products like butter, milk, and seasonal vegetables (RIHPC 1982:19).

Between 1800 and 1900 the Industrial Revolution transformed the United States, with Rhode Island becoming the most intensively industrialized state in the country. Blackstone Valley, previously an agricultural hinterland, became the scene of much of the industrial development. Discrete mill villages grew up along the banks of the Blackstone River as the settlement pattern became increasingly clustered from Woonsocket to Pawtucket. Throughout the nineteenth century the economy of Lincoln continued its shift from agriculture to industry, with a particularly strong reliance on textile manufacturing. The population growth in this area led to the reorganization of Smithfield in 1871. Several townships, including Lincoln, were formed at this time.

This economic prosperity ended with the stock market crash of 1929 and the Great Depression. During the 1930s and 1940s, Lincoln suffered through a series of mill cutbacks and closings as a result of competition from southern textile producers. To compete, many factories implemented wage cuts, a move that lead to a series of strikes. A national effort to unionize southern workers in 1934 lead to one of the largest strikes in Rhode Island centered on the mills at Saylesville. By 1945 Lincoln had become a suburban town, part of the large metropolitan area of Providence.

Land Use History-OU2 Project Area

The OU2 project area is located between the two historic mill villages of Lonsdale to the south and Berkeley to the north in the town of Cumberland. The project area is primarily situated on the east side of the Blackstone River in the town of Cumberland (Pratt Dam, Nunes Property, Lenox Street Well, Unnamed Island, J.M. Mills Landfill). The project area includes a narrow land area on the west side of the river between the Blackstone Canal and the river within the town of Lincoln, and the Quinnville Well Field. The narrow land area between the canal and the river includes the historic 10-foot wide canal towpath, most of which was above the existing floodplain in a double berm construction (Morenon and Raber 1989:17). This section of the river was likely used by English settlers as agricultural farmlands in the seventeenth and eighteenth centuries, although later nineteenth and early twentieth century maps depict mostly ponds and wetlands associated with the Blackstone River and the confluence of Monastery Brook.

The Blackstone Canal and towpath along the western perimeter of the OU2 project area was completed under chief engineer Holmes Hutchinson in 1828 and ran forty-five miles from Providence, Rhode Island to Worcester, Massachusetts. At completion, the canal passed in and out of the Blackstone River sixteen

times and ran in the river for approximately ten percent of its forty-five mile distance. A total of forty-nine locks, of which all but one were granite, accommodated the elevation change from sea level in Providence to 168 feet at Woonsocket, to 451 feet at Worcester. The canal prism was generally eighteen (bottom) to thirty-four (top) feet wide and four to six feet deep; the towpath at least ten feet wide; and the waterway accommodated boats between forty-five and seventy feet long. The finished canal served as a transportation corridor for the movement of agricultural products, raw materials, manufactured goods, and passengers between Worcester and Providence for nearly two decades. Following successful attempts to close operations because of unprofitability of the operations, the Blackstone Canal collected its last toll in 1848, one year after the rival Providence and Worcester Railroad opened (Fitch 1988). The railroad (still active) runs through the eastern perimeter of the OU2 project area on a raised embankment, parts of which are now obscured by the adjacent landfill. Historical maps do not identify any railroad-related resources in the project APE.

The 1828 Edward Phelps survey map of the Blackstone Canal depicts a cart bridge, 7 mile marker, and lay-by on the section of canal adjacent to the OU2 project area (Figure 4-4). The cart bridge and mile marker are adjacent to property belonging at that time to John Wilkinson Heirs and the lay-by is at the boundary with land belonging to Stephen H. Smith to the north. The 1838 (Nelson) map of Cumberland depicts the Blackstone Canal along the western side of the OU2 project area as well as a prominent easterly bend or meander in the Blackstone River at this location (see Figure 4-1). The 1851 (Walling) map of Providence County depicts Hunt Dam at the southern end of the project area and the defunct Blackstone Canal is identified as the "Wilkinson Trench" (see Figure 4-2). A later Walling map (dated 1855) depicts the dam across the river, but does not identify the canal as such.

Local industrialists recognized the potential of the canal to serve their interests and made up a sizable proportion of investors in the waterway. The prominent firm of Brown & Ives, with principals Nicholas Brown and his son-in-law Thomas P. Ives, invested in the canal while simultaneously purchasing land under the name of the Lonsdale Water Power Company along the canal's projected route near the current project area. In exchange for allowing the canal to run through their property, Brown & Ives obtained rights to use water from the canal prism for manufacturing. To take advantage of these water rights, they began construction of the Lonsdale Mill (now referred to as "Old Lonsdale") in 1831 adjacent to the canal on the south edge of the project area in Lincoln. They incorporated the Lonsdale Company in 1834. Following the closure of the canal, much of the land taken by eminent domain in Rhode Island to construct the canal reverted back to its original owners and/or was acquired by local mill owners following the canal's closure in 1848. The Lonsdale Company bought and maintained the section of Blackstone Canal between the villages of Lonsdale and Ashton for over 100 years after the canal closed (Kierstead 2003:11; Morenon and Raber 1989:87; Worcester Historical Museum 2009:76, 105-16).

"Old Lonsdale" utilized the Blackstone Canal as a power canal and took advantage of the elevation difference between the canal and the river (impounded approximately 2.5 miles upstream at Ashton Dam), which provided 23 ft of head to generate power (Kierstead 2003). As the Lonsdale Mill expanded its operations, the company constructed a large dam across the Blackstone River within the current project APE. The early construction history of this structure could not be precisely determined. According to Klyberg (2010), the Lonsdale Company may have built the Hunt Dam as early as 1826. However it is unclear, given the physical infrastructure evident in historical maps of the period, which Lonsdale mill would have been the customer for the additional waterpower provided. The structure may have been completed in anticipation of an expansion planned for the near future, but delayed. There was a structure extant before 1846, as indicated by the description of the dam provided in the 1883 Annual Report of the Commissioner of Dams and Reservoirs:

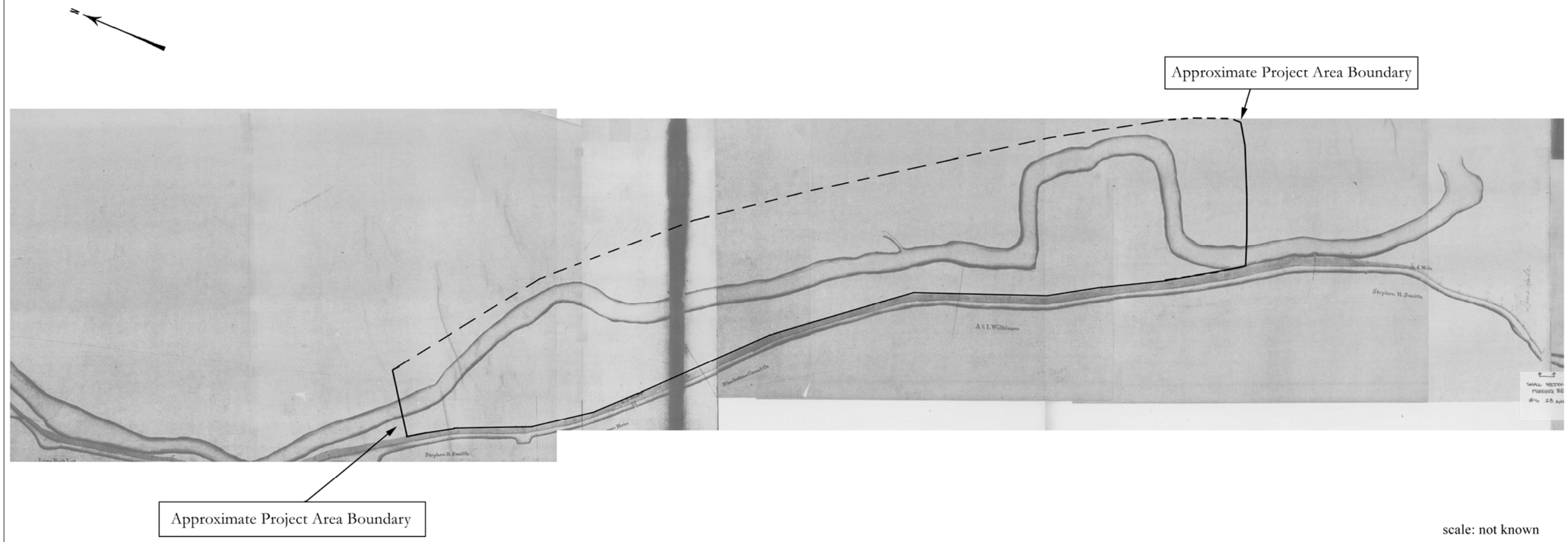


Figure 4-4. 1828 map of the Blackstone Canal, showing the approximate boundaries of the OU2 project area adjacent to the canal (source: Phelps 1828).

> "This dam was rebuilt in 1846. It is a wooden structure, built on piles, capped with mud sills and planked. A wooden slope of plank extends upstream from top of dam to the base, with an angle of 45 degrees with the base. The frame is of heavy timber and filled with stone. The structure is well built. It has no leakage, and appears to be secure in all its parts. The rollway extends the entire length of the dam and discharges the full volume at all stages of the water" (Stone 1883:60).

The Hunt Dam was situated between the Blackstone Canal and the Providence and Worcester Railroad tracks, with its west abutment built into the side of the canal berm. The location and nature of water height control features such as slide gates and flashboards is unknown (Kierstead 2003). A railroad spur connecting the Lonsdale Company mills with the Providence & Worcester mainline was also present across the river just below the dam. The railroad track was built on a wood pile trestle structure (Anon. 1895; Kulik and Bonham 1978). The Hunt Dam is shown schematically on Walling's 1851 and 1855 maps, but with out any discernable physical infrastructure connecting it to the Lonsdale Mills. In 1860, the Lonsdale Company began construction of "New Lonsdale" (a/k/a the "New Village") on the east side of the river in Cumberland. The first mill in this new complex was No. 4, formerly located between Mendon Road (present Route 122) and the railroad tracks. The 1870 (Beers) map of Cumberland depicts the east end of the mill pond with a small structure, presumably a headgate for a long, narrow power canal extending southeast from the pond to Mill No. 4 (Figure 4-5). This long, narrow power canal paralleled the west side of the Providence and Worcester Railroad tracks, crossing under Mendon Road (present Route 22) and then under Mill Street to the mill complex on the north (east) bank of the Blackstone River.

The 1888 bird's eye view of Cumberland depicts the Hunt Dam across the Blackstone River between the main line railroad and the canal, with an unidentified flat-roofed structure at the east end of the dam (Figure 4-6). The railroad spur track and trestle over the river are also depicted just south of the dam. The power canal that parallels the main line railroad between the mill pond and Mill No. 4 of the Lonsdale Co. is also depicted along with a structure of unknown function at the south end of the pond between the power canal and railroad tracks. The two-and-a-half-story, gable-roofed building with a two-story addition does not appear on any other maps. It may have been a short-lived railroad structure, or it could be an erroneous representation of the gate house that is shown on other maps at this location.

In 1893/1894 the Lonsdale Company replaced the Hunt Dam and the adjacent railroad trestle with the new "Pratt Dam" (where the bikeway now crosses the Blackstone), a combination spillway/gate structure/railroad bridge built of granite rubble and coursed granite ashlar. The new dam was part of a system built to increase waterpower capacity at the New Lonsdale mill and to connect the old and new Lonsdale villages. The journal *Engineering News* and the 1894 Annual Report of the Commissioner of Dams and Reservoirs included plans and a description of the new structure, called the Pratt Dam. John W. Ellis, a civil engineer in Woonsocket, designed the structure. The new dam was located about 100 ft south of the original dam with the gate chamber at its east end. The excavation for the dam's foundation was designed to extend to at least six feet below the top of the apron, and the majority of the excavated earth for the dam and abutments was to be placed in the bed of the river northerly of the dam as backfill. The foundations for the gate chamber, abutments, and dam were to be built of "well bonded rubble masonry" and the foundation for the apron of the dam to be composed of "concrete and rubble masonry" (Commissioner of Dams and Reservoirs 1894:13-14). The apron itself was to be constructed of hard pine timbers "filled and rammed with concrete to the top of the timbers" and the dam itself was to be constructed of an ashlar face with rubble backing with dam stone coping on top (Commissioner of Dams and Reservoirs 1894:13-14). The abutments and gate chamber were to consist of rubble masonry, partially ashlar faced. All of the stone, timbers, and cement for the new dam construction were provided by the Lonsdale Company. The design of the new dam and railroad track ensured that the operations of

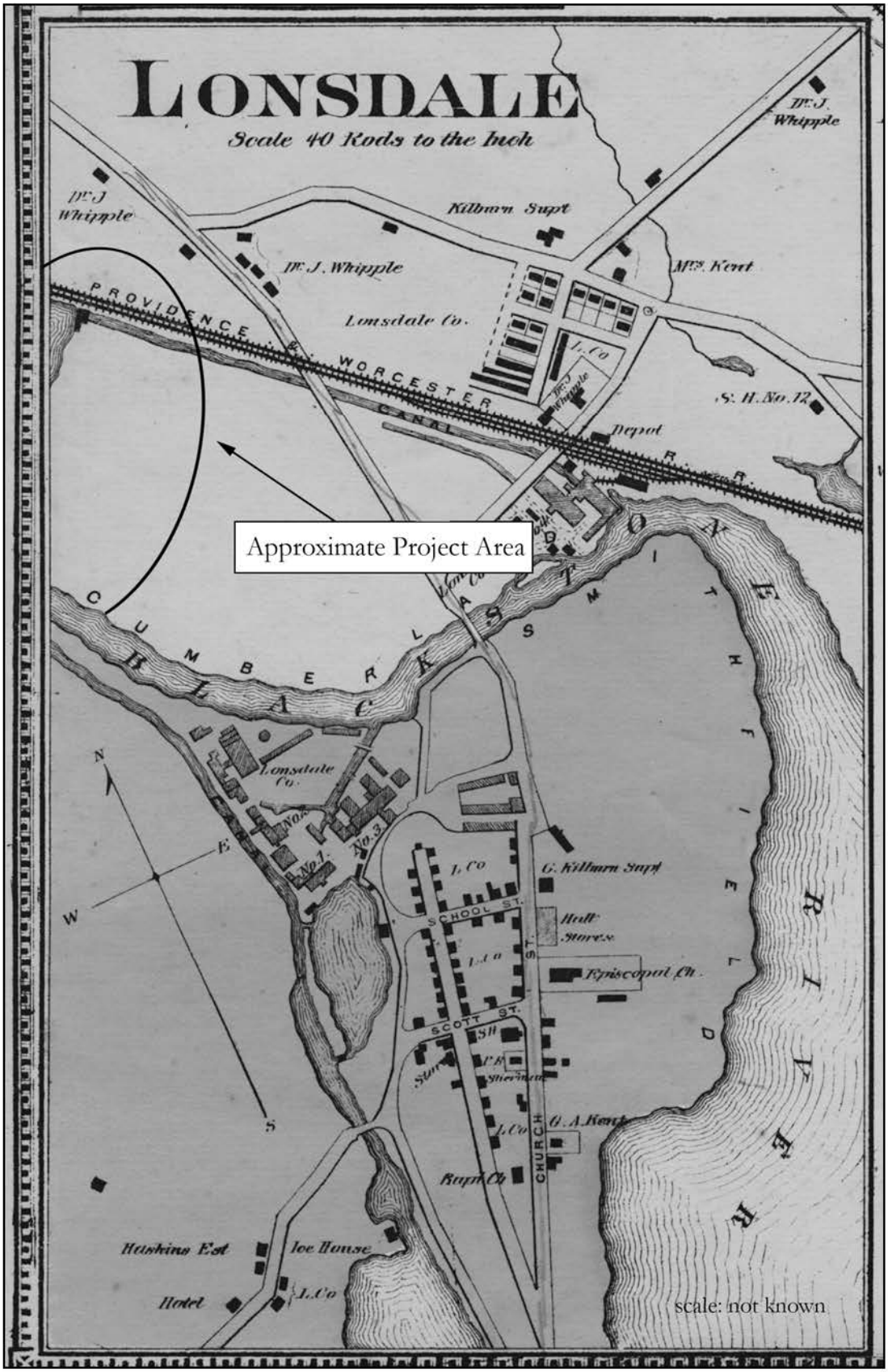


Figure 4-5. 1870 map of the Lonsdale Company property in Cumberland, showing the southern end of the OU2 project area below New Pond (source: Beers 1870

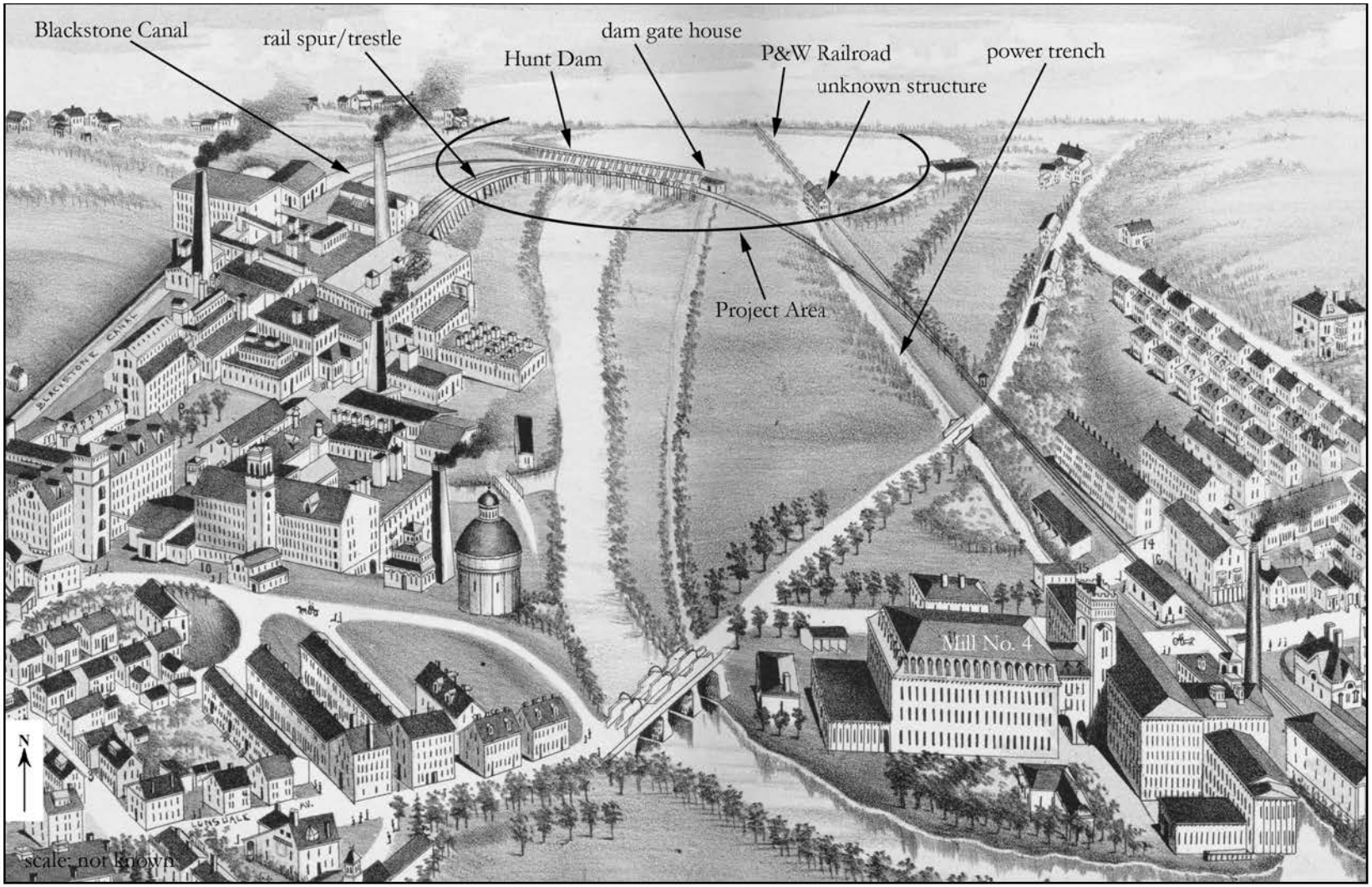


Figure 4-6. 1888 bird's eye view of Cumberland, showing detail of the OU2 project area (source: Bailey & Co. 1888).

the company could continue uninterrupted and obviated the need for expensive coffer dams (Anon. 1895). Figure 4-7 depicts the location of the "old" Hunt Dam and railroad track trestle structure across the riverat this location, which corresponds to the southern portion of the OU2 project area (Commissioner of Dams and Reservoirs 1894:13-15; Engineering News 1895:166; Kierstead 2003:13).

The 1895 (Everts and Richards) atlas maps of Cumberland and Lincoln depict an enlarged mill pond upstream of the Pratt Dam that occupies nearly all of the OU2 project area and is bisected by the Providence and Worcester Railroad (Figures 4-8 and 4-9). The Pratt Dam spillway across the river is depicted at the southwest side of the project area, just upstream of the Lonsdale mills. Strangely, the railroad spur track atop the dam structure is not indicated. It may not have been completed at the time of the Everts and Richards survey. The gatehouse and long, narrow power canal depicted on the 1870 (Beers) map at the southeast side of the pond just west of the Providence and Worcester Railroad tracks were still present at that time. Several structures including an ice house were present on the southeast side of the pond. The gatehouse and narrow power canal on the west side of the railroad tracks and some of the structures on the east side of the tracks would have been situated on the present Nunes Property and the Lenox Street Well Site within the OU2 project area.

The pond configuration of the OU2 project area is clearly depicted on the 1894 USGS topographic map (Figure 4-10). This map clearly depicts the curved railroad spur across Pratt Dam. The railroad spur is still shown on the 1944 USGS map (surveyed in 1937 and 1938), and the mill pond was called "New Pond" by that time (Figure 4-11). The 1949 USGS map depicts nearly an identical configuration in the OU2 project area, although the southern boundary of the present Nunes Property was adjacent to the

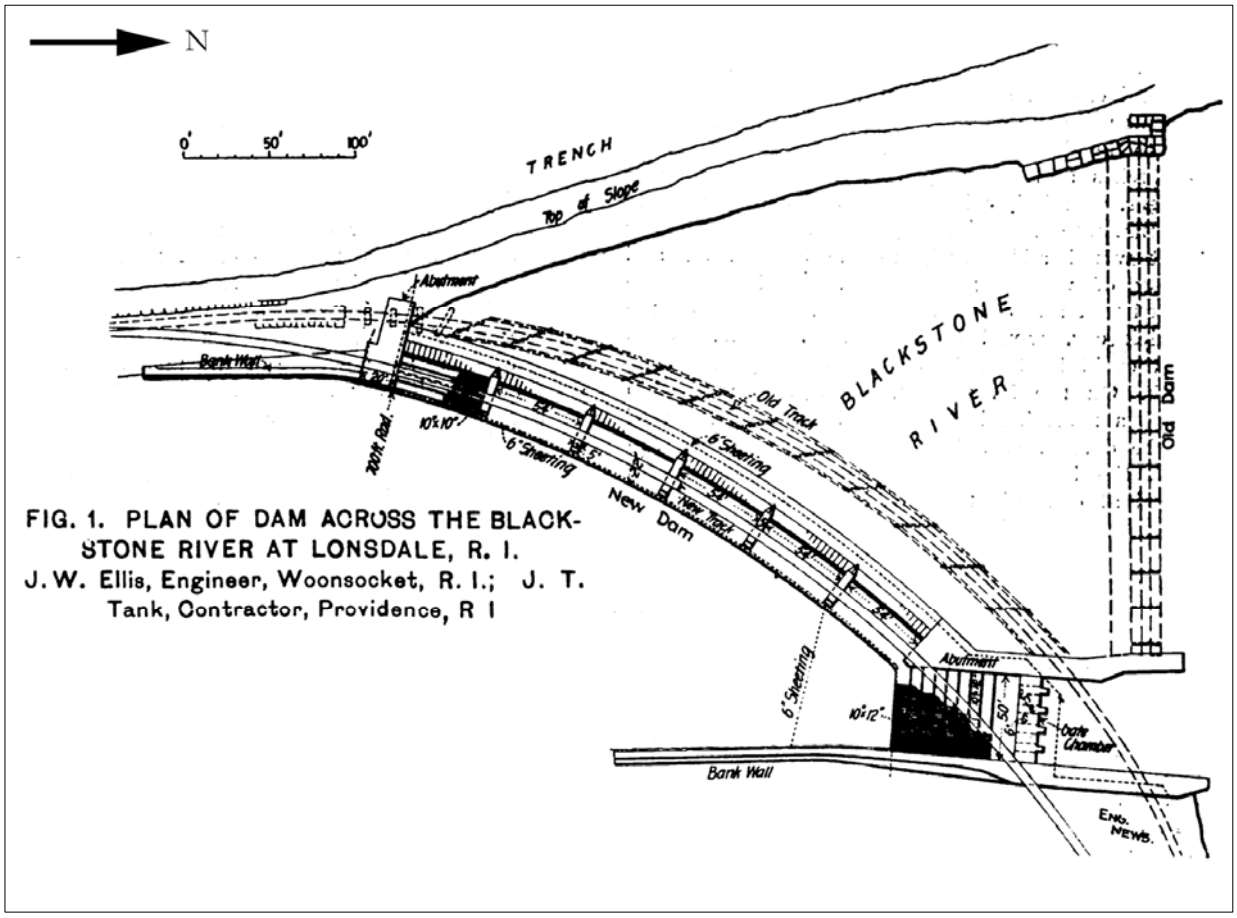


Figure 4-7. 1895 plan of the "new" Pratt Dam across the Blackstone River and the "old" Hunt Dam to the immediate north (source: Engineering News 1895).

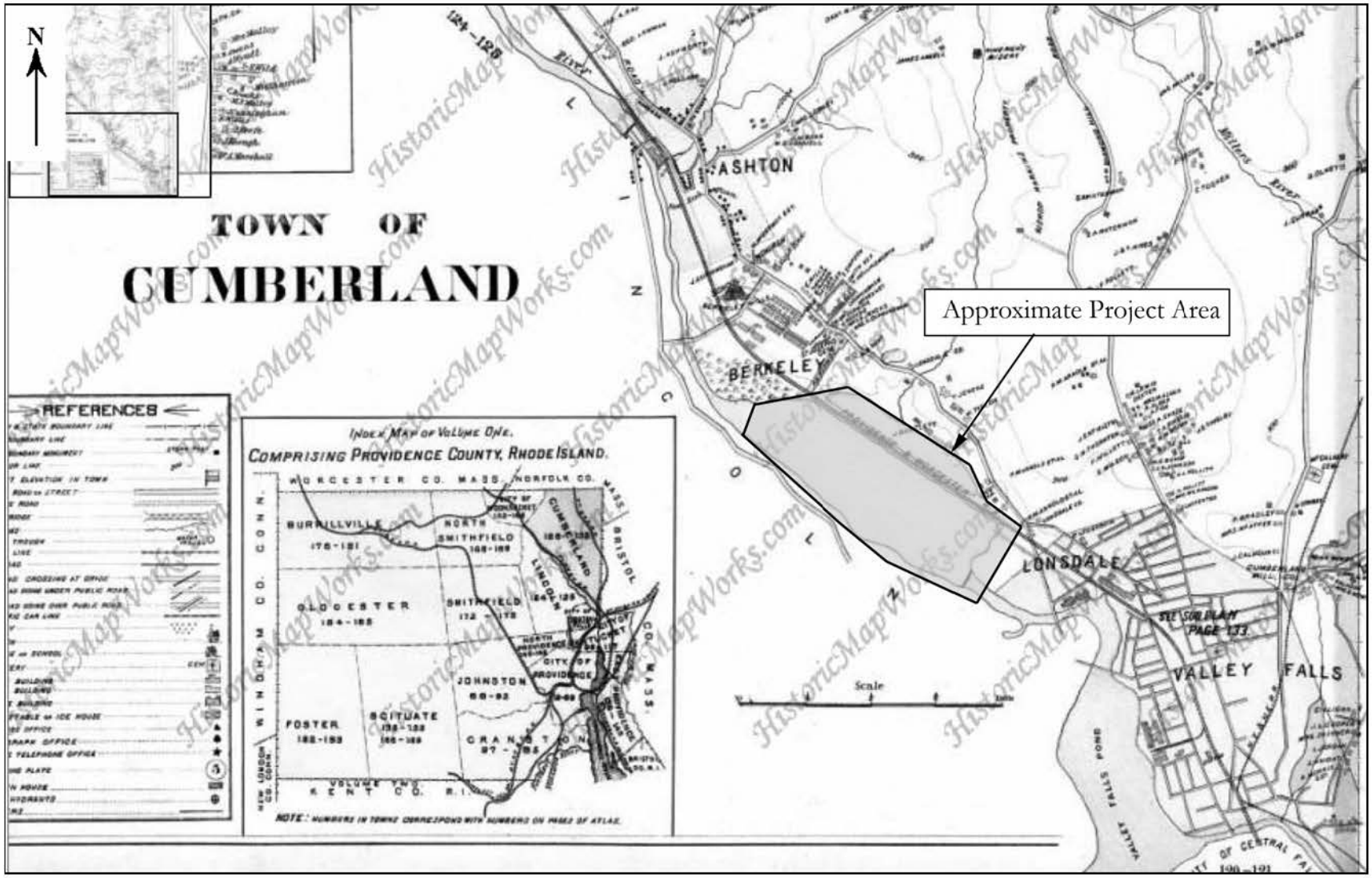


Figure 4-8. 1895 map of Cumberland, showing the approximate location of the OU2 project area (source: Everts and Richards 1895).



Figure 4-9. 1895 map of Lincoln, showing the approximate location of the OU2 project area (source: Everts and Richards 1895).

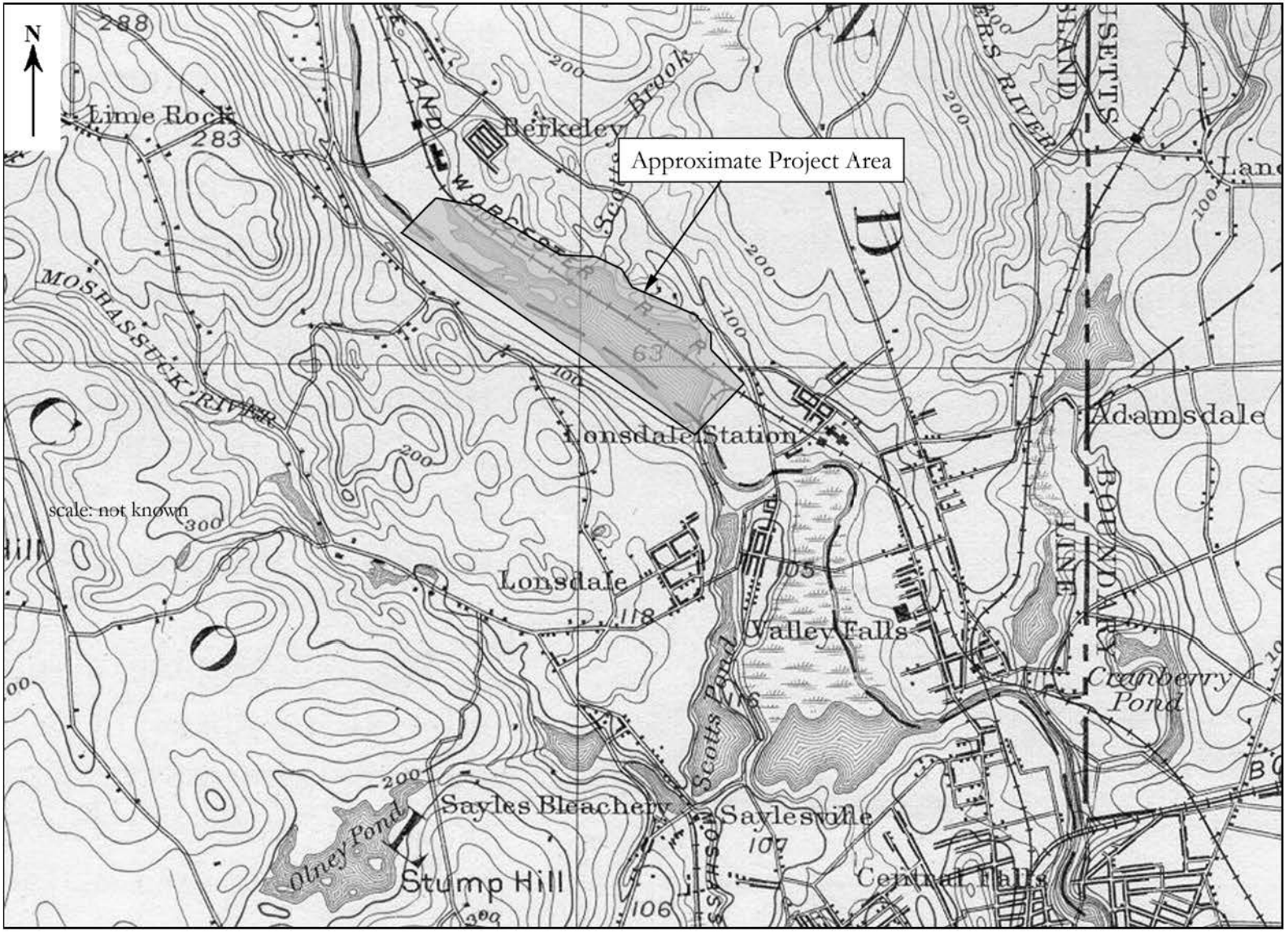


Figure 4-10. 1894 USGS Providence, RI-MA topographic quadrangle map, showing the approximate location of the OU2 project area (source: USGS 1894).

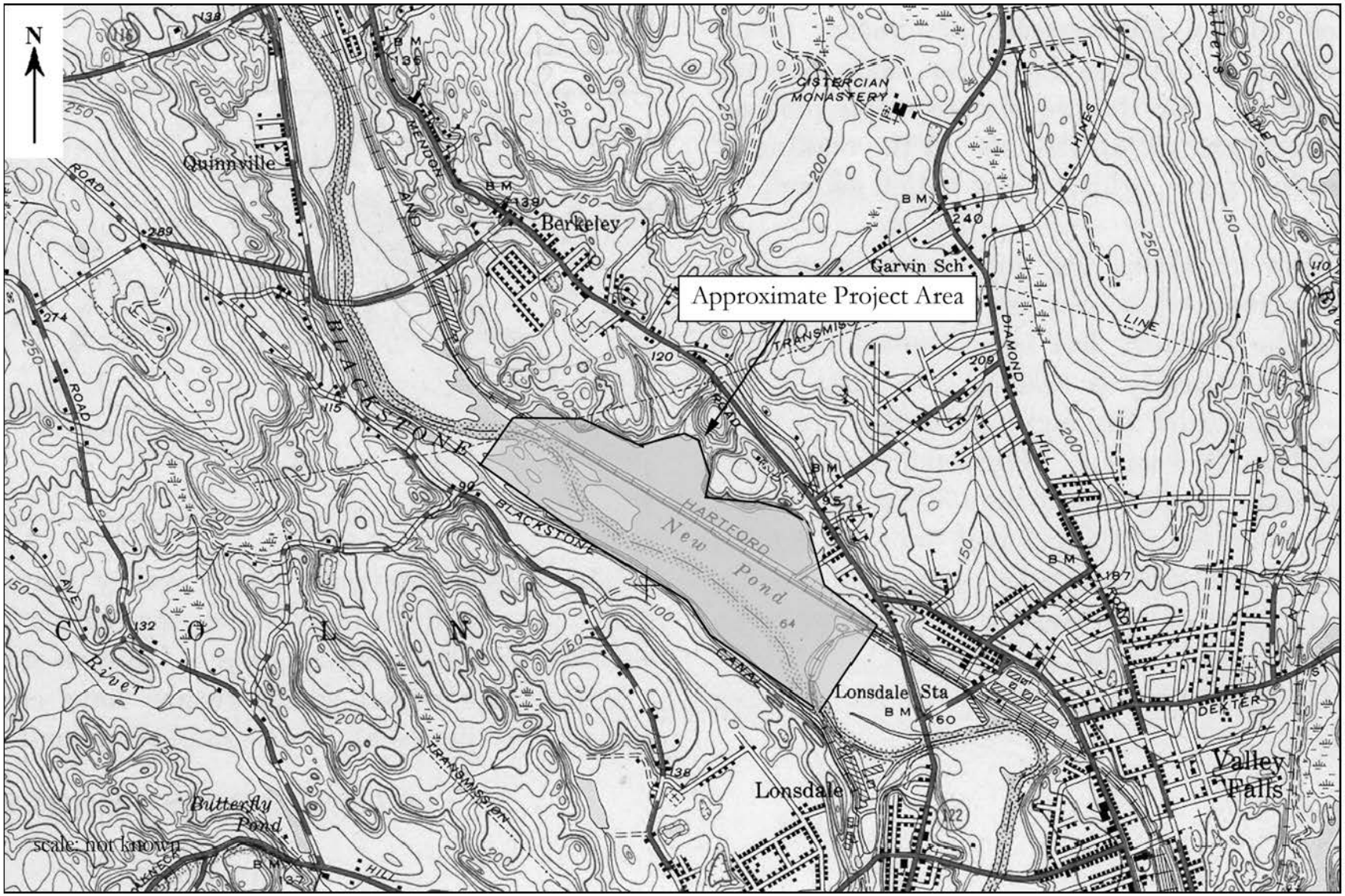


Figure 4-11. 1944 USGS Pawtucket, RI-MA topographic quadrangle map, showing the approximate location of the OU2 project area (source: USGS 1944).

1930s auto speedway on the Cumberland side of the river (Figure 4-12). The "Lonsdale Sports Arena" was built in 1947. It was a 33,000 seat oval arena that contained a one-third mile car high banked racing track. It was a popular entertainment venue for nearly ten years. The speedway was closed after extensive flood damage in 1954 and 1955 (Anon 2006). It was torn down in 1956 and the property has been transformed into the present Super Stop & Shop and strip mall complex on Mendon Road. The southern extend of the OU2 project area borders or partially overlaps the former speedway site.

The Lonsdale Co. (Pratt) dam, No. 4 mill power trench, railroad main line and spur track, and nearby roads all suffered heavy damage from flooding associated with the 1954 and 1955 storms (RIDEM files). By 1955 the state and PRPs were studying the draining of New Pond into the Blackstone River and the abandonment of the No. 4 mill power trench since they no longer served for power generation (RIDEM files). In May 1956 the then owner of the dam and adjacent parcels, J.M. Mills Inc. of Cumberland, requested state permission to permanently lower the water level of New Pond, make structural changes to Pratt Dam and its appurtenances, and close of the power trench with fill from north of Mill Street to the Blackstone River (RIDEM files).

A series of aerial photographs dated 1939, 1952, 1962, 1976, 1981, and 1988 depict the changing land conditions within and surrounding the OU2 project area during the mid-to-late twentieth century (see Appendix B). These changes were primarily due to the flooding from severe storm events in the 1930s and 1950s; abandonment of the dam, gate house, and railroad spur track for industrial purposes by the early 1950s; and the 1954 purchase of the former New Pond, dam, and surrounding parcels by J.M. Mills for a landfill, which resulted in the draining of the pond and filling of the mill power trench, and other structural modifications to the dam (RIDEM files).

• The 1939 aerial shows the mill pond conditions similar to the 1944 and 1949 USGS maps. The pond was still bisected at that time by the railroad tracks. Very little land surfaces are visible, except at the northern end of the pond. The dam gate structure and power trench at the south end of the pond paralleling the main line railroad track are clearly visible.

• The 1952 aerial depicts similar conditions although more land areas appear in New Pond including the vicinity of the Unnamed Island. Some filling appears to have occurred in proximity to the gate structure and the power trench that paralleled the railroad tracks at the south end of the pond, probably in relation to the creation of the Lonsdale auto speedway (circular tracks).

• The 1962 aerial does not indicate much difference in the pond, except at the southern end where the dam's gate structure was no longer visible and the power trench had been completely filled in. More land appears to have been created by filling in the area north of the abandoned auto speedway and filling had also occurred on the opposite side of the tracks in the former mill pond. Visible in the northwest corner of the project area is the Town of Lincoln's Well No. 1. This was constructed in 1957 on a formerly inundated parcel adjacent to the Blackstone Canal. Comparison of the 1951 and 1962 aerials indicates excavation activity on the parcel. This may have been an effort to obtain fill material to be used for the well building pad and associated access roads.

•The 1972 aerial shows that the Unnamed Island had been fully formed by that time, presumably as a result of removing dam structures and draining the former mill pond into the Blackstone River. The river curved around its eastern side to form the distinct oxbow bend that exists today (possibly along an approximation of its original channel). Paths or roads were also visible on the Unnamed Island. Even more land had been created on the north side of the dam and rail spur structures at the south end of the former mill pond (new Blackstone River bend) and auto speedway. This area had become the site of the Nunes Property transfer station. The J.M. Mills landfill to the north had resulted in a substantial new land area on both sides of the railroad tracks.

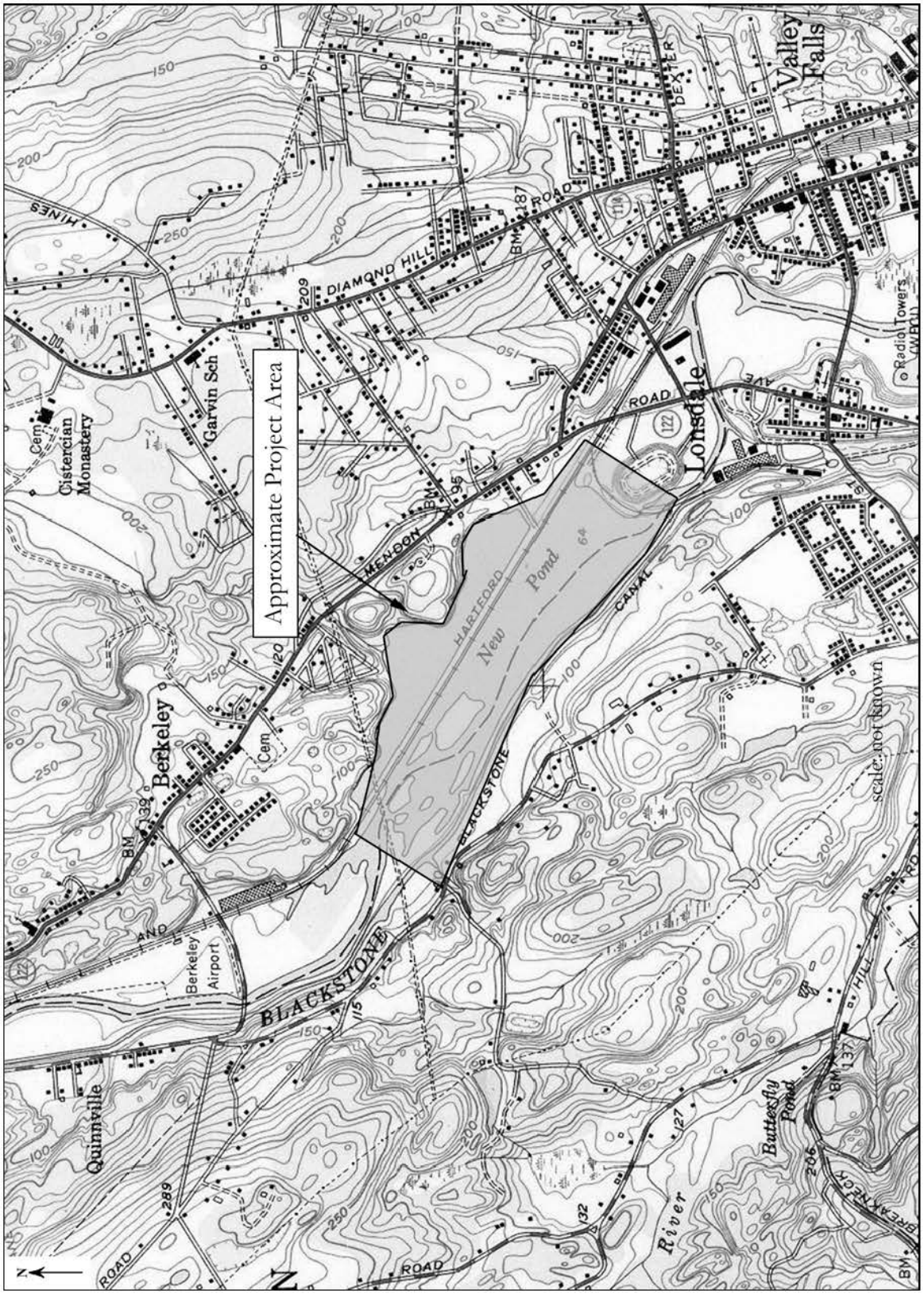


Figure 4-12. 1949 USGS Pawtucket, RI-MA topographic quadrangle map, showing the approximate location of the OU2 project area (source: USGS 1949).

• The 1981 and 1988 maps depict increases in the surface water of the Unnamed Island, indicating that soil removal was taking place through that period. The landfill continued to grow in thickness, and the lands on the east side of the Providence and Worcester Railroad emerged as vegetated wetlands beyond the railroad embankment.

CHAPTER FIVE

RESULTS OF THE RECONNAISSANCE SURVEY

The OU2 project area, which corresponds to the recommended project APE, is comprised of six property units that include from north to south: Quinnville Well Field, Lincoln; J.M. Mills Landfill, Cumberland; Unnamed Island, Cumberland; Wetlands A, B, C, and D, Cumberland; Lenox Street Well, Cumberland; Nunes Property, Cumberland; Pratt Dam (a/k/a Lonsdale Dam and Railroad Bridge) and Pond F, Cumberland and Lincoln (Figure 5-1). The Blackstone River forms the town boundary line and meanders through the various property units. The Providence and Worcester Railroad easement traverses the Nunes Transfer Station Property and the Landfill in the eastern portion of the project area/APE following a southeast-northwest axis. The paved bike path (former Blackstone Canal tow path) forms the western boundary of the OU2 project area/APE and the canal itself is open along the entire length to the west side of the bike path embankment. The Phase I reconnaissance survey results are organized below by project property unit from north to south.

Quinnville Well Field

The Quinnville Well Field is situated in the northwest portion of the OU2 project area/APE within the town of Lincoln (see Figure 5-1). It occupies 24 acres of woodland and wetlands. It is accessed from a raised packed dirt and gravel road off the paved bike path/towpath. A review of historic town, atlas, USGS maps, and aerial photographs indicates that this parcel was low-lying river floodplain at the northern end of the mill pond created by the construction of and improvements to the Hunt Dam in the early-mid-1800s. The well field is located across the river from, and slightly north of, the present-day J.M. Mills Landfill. It was presumably named after the historic village of Quinnville, located on a steep bluff of the Blackstone River directly across from the villages of Ashton and Berkeley in Cumberland (outside the project area/APE). The first textile mill in Lincoln was constructed in Quinnville on land of Captain Wilbur Kelly in 1815. Kelly built the mill directly on the Blackstone Canal, with the mill on the left (west) side of the canal's tow path and the workers' houses on the right (east) side. The mill was acquired by the Lonsdale Company in the 1840s and operated as a sheeting factory and eventually as a storehouse adjunct to the company's extensive operations across the river in Ashton (RIHPC 1982). The Captain Wilbur Kelly House stands today on the Lincoln side of the river nearly across from the Ashton Mill (Ashton Historic District), and it is currently used by the Blackstone River Vally National Heritage Corridor as a visitor center adn transportation museum (see Figure 1-3).

The Quinnville Well Field land area appears to have been partially or completely submerged throughout most of the nineteenth-century before and following the construction of the 1894-95 Pratt Dam that replaced the Hunt Dam. As described in Chapter 4, according to the late nineteenth and twentieth-century USGS topographic maps and aerial photographs, a large portion of the land mass in this area emerged during the second half of the twentieth century as a result of the draining of New Pond and natural siltation processes. The present land surface is extremely hummocky with numerous low-lying wet depressions that reflect the natural siltation and historic inundation of this area. The soils on this parcel are characterized as moderately well-drained Podunk fine sandy loam (flood plain soils).

One monitoring well (MW-A2) installed in the well field in 1980 by the Town of Lincoln indicates the presence of fine sand from 0-15 ft below surface (see Appendix C-1 and D). Five soil samples (SO-001-BG thru SO-005-BG) taken from 0-1 ft below surface in the northern portion of the parcel indicate the

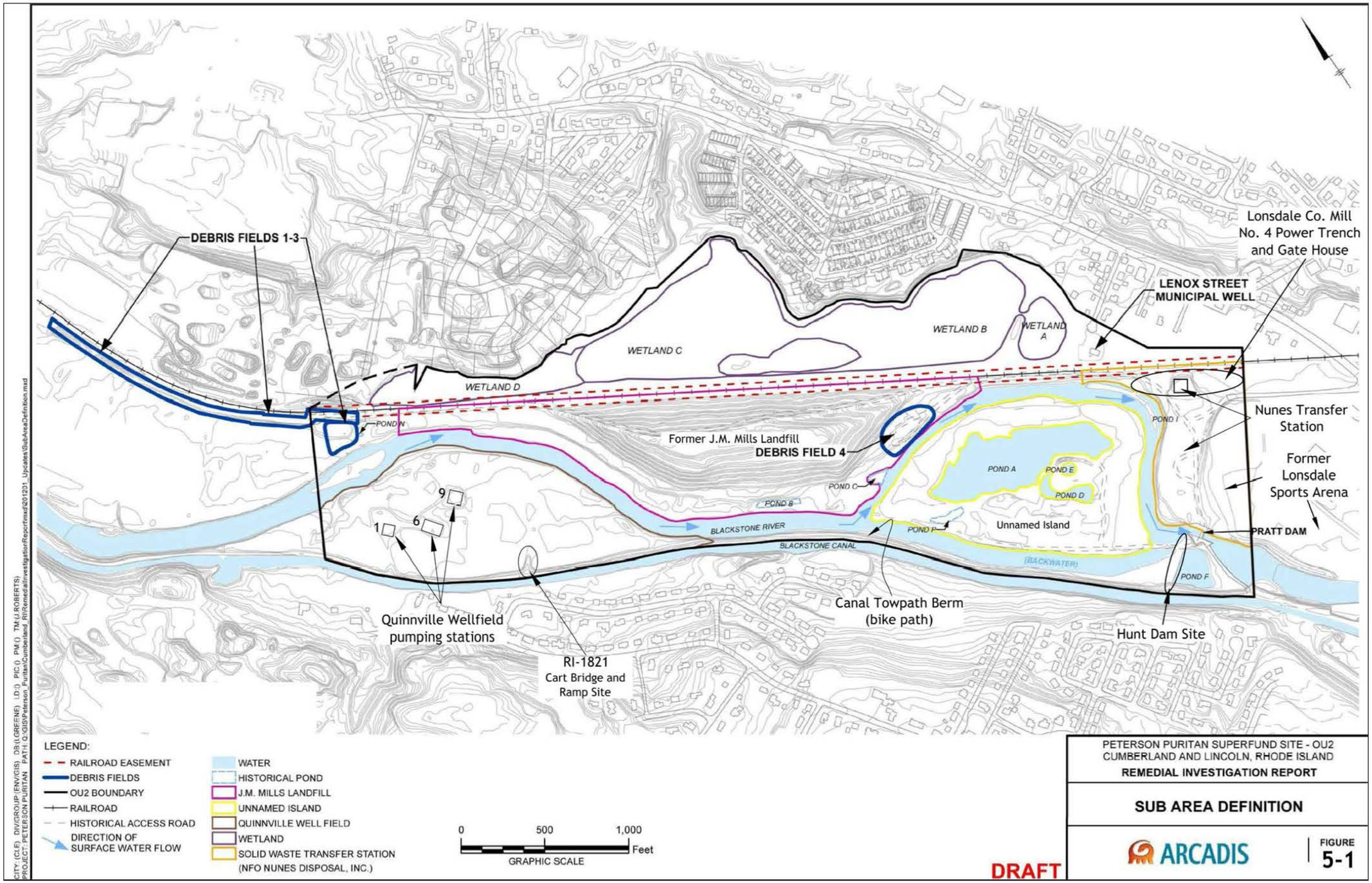


Figure 5-1. Existing conditions base map of the OU2 project area, showing the locations of previously recorded and newly identified archaeological resources.

presence of dark brown, brown, and gray-brown fine to coarse silt and sand (likely alluvial deposits) (see Appendix C-2 and D). Four additional soil samples (SO-044-QW, SO-045-QW, SO-075-QW, and SO-076-QW) taken from 0-1 ft below surface in the northern half of the parcel indicate the presence of dark brown, brown, and light olive brown fine sand (also likely alluvial deposits) (see Appendix C-2 and D). There are no available soil sample logs for the southern half of the parcel, but it is likely that soils are similar to those indicated in the northern half.

The Town of Lincoln installed its first municipal water supply well in the Quinnville Well Field in 1957 (Pumping Station No. 1). In 1969 and 1978 Lincoln installed two more wells (Pumping Station Nos. 6 and 9, respectively) at this location. By 1979 the Quinnville Well Field supplied Lincoln with approximately 45 percent of its water. During routine sampling of wells in 1979, the Rhode Island Department of Health (RIDOH) discovered volatile organic compounds (VOCs), some exceeding EPA drinking water guidelines, in the three Quinnville wells. The wells were closed, and the Town of Lincoln constructed two new wells in the Blackstone Valley aquifer, one north and one south of the Quinnville Well Field (EPA 1993). The well field's physical infrastructure consists of an access road and three enclosed well heads/pumping stations, all of which are situated on artificial landforms. The dirt and gravel access road leads east from a gated opening on the Blackstone Canal/Greenway and curves irregularly to the southeast to reach the three well heads, each surrounded by a chain link fence enclosure. The first to be reached is Pumping Station No. 1, identified by an enameled sign. The pumping station is entirely concrete, with a flat slab roof, block walls, and a slab foundation (Figure 5-2). A block chimney is located on the south elevation. A metal slab door is centered on the west elevation. A pair of window openings, now covered with plywood, are located on the north elevation. The second well head to the south, Pumping Station No. 6, is a ribbed, precast concrete hut with a flat roof and a steel slab entry on the south elevation (Figure 5-3). The third well head, Pumping Station No.9, is now a ruin (Figure 5-4).

The Quinnville Well Field and southern narrow land area between the present river courses are adjacent to the historic Blackstone Canal and towpath (present bike path). As discussed in Chapter 4, the 1828 Phelps map of the canal depicts a canal-related cart bridge, mile marker, and lay-by in this vicinity. A 1989 Phase I archaeological survey of the Blackstone River Bikeway in Rhode Island identified the remains of the canal-era cart bridge and ramp (RIHPHC archaeological site #RI-1821) just southeast of the Quinnville Well Field building area (see Figure 5-1 and Figure 5-5). The cart bridge site is recorded as a contributing archaeological element (Feature 1A) in the Blackstone Canal Historic District nomination (Adams 1991). The 1989 subsurface testing within the towpath adjacent to the cart bridge axis resulted in the recovery of late nineteenth through twentieth century artifacts (coal and slag, bottle glass, ceramics, shell) in fill deposits. The cart path ramp itself is discernable as a topographic anomaly that grades down to the river floodplain (Figure 5-6). A north to south break in the ramp at its eastern end may represent an historic pathway between former agricultural fields. A stone wall was also present along the canal towpath berm at the ramp location. The stone wall was probably used to stabilize the towpath berm and prevent slumping into the river floodplain. No stone abutments along the canal were observed during the 1989 survey and the western bank of the canal had been infilled by local residents, which obscured the cart path on the opposite side (Morenon and Raber 1989:88-98).

The results of the 1989 Phase I subsurface testing in this area suggested that the cart bridge was not built as a separate facility, but rather in tandem with the towpath for the canal. This implies that the area on both sides of the canal was being used for agricultural purposes prior to the canal's construction. The cart bridge reflects the articulation between agriculture and canals in the early nineteenth century. A few hundred meters north of the cart bridge the canal bordered active farm fields and the Wilkinson (Spaulding) House, which predated the canal (Morenon and Raber 1989:149).

The EPA environmental site investigations for the OU2 study area included surface soil sampling in the well field. This sampling indicates the presence of natural alluvial deposits from ground surface to at



Figure 5-2. 2011 photograph of Pumping Station No. 1 of the Quinnville Well Field (PAL Map Figure No. B), view looking south. ***This resource, which was built in 1957, is not eligible for listing in the National Register.***



Figure 5-3. 2011 photograph of Pumping Station No. 6 of the Quinnville Well Field (PAL Map Figure No. B), view looking southwest. ***This resource, which was built in 1969, is not eligible for listing in the National Register.***



Figure 5-4. 2011 photograph of Pumping Station No. 9 of the Quinnville Well Field (PAL Map Figure No. B), view looking south. ***This resource, which was built in 1978, is not eligible for listing in the National Register.***



Figure 5-5. 2011 photograph of the cart path ramp (RI-1821) in the Quinnville Well Field portion of the OU2 project area, view looking east. ***This resource is listed in the National Register as Feature 1A of canal Section 5.***

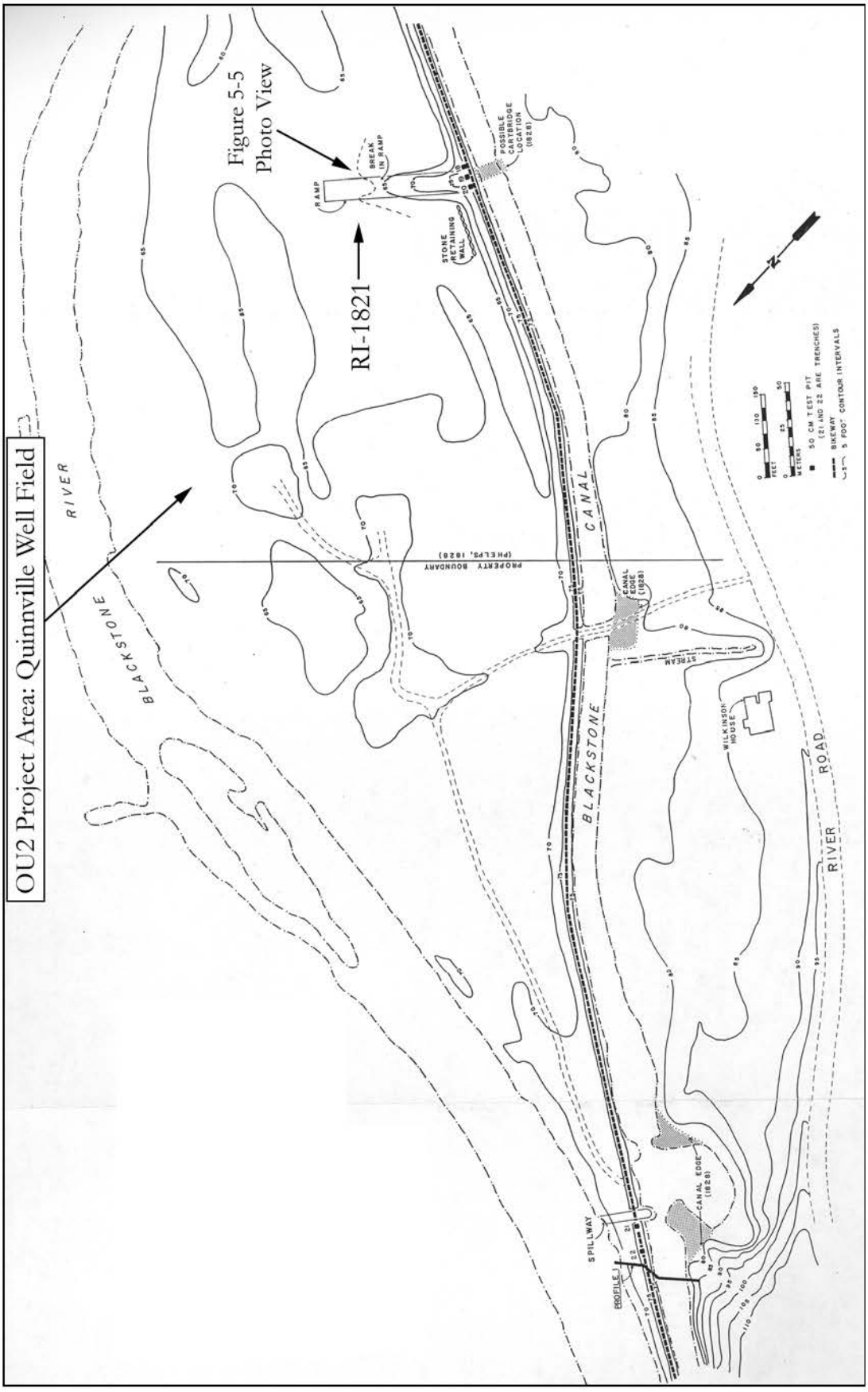


Figure 5-6. 1989 survey map of the previously identified cart path ramp (RI-1821) in the Quinnville Well Field portion of the OU2 project area (source: Morenon and Raber 1989).

least 1 ft below surface. The uppermost (1-3 ft) alluvium is probably of recent age (>100 years old), but the alluvial deposits that purportedly extend to depths of 20 ft in the OU2 study area would have the highest potential for pre-contact/contact/early historic period Native American cultural deposits. The Quinnville Well Field parcel therefore is assigned archaeological sensitivity, excluding the artificial landforms created for the well field structures (Figure 5-7). The recorded location of RI-1821, the Blackstone Canal-era cart ramp and bridge, is also assigned archaeological sensitivity for post-contact EuroAmerican archaeological resources associated with agricultural land uses in the late eighteenth and early/mid-nineteenth centuries.

J.M. Mills Landfill

The J. M. Mills Landfill is situated in the central portion of the OU2 project area/APE within the town of Cumberland (see Figure 5-1). The area within this tract occupied by waste is approximately 38 acres. The main mass of refuse encompasses a trapezoid-shaped area that is approximately 2,300 ft long on its long (railroad) side, 1,000 ft long on its short (Blackstone River) side, 600 ft wide (transverse to the Blackstone River) and approximately 23 acres in size. It rises to an elevation of approximately 145 ft NGVD29 and the estimated average elevation of the bottom of the waste is 49 ft NGVD29 (Arcadis 2012:190). According to the EPA the landfill was used for the disposal of wastes, including wastes containing hazardous substances from 1954 through 1986. Sewer sludge was also disposed at the facility as part of the daily operation. Various types of large, bulky solid materials (including, but not limited to, tanks, crushed drums, pre-cast concrete structures, railroad ties, and demolition debris) are deposited aside of the landfill, along the north and south access roads and along the bank of the river (Figure 5-8). EPA conducted a removal action at the site in 1992, which included constructing a fence around its perimeter and removing drums that contained materials from the base of the landfill. In November 1997 a second removal action was conducted at the site to address the presence of asbestos-containing wastes found outside of the fenced-in area. The security fence was extended to limit further dumping and maintain access restrictions in this portion of the site. Soils along the river and within OU2 have been found to be contaminated with polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), and heavy metals.

The municipal and industrial waste and fill materials in the landfill portion of the OU2 project area/APE are approximately 100 ft thick. Stacked precast concrete walls (drylaid) are present along the base of the landfill waste closest to the river shoreline (Figures 5-9 and 5-10). These retaining walls are approximately 6 to 12 ft high and run along the southwest perimeter of the landfill. The USDA classifies the landfill as containing Dump soils (human transported materials). The EPA environmental site investigations for the OU2 study area included soil testing of the perimeter of the landfill mass. A total of 19 test trenches (LF-TT-01 thru LF-TT-11 and LF-TP-01 thru LF-TP-04) that measured 5-10 ft long by 4 ft wide by 5-16 ft deep each were excavated in this area (see Appendix C-3). These trenches confirmed that additional buried waste is present beneath the floodplain of the Blackstone River at the toe of the landfill and in a strip extending from the northern edge of the main mass of refuse (Arcadis 2012). Waste encountered during these test trenching activities adjacent to the river had approximately 0-2 ft of soil cover and extended to or below the groundwater surface. Waste materials typically found in the test trenches included plastic, brick, wood, hose, and tires (Arcadis 2012:190). The test trenches indicate that grayish brown poorly sorted sand and gravel (loose and wet) is present at depths greater than 9-15 ft below surface (see Appendix D). This soil stratum could represent natural (pre-landfill) sediments intermixed with alluvial deposits.

There is a narrow strip of land that follows the Blackstone River shoreline around the landfill mass where no waste materials were encountered. A monitoring well (GLF-700a) placed in this area indicates the presence of brown to gray silty fine to coarse sand and gravel from 0 to 70 ft below surface at the limit of the boring (see Appendix C-1 and D). These sediments do not contain fill or waste materials, and appear

to represent natural alluvial deposits in the upper 20 ft and glaciofluvial deposits below that depth. Similarly an environmental test pit (LF-TP-04) placed at the far northern extent of the landfill mass between the railroad and the river indicates the presence of grayish brown silt and sand from 0-1 ft below surface underlain by yellowish brown sand and gravel from 3-7 ft below surface, indicative of natural soil horizons with no waste or fill materials (see Appendix D). There are also two ponds at the southwest side of the landfill mass (Ponds B and Pond C), which both contain silt and silty clay and sand sediments below the water table (Arcadis 2012).

A review of historic town, atlas, USGS maps, and aerial photographs indicates that the landfill is located in the nineteenth-century New Pond (mill pond) created when the first Hunt Dam and later Pratt Dam were erected to the south in the nineteenth-century. Prior to the first damming of the floodplain of the Blackstone River at this location in the early-mid 1800s, it is likely that the New Pond area including the landfill consisted of low-lying (floodplain) terrain. The 1838 Nelson map of Cumberland depicts a meandering Blackstone River at and below the confluence with Monastery Brook at this location (see Figure 4-1). Following that time, the area is depicted as being within the mill pond until the 1960s and 1970s.

No archaeological sensitivity is assigned to the landfill waste and fill materials. Natural (alluvial and glaciofluvial) deposits are present below the waste in the delineated landfill mass and just below the ground surface along the perimeter and shoreline of the Blackstone River. Natural sediments also appear to be present in Ponds B and C bottoms along the southwest perimeter of the landfill waste. The upper 20 ft of alluvial deposits would have the highest potential for pre-contact/contact/early historic period Native American cultural deposits and are assigned archaeological sensitivity (see Figure 5-7).

Unnamed Island

The Unnamed Island occupies 30 acres circumscribed by the run-of-the river meander on its east side and the "backwater" of the river on its west side in the town of Cumberland (see Figure 5-1). The two modern-day river courses in this area converge on the north side of the Pratt Dam spillway (tubes) and empty into the run-of-the river to the south. The island is currently wooded, and there are no standing structures or documented built structures (Figure 5-11 thru 5-14). A review of historic town, atlas, USGS maps, and aerial photographs indicates that the Unnamed Island was historically located in the nineteenth-century New Pond (mill pond) created when the first Hunt Dam (ca. 1840s) and later Pratt Dam (1893/94) were erected across the Blackstone River to the south. Prior to the erection of the earlier Hunt Dam, it is likely that the New Pond area including the Unnamed Island consisted of low-lying (floodplain) terrain. The 1838 Nelson map of Cumberland depicts a prominent northeasterly bend in the Blackstone River just below the confluence with Monastery Brook at or near this location. The Unnamed Island as a lowlying landform was submerged in the mill pond throughout the second-half of the nineteenth century and in aerial photographs dated 1939, 1951, and 1962. The island area first appears in the 1972 aerial photograph, and is most likely the result of the draining of the pond by the landfill owners in the 1960s. The split in the river around the island, consisting of the easterly course or bend (which most closely resembles the river's course on the 1838 Cumberland map) and the straight westerly course above the dam (so-called 'backwater'), also first appears in the 1972 aerial photograph. Since that time, the island has been accessed across the spillway and made land of the Pratt Dam to the south. An artificial road bed of packed dirt and gravel fill is still visible in this portion of the project area/APE today (Figure 5-15).

The Unnamed Island is primarily characterized as containing two general areas of delineated solid waste. One area of waste surrounds Pond E between Pond D and the southern portion of Pond A. The other area is elongated and extends on the west side of the island parallel to the back channel of the river between the channel and west of Ponds A and D. The Pond E area corresponds to a former three-sided berm that

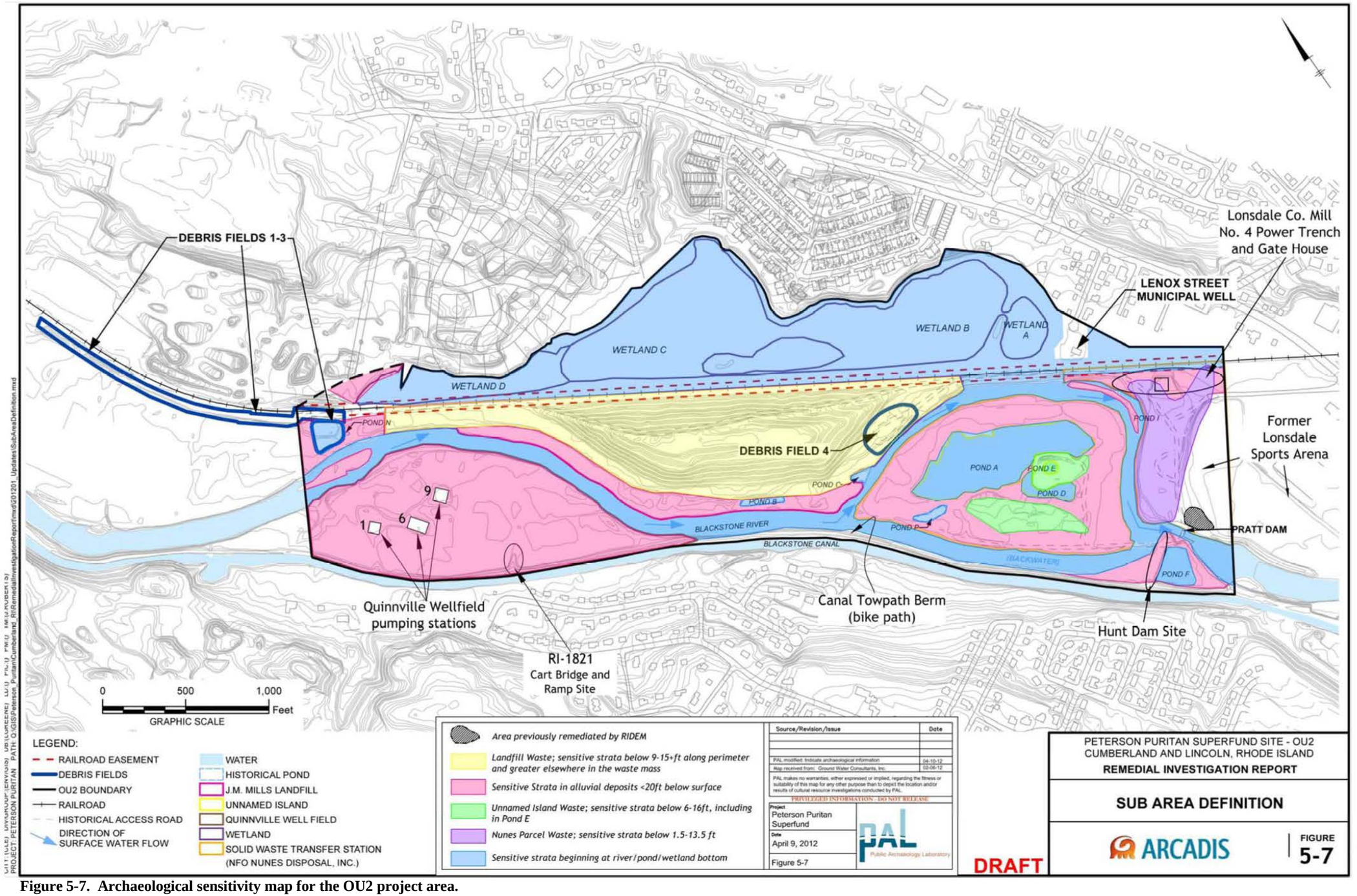


Figure 5-7. Archaeological sensitivity map for the OU2 project area.



Figure 5-8. 2011 photograph of typical ground surface along the base of the landfill waste mass near Pond B, view looking southeast.



Figure 5-9. 2011 photograph of stacked precast concrete walls (drylaid) along the base of the landfill waste mass closest to the river shoreline near Pond C, view looking northeast.



Figure 5-10. 2011 photograph detail of stacked precast concrete walls (drylaid) along the base of the landfill waste mass closest to the river shoreline near Pond C, view looking southeast.



Figure 5-11. 2011 photograph of the west side of the Unnamed Island, looking east across the "backwater" portion of the Blackstone River.



Figure 5-12. 2012 photograph of the southeast side of the Unnamed Island, looking south from the southeast curve of the run-of-river meander.



Figure 5-13. 2012 photograph of the south end of the Unnamed Island, looking west from the southeast curve of the run-of-river meander.

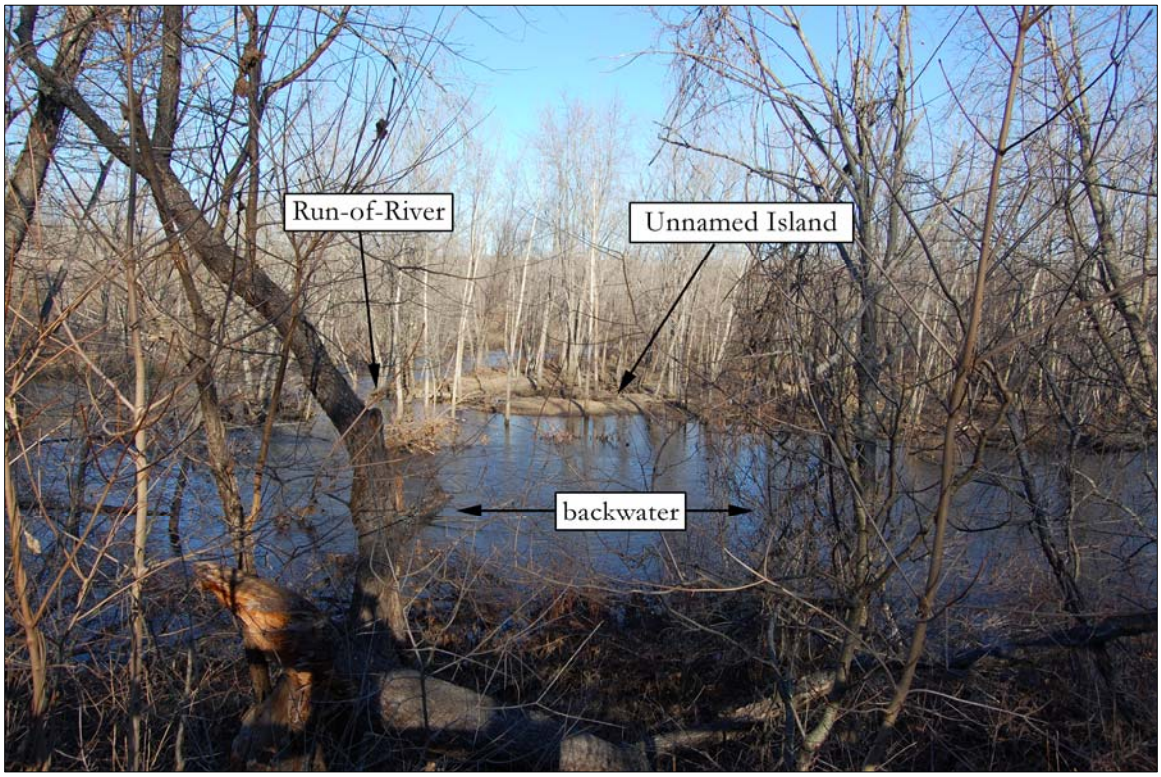


Figure 5-14. 2011 photograph of the northwest end of the Unnamed Island, looking southeast from the bike path.



Figure 5-15. 2012 photograph of the artificial road bed of packed dirt and gravel at the southwest side of the Unnamed Island, view looking east.

was present around 1970. The waste consists mainly of brick and metal piping as well as a large number of tires, both buried and on the surface, within and in the vicinity of Pond E. The waste is estimated to be about 4.8 ft thick across an approximate 1.1-acre area, buried to depths of at least 8 ft below surface. The southern side of Pond A contains buried waste that includes household appliances, brick, wire, car parts, and a steel tank. The second and larger area of waste disposal is identified on the southwestern side of the island. The waste consists mainly of industrial debris including plastics, wire, glass, wood, tires, and some medical waste. These materials are buried under 1 to 2 ft of soil and extend to depths of 6 to 16 ft below surface (to depths below the water table) across an approximate 2.3-acre area (Arcadis 2012).

The EPA environmental site investigations for the OU2 study area have included soil testing throughout the Unnamed Island. This testing includes 34 test trenches (UI-TT-01 thru UI-TT-32) that ranged from 12-30 ft long by 4-8 ft wide by 3-16 ft deep each (see Appendix C-3). As noted above, these trenches confirm the presence of waste materials from ground surface to depths of between 6 and 16 ft primarily in two delineated areas on the southwest side of Pond A. Natural alluvial sediments ranging from dark gray silty sand, brown silty sand, to light gray sand and river gravel are present in some areas below the waste. In areas outside of the delineated waste, soil profiles appear to be natural, consisting of yellowish brown, dark brown, and light gray silt and sand from ground surface to depths of at least 12 ft at the limit of test trenching (see Appendix D). Ponds A and D on the island contain coarse sand and silt sediments below the water table (Arcadis 2012).

No archaeological sensitivity is assigned to the waste materials on the Unnamed Island. Natural (alluvial and glaciofluvial) deposits are present below the waste in the delineated areas and just below the ground surface in the non-waste land areas identified on the island. Natural sediments also appear to be present in Ponds A and D and probably P bottoms. The upper 20 ft of alluvial deposits would have the highest potential for pre-contact/contact/early historic period Native American cultural deposits and are assigned archaeological sensitivity (see Figure 5-7).

Wetlands A, B, C, and D

A series of delineated wetlands, designated Wetlands A, B, C, and D are present on the east side of the railroad tracks on land owned by the Town of Cumberland (see Figure 5-1). These wetlands were historically included in the "New Pond" mill pond from the mid-1800s until the mid-1900s as discussed above. Prior to that time, the area was likely low-lying (floodplain) of the Blackstone River, included in the large area of the landfill and Unnamed Island parcels to the west. There are no buildings or other structures within these four wetland areas, although modern housing developments have recently been constructed to the east off Mendon Road (Route 122) (Figure 5-16).

Monastery Brook is the principal drainage into the wetlands. The brook originates in high wetlands at an elevation of approximately 210 ft NGVD29, approximately 7,000 ft north of the OU2 project area/APE near the former Cistercian Monastery (present Cumberland Public Library). Monastery Brook flows into the northeastern section of Wetlands C along with an unnamed intermittent stream that originates in a quarried area about 600 ft to the north (Arcadis 2012).

Wetlands A, B, C, and D contain sediments that range from silty clay to sand and gravel, with varying amounts of organic matter (Arcadis 2012). The natural wetland bottom sediments are sensitive for pre-contact/contact/early historic period Native American cultural deposits that pre-date the damming of the river and inundation of the floodplain in the nineteenth century.



Figure 5-16. 2011 photograph of the wetlands on the east side of the railroad tracks across from the J.M. Mills Landfill, view looking southeast.

Lenox Street Well

The Lenox Street Well is on a small (less than one acre) area of natural land that historically bordered the former New Pond (mill pond) until the mid-twentieth-century. It is situated in the southeastern portion of the OU2 project area/APE within the town of Cumberland on the east side of the P&W Railroad tracks (see Figure 5-1). The well site is bounded on the north by Wetland A (part of the former New Pond), on the west by the railroad tracks, on the south by the railroad embankment, and on the east by Lenox Street and private house lots. Like the Quinnville Well Field in Lincoln, the Lenox Street Well was part of a municipal water supply system. It was added to the Cumberland system in 1964, and until approximately 1967, along with the Martin Street well, supplied most of Cumberland's water needs. By 1979, when it was closed because of the presence of contaminants (as discussed above for Quinnville), the Lenox Street well was the source of only four percent of the town's water supply. Most of Cumberland's water by that time came from surface sources and from the Manville wells located several miles up-valley from the site (EPA 1993). The USDA classifies this area as containing excessively drained Merrimack sandy loam on outwash plains and terraces.

A review of nineteenth-century town maps indicates that the earliest structures on or near this parcel appear on the 1888 (Bailey) bird's eye view. One large one-story rectangular building appears at the end of the pond (see Figure 4-6). The 1895 (Everts and Richards) map of Cumberland depicts an ice house and two other outbuilding structures along a cart path close to the southern edge of the mill pond at or near this same location (see Figure 4-8). No structures are shown at this location on later maps, but Lenox Street is depicted as having extended to the edge of the railroad tracks on the 1944 and 1949 USGS topographic maps (see Figures 4-11 and 4-12). It is possible that the well site was constructed at or near.



Figure 5-17. 2011 photograph of the east (street) side of the Lenox Street Well building, view looking west.



Figure 5-18. 2011 photograph of the west (woods) side of the Lenox Street Well building, view looking southeast.

the documented location of these late nineteenth-century structures. There is no visible evidence of any structural remains at this location within the OU2 project area/APE.

The well site contains one building sited within a chain link fence enclosure (Figure 5-17). An asphalt drive, accessed from the west end of Lenox Street, leads to a paved parking and equipment storage area on the east side of the enclosure. The west side of the lot is overgrown with brush (Figure 5-18). The ca 1964 light industrial structure has a side-gable roof, brick walls, and concrete slab foundation. The shallow-pitched roof, which appears to have been added in the last 10-20 years, is clad in asphalt and has a stepped vinyl and wood soffit and plywood gable ends. Two vehicle openings fitted with vertical lift roll doors are symmetrically placed on the north elevation. The brick walls are laid in common bond below the height of the door lintels, with decorative panels consisting of brick headers in a stacked bond above each door. Metal lettering on the east elevation spells out “Cumberland Water Works”.

One monitoring well (MW-110A, B, C) was installed by the Town of Cumberland near the Lenox Street Well at the southern edge of the street turnaround (see Appendix C-1). The well contained sand and gravel to 17.5 ft below ground, underlain by glacial till to 65 ft, and bedrock to the limit of the boring depth at 100 ft (see Appendix D). An EPA soil sample (SO-059-WT [Borehole #GP-1]) taken just north of the Lenox Street Well indicates the presence of fill/waste materials to 8 ft below surface at the limit of the boring. The upper fill consists of very dark gray silt and sand with brick fragments from ground surface to 3 ft, underlain by very dark gray silt with brick and glass fragments to 5 ft, and black silt and sand with brick fragments to 8 ft at refusal (see Appendix D). This fill may be related to push materials adjacent to Wetland A during the construction of the Lenox Street Well.

No archaeological sensitivity is assigned to the Lenox Street Well portion of the OU2 project area/APE (see Figure 5-7). The natural soils in this area along with pre-mid-twentieth-century landscape appear to have been completely impacted by the construction and use of the well site in the 1960s and 1970s.

Nunes Transfer Station Parcel

The Nunes Transfer Station parcel is situated in the southern portion of the OU2 project area/APE within the town of Cumberland (see Figure 5-1). It was most recently used as a solid waste transfer station. The transfer station is accessed from Mendon Road (Route 122) via an asphalt-paved driveway that parallels the P&W Railroad easement. The mostly open lot consists of a single large waste receiving/sorting area for trucks and heavy equipment and a single building on the east side of the lot, adjacent to the P&W ROW (Figure 5-19). Chain link fencing and cast concrete barriers enclose the west and north edges of the lot. Additional cast concrete barriers were used for open storage bays and as components of ad hoc work spaces on the northwest side of the receiving area (Figure 5-20).

The light-industrial building was designed as a waste sorting facility with truck-to-truck transfer capability. It is sited on an artificially raised embankment with two floor levels, with the lower level to the east (Figure 5-21). The upper level building is a circa 1980, high-bay, steel, Butler-type building resting on raised poured concrete sills. The lower level consists of a pair of circa 1950 enclosed truck loading bays with a flat roof, concrete block and poured reinforced concrete walls, and packed dirt floors. There is a high degree of variation and irregularity in the concrete walls, suggesting multiple episodes of structural modification and addition. Included in the lower portions of the east and west walls are distinctive trapezoidal concrete abutment/foundation walls, one of which is cast with the date 1903 and curves to the northeast to exit to a terminus point outside the building (Figures 5-22, 5-23, and 5-24). These walls are plank-formed concrete with a coarse rounded aggregate. Pockets are cast into the concrete and a steel bracket is bolted to the concrete on the east wall, both presumably for structural components of a now-missing superstructure. The east foundation wall appears to be completely intact (see Figure 5-22). The west foundation wall has been altered by partial demolition and the addition of



Figure 5-19. 2011 photograph of the Nunes Parcel transfer station building and surrounding area, view looking northeast.



Figure 5-20. 2011 photograph of ad hoc work space concrete structures on the Nunes Parcel, view looking northwest.



Figure 5-21. 2012 photograph of the Nunes Parcel transfer station multi-story building, view looking north along the documented (filled) mill power trench alignment.



Figure 5-22. 2012 photograph of the transfer station lower building foundation, interior east wall, Nunes Parcel transfer station building.



Figure 5-23. 2012 photograph of the 1903 date cast into the lower east foundation wall, Nunes Parcel transfer station building.



Figure 5-24 2012 photograph of the exterior east wall outside of the Nunes Parcel transfer station building, view looking southwest.

modern reinforced concrete (Figure 5-25). Both of these 1903 wall components may be surviving structural elements of the gate house that formerly stood at this location.

A review of historic and topographic maps and aerial photographs indicates that most of this property, excepting the east edge adjacent to the P&W Railroad ROW, is made land that post-dates the mid-twentieth century. Prior to that time it was contained within the southern limit of New Pond (millpond) between the river and ca. 1894 Pratt Dam and railroad trestle on the west and the P&W Railroad tracks on the east. At the east edge of the parcel, the power canal for the Lonsdale Mill No. 4 was present immediately west of the tracks from the mid-1800s to the 1960s, when it was filled as part of the landfill operations. Historical maps and photographs indicate that a gate house structure was present at the head of the power trench as early as the 1870s (see Figure 4-5), although there is some inconsistency in the maps. Both the 1870 map and the 1895 (Everts and Richards) map depict the gate house structure in a similar shape and location, with the 1895 structure shown as wood frame construction (see Figure 4-8). None of the late nineteenth and early-mid twentieth century USGS topographic maps depict a structure at this location. The gate house as shown on the 1870 map is not indicated on the 1888 (Bailey) bird's eye view. Instead, a larger two-story structure is indicated near this same location, but between the canal and the railroad instead of straddling the canal (see Figure 4-6). This may be a different structure or an error on the part of the map's publisher. By the 1930s, this structure seems to have been replaced with a new gate house. An aerial photograph from 1939, and aerial and dam inspection photographs from 1951 and 1955, respectively, show a one-story, three-bay-by-one-bay, flat-roofed structure with three filled window openings on the south elevation (RI DEM Files:Photograph dated August 22, 1955; RIGIS:2002). By the 1962 aerial photograph, the filling of the power trench obscured any structure that may still have been present at that time (RI GIS:1962).



Figure 5-25. 2012 photograph of the transfer station lower building foundation, interior west wall, Nunes Parcel transfer station building.

Currently, there is no visible evidence of the nineteenth-century gatehouse structure. It may have been buried and/or destroyed by the construction of the 1903 gatehouse structure that forms the foundation component of the modern transfer station building.

The southern portion of the Nunes Transfer Station Property contained the curved railroad spur track and earthen dam that serviced the Lonsdale mills. The 1888 bird's eye view indicates that the majority of this spur track was built on an elevated trestle across the river and floodplain (see Figure 4-6). The southern part of the Nunes property also abuts the land area below New Pond (millpond) that became the site of the 1930s Lonsdale Sports Arena speedway. Twentieth-century aerial photographs document extensive disturbances including grading and filling in this area related to the use and post-abandonment of the speedway. This area is presently vacant and overgrown space behind the modern shopping plaza that fronts Mendon Road (Route 122) (Figure 5-26). The USDA classifies the Nunes Property and this area to the south as containing soils associated with the Udorthents-Urban land complex.

The EPA environmental site investigations for the OU2 study area have included soil testing throughout the Nunes Parcel. This testing includes 23 test pits (TP-01 thru TP-23) that ranged from 7-13 ft long by 3-6 ft wide by 4-19 ft deep each (see Appendix C-3). The test pits resulted in a delineation of buried solid waste that ranges between 1.5 and 10 ft thick below ground surface, with a general thickness of between 4 to 6 ft below ground surface. One area (TP-13) contained waste material that is at least 13.5 ft thick. The waste encountered in the test pits consists of typical municipal refuse types (e.g., cans, fabric, plastic) well mixed with soil. The debris area extends to near the Blackstone River's bank at the central portion of the Nunes Parcel and into the northwestern portion of the property about 200-250 ft west of the transfer station building (Arcadis 2012). Natural alluvial sediments ranging from dark brown to light brown and brown sand and rounded (river) gravel and clay are present in most areas below the waste. In areas outside of the delineated waste, soil profiles appear to be natural, consisting of dark brown and brown (topsoil), and dark gray sand and gravel from ground surface to depths that reached 11 ft at the limit of test trenching (see Appendix D).

A small area at the southwest side of the Nunes Parcel near the Pratt Dam was remediated in 2004 by RIDEM as a component of the construction of the Blackstone River Bikeway. The removal action consisted of the removal of approximately 11,600 tons of soil from this area, which was then backfilled with clean fill and portions asphalted to complete the bikeway section (Arcadis 2012) (see Appendix C-3).

No archaeological sensitivity is assigned to the delineated waste materials and the disturbed former speedway portion of the Nunes Parcel. Natural (alluvial and glaciofluvial) deposits are present below the waste in the delineated buried solid waste area and just below the ground surface in the remaining portions of the parcel, with the exception of the 2004 RIDEM remediation area. The upper 20 ft of alluvial deposits would have the highest potential for pre-contact/contact/early historic period Native American cultural deposits and are assigned archaeological sensitivity (see Figure 5-7).

The documented location of the late-nineteenth-century/early-twentieth-century Lonsdale Co. Mill No. 4 power trench and gatehouse (the early twentieth-century portions of which appear to serve as the lower structural level of the transfer station building described above) on the Nunes Parcel are sensitive for belowground waterpower infrastructure resources. Any such resources would be associated with the historic operations of Lonsdale Co. Mill No. 4, which is included in the Lonsdale NR Historic District (see Figure 5-7). The physical integrity and significance of any buried power trench or gatehouse remains on the Nunes Parcel are not known at this time.



Figure 5-26. 2012 photograph of the southern boundary of the Nunes Parcel with the former speedway lot behind the Stop and Shop plaza on Mendon Road, view looking southeast.



Figure 5-27. 2012 photograph of the Hunt Dam remains at the north side of Pond F, view looking north.

Pratt Dam, Pond F, Blackstone River Channels, and Adjacent Lands

The remainder of the OU2 project area/APE is included in the ca. 1894 Pratt Dam, Pond F, Blackstone River channels, and adjacent lands that border the Blackstone Canal towpath (bike path). The southwest end of the OU2 project area/APE contains the remains of the ca. 1846 Hunt Dam built and maintained by the Lonsdale Company for their mills until the Pratt Dam was constructed almost fifty years later. The archaeological remains of the dam are visible at the northwest side of Pond F and across the pond slightly upstream of the Pratt Dam (Figure 5-27). These remains include the east and west dam abutments and portions of the dam spillway structure. The west abutment is built into the side of the Blackstone Canal

towpath berm (Figure 5-28). This hollow, three-sided structure is built on a rectangular plan measuring approximately 20 ft in length and width and rises to a maximum height of approximately 6 ft above grade. It is constructed of irregular, split-faced granite and siltstone with mortared joints (Figures 5-29 and 5-30). The east face of the abutment forms the shoreline of Pond F. It extends beyond the abutment proper, stepping down in height and continuing about 60 additional ft on a southwest course downstream as a retaining/training wall at the toe of the canal berm. Indications of an upstream retaining wall are visible at grade adjoining the north face of the abutment. The remnants of the upstream toe/foundation and face of the dam spillway extend on an east-west trajectory across Pond F (Figure 5-31). The toe of the dam is a linear feature constructed of unreinforced cast concrete with a coarse aggregate (Figure 5-32). This feature is approximately 12 inches wide and extended about 8 inches above the water level at the time of the second (2012) site visit. Near the spillway's east end, heavy planking atop the concrete toe projects at an angle from the ground surface. The planking is laid in two overlapping courses oriented longitudinally and transversely to the spillway axis and is presumed to be a remnant portion of the upstream face of the dam (Figure 5-33). The dam's east abutment is now incorporated into the upstream end of the current Pratt spillway well (Figure 5-34). It is still discernable through differences in the overall width of the wall and a difference in the character of the stone work (see also discussion below of the Pratt /Lonsdale Dam).

These remains are consistent with the "old dam" structure as depicted on the 1895 railway engineering plan and as described in the 1883 Annual Report of the Commissioner of Dams and Reservoirs (see Figure 4-7). No remains of the "old track" for the railroad spur or its abutment at the toe of the Blackstone Canal towpath are currently visible. It is likely that this earlier railroad structure was removed and/or incorporated into the Pratt Dam.

The site of the Hunt Dam remains including the stone abutment and spillway is an archaeologically sensitive area for additional belowground resources including possible associated artifact assemblages, particularly in proximity to the west dam abutment adjacent to the canal towpath berm (see Figure 5-7). Prior to the current survey the Hunt Dam archaeological site remains had not been identified as an historic resource area. As such, the Hunt Dam remains are being treated as a new historic resource that has not yet been evaluated in terms of its National Register eligibility.

The Blackstone River bottom, including the back channel, and Pond F contains fine to coarse sand with varying amounts of gravel. The inlet bottom near the Nunes Parcel transfer station (referred to as the Nunes Inlet) contains sand and silt sediments (Arcadis 2012). The natural river and wetland bottom sediments as well as the adjacent areas of intermittently dry land are sensitive for pre-contact/contact/early historic period Native American cultural deposits that pre-date the damming of the river and inundation of the floodplain in the nineteenth century (see Figure 5-7).



Figure 5-28. 2011 photograph of the Hunt Dam stone abutment at Blackstone Canal tow path (bike path) and Pond F shoreline, view looking east.



Figure 5-29. 2011 photograph of the Hunt Dam abutment, detail of the north face stone work, view looking southeast.



Figure 5-30. 2011 photograph of the Hunt Dam abutment, detail of the east face stone work, view looking west.



Figure 5-31. 2012 photograph of the Hunt Dam masonry spillway across Pond F, view looking west.



Figure 5-32. 2012 photograph of the Hunt Dam spillway, detail of concrete and coarse aggregate structural remains, view looking southwest.



Figure 5-33. 2012 photograph of the Hunt Dam remnant wood planking (upstream face of the dam), view looking southeast near the gravel road bed to the Unnamed Island.



Figure 5-34. 2011 photograph of the Hunt Dam east abutment in the upstream end of the current Pratt/Lonsdale Dam spillway well, view looking west.

Historic Properties – National Register Listed Resources

The reconnaissance survey identified two historic properties listed in the National Register of Historic Placed within the OU2 project area/APE: the Lonsdale Historic District "Old Village" (PAL Map No. C) and the Blackstone Canal (PAL Map No. A). Two contributing elements within these districts, the Pratt/Lonsdale Dam and Railroad Bridge (PAL Map No. 4) and the earthen ramp and stone abutment (Blackstone Canal Feature 1A, PAL Map No. 1) are also located within the OU2 project area/APE.

Three additional resources over 50 years of age were identified in the OU2 project area/APE but do not appear eligible for listing in the National Register: the Quinnville Well Field (PAL Map No. B; see Figures 5-2, 5-3, and 5-4), the Lenox Street Well (PAL Map No. 2; see Figures 5-17 and 5-18), and the Nunes Parcel Transfer Station (PAL Map No. 3; see Figures 5-21 thru 5-25). These resources are discussed above under their respective property unit locations.

Brief descriptions and photographs of the identified historic properties (NR eligible) within the project area/APE are provided below. These resources are depicted on Figure 5-35 and summarized in Table 5-1.

The resources older than 50 years of age that are evaluated as Not Eligible for listing in the National Register are also listed in the Table 5-1 and included on Figure 5-35.

Blackstone Canal

The Blackstone Canal (PAL Map No. A) between Providence and the Rhode Island-Massachusetts state line was listed in the National Register as an expanded and revised district in 1991 (Fitch 1991). The

Table 5-1. Architectural Resources Over 50 Years of Age Located Within the OU2 Project Area/APE.

Map Resource ID No.	Name	Address	Town	Resource Type/Style	Date	NR Status*
A	Blackstone Canal	Moshassuck and Blackstone River Valleys, from Smith Street, Providence to the Massachusetts State Line	Providence, Pawtucket, Lincoln, Woonsocket, North Smithfield	Earth and stone waterway	1824-1849	NRDIS
B	Quinnville Well Field	River Street	Lincoln	Municipal water well field, no style	1957, 1969, 1978	NE
C	Lonsdale Historic District – "Old Village"	Carrington, Cook, Front, John, Main, and School streets, Lonsdale Ave.	Lincoln and Cumberland	Industrial village	1853-1901	NRDIS
1	Earthen ramp and stone abutment / Blackstone Canal Feature 1A	Blackstone Canal, northwest of Milepost 6	Lincoln	Cart path and bridge abutment	Ca. 1828	NRDIS-C
2	Lenox Street Well	Lenox Street	Cumberland	Municipal water well, no style	Ca. 1964	NE
3	Nunes Parcel Transfer Station	Mendon Road	Cumberland	Prefabricated steel and concrete block industrial building	1903/ca. 1950, ca. 1980	NE
4	Pratt/Lonsdale Dam and Railroad Bridge	Off Old Willow Way	Lincoln and Cumberland	Combined stone gravity dam and pony truss bridge	1894	NRDIS-C

*** National Register Status Key**

NRDIS – Property Listed in the National Register

NRDIS-C – Property contributing to an National Register-listed district.

NE – Property determined or recommended as not eligible for listing in the National Register

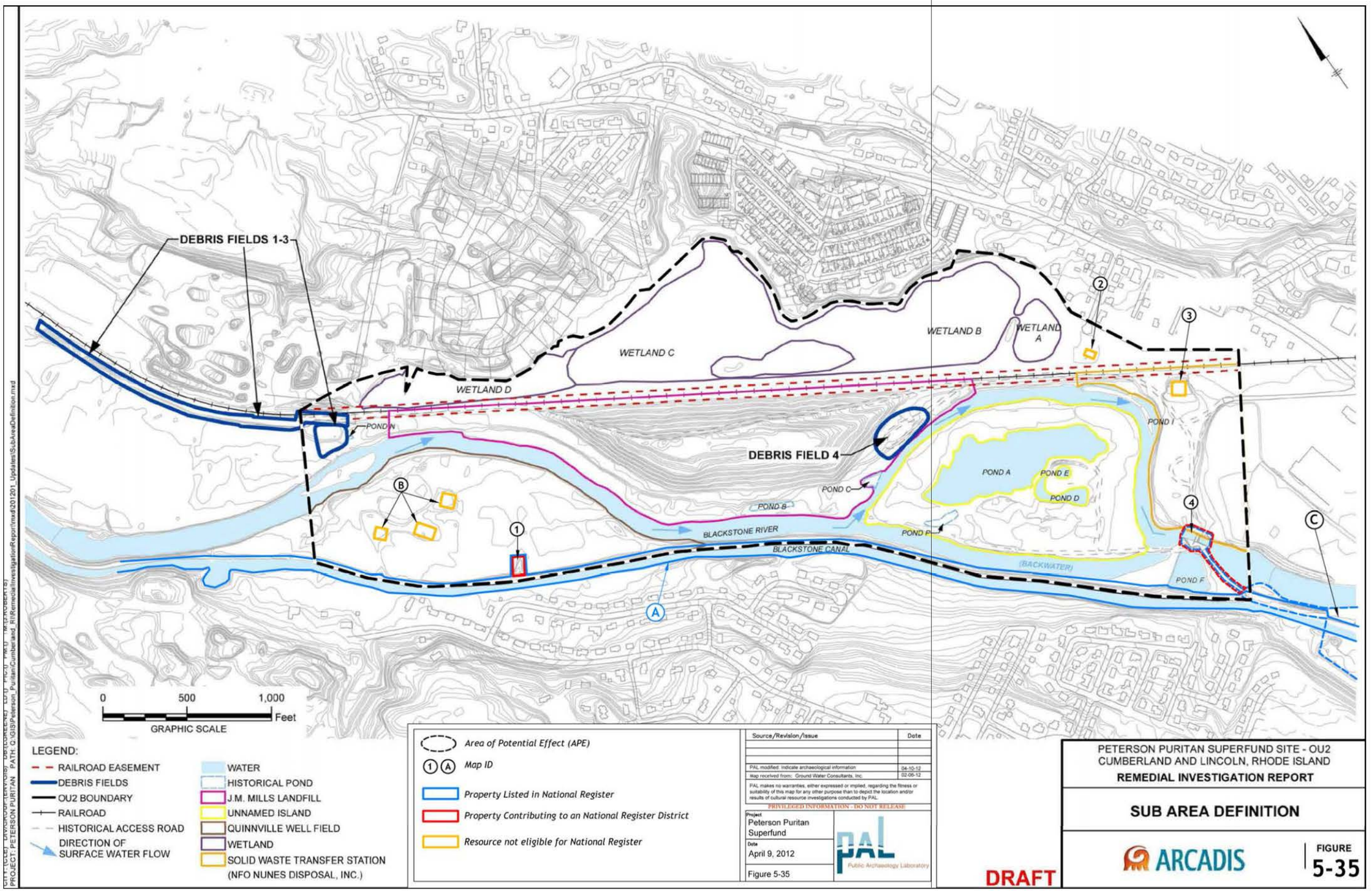


Figure 5-35. Historic above-ground properties located within the recommended OU2 Area of Potential Effect (APE).

portion of the Blackstone Canal designated "Section 5" (not an historical designation) in the National Register nomination runs along and defines the western limit of the OU2 project area/APE (Figure 5-36). The canal's water-filled earthen prism (partially lined with rubblestone) and the paved towpath (now the Blackstone Greenway) are outside of the OU2 project area/APE, while the north slope of the towpath berm lies just inside the project boundary.



Figure 5-36. 2011 photograph showing a typical view of the Blackstone Canal (PAL Map No. A) within the recommended OU2 APE, view looking north. ***This resource is an historic property listed in the National Register.***

The Blackstone Canal is an earth, stone, and wood artificial waterway that operated between 1826 and 1828 (see Chapter 4 discussion). The canal is significant under National Register Criteria A, C, and D in the areas of commerce, transportation, engineering, and archaeology. Constructed during the Age of Internal Improvements, the canal promoted growth within the Blackstone River corridor by connecting geographic hinterlands with the economic and social centers of Providence and Worcester. The canal was built under the direction of leading American engineers and embodies the distinctive design, materials, workmanship, and methods of construction for its time. The period of significance for the property is 1824-1849. According to the National Register nomination, Section 5 contains "the longest, most intact length of trenched canal and towpath in Rhode Island (Fitch 1991:7.14, 8.1-8.2).

As described in the National Register nomination's Verbal Boundary Description, the boundaries of the district are generally defined by the physical edges of the canal bank, towpath berm, and/or basins or other features (where applicable) and are intended to include the entire area of the earth or masonry canal structures. In canalized sections such as Section 5, the "basic boundary dimension" is defined by the widths of the combined standard canal prism (34 feet) and towpath (10 feet), with allowances of 6 feet for towpath berm slopes; for a total width of 50 feet (Adams 1991:10.4). Beginning and end points of the canal district were mapped in the nomination, but the longitudinal boundaries were not. VHB's

Blackstone Canal Preservation Study (VHB 2010) used the property boundaries provided in the National Register as a basis for Geographic Information System (GIS) boundary mapping (VHB 2010). The resource boundaries on Figure 5-35 are therefore approximate and derived from VHB's 2010 canal study with modifications as necessary to adjust for observed conditions in the field during PAL's survey (VHB 2010:13-14,27-28, Figure 9).

Earth Ramp and Stone Abutment – Blackstone Canal

In addition to the canal prism and towpath, one contributing feature of the Blackstone Canal property is also within the OU2 project area/APE. Feature 1A of Section 5, an earthen ramp and stone abutment (RIHPHC archaeological site #RI-1821, PAL Map No.1), is located adjacent to the canal towpath in the Quinnville Well Field parcel (see Figure 5-5). These cart bridge remnants are labeled on the Edward Phelps map of 1828 as located on land of "John Wilkinson Heirs" (see discussion above) (Fitch 1991:7.23; Phelps 1828).

Lonsdale Historic District

The Lonsdale Historic District (PAL Map No. C) was listed in the National Register of Historic Places in 1984. The district includes two non-contiguous industrial villages in the towns of Lincoln (the "old village") and Cumberland, Rhode Island (the "new village"), both of which are within the Blackstone River valley (Kennedy 1984). The new village lies outside of the OU2 project area/APE. The old village, whose north boundary overlaps with the current APE, includes several mills dating from between 1833 and 1901, warehouses, worker housing, a short section of the Blackstone Canal, and the Pratt Dam (see Blackstone Canal section above). All of these resources excepting the Pratt Dam are outside of the project area/APE (Kennedy 1984:Section7).

The Lonsdale Historic District is significant under National Register Criteria A and C in the areas of architecture, community planning, and industry. Lonsdale Company was a regionally-important textile manufacturer in an industry that made a substantial contribution to the nineteenth-century Rhode Island economy. The village and company were established by Brown and Ives, with principals Nicholas Brown and son-in-law Thomas P. Ives, who were members the prominent Brown family of Providence. The firm began land acquisitions and construction for the Lonsdale Company in the old village in 1831 and incorporated the firm in 1834. Power for the mills was generated water drawn from the Blackstone Canal (see additional discussion in Chapter 4). By 1850, the complex in Lincoln was a fully-integrated cloth production facility, one of the first in the state. It included several mill lofts (numbered 1-3), as well as a bleachery and dye works. After the Civil War, lands on the Cumberland side of the Blackstone were the focus of expansion, with the most noteworthy infrastructure of this period being the steam-powered Ann & Hope Mill, completed in 1886 and one of the nation's largest mills at the time (Kierstead 2003:11-12). The Lonsdale Company also oversaw both the working and private lives of its mill hands with a paternalistic philosophy that resulted in the construction of worker housing, churches, schools, and stores. Today, the village is one of the best preserved factory villages in the Blackstone Valley. The period of significance of the district is identified as "1830s through 1920s". The Lonsdale Company, along with other corporate holdings, was sold to Royal Little in 1944, and thereafter disposed of by the Textron Corporation (Kennedy 1984:Section 8; RIHS Library n.d.:2).

Pratt/Lonsdale Dam and Railroad Bridge

One contributing resource to the Lonsdale Historic District, the Pratt/Lonsdale Dam and Railroad Bridge (National Register Map No. 29, PAL Map No. 4 in the Lonsdale Historic District National Register Nomination, also included in the RIHPHC's *Rhode Island Statewide Survey*) is located within the OU2 project area/APE (Figures 5-37 and 5-38).



Figure 5-37. 2011 photograph showing the spillway for the Pratt/Lonsdale Dam and Railroad Bridge (PAL Map No. 4), view looking southwest. ***This property is a contributing resource (Map No. 29) within the Lonsdale Historic District, which is listed in the National Register.***



Figure 5-38. 2011 photograph showing the gate for the Pratt/Lonsdale Dam and Railroad Bridge (PAL Map No. 4), view looking southwest. ***This property is a contributing resource (Map No. 29) within the Lonsdale Historic District, which is listed in the National Register.***

This combination curved dam and railroad bridge spans the Lincoln-Cumberland corporate boundary. The dam/bridge consists of two sections organized along a footprint that curves from south to northeast. At the south, within Pond F, is a low spillway constructed of granite rubble and split slabs. The spillway is subdivided by five stone cutwater piers that have gate slots set into their side faces. Modern, steel, Pratt pony trusses span these piers. To the east, a granite block gate with four Roman arch gates and sluiceways spans the main channel of the Blackstone River. A modern concrete slab deck has been constructed atop the gate. Wing walls extend upstream from the gate. In contrast to the granite ashlar used elsewhere in the gate, the upstream (north) end of the west wingwall is constructed of crudely split, dry-laid slabs and the width of this portion of the wingwall is narrower. This portion of the wingwall appears to be the abutment of the earlier Hunt Dam (archaeological resource) erected by the Lonsdale Company (see Figure 5-34).

The Lonsdale Company built the Pratt/Lonsdale Dam and Railroad Bridge in 1893-1894 to increase water power to and to serve as a rail link for mills in the old village complex (see Chapter 4 discussion). The structure created the so-called New Pond, which provided 12 feet of operating head for the Lonsdale Company's Mill No. 4, located on the northeast side of the river in Cumberland (outside the OU2 project area/APE). A long power canal, constructed parallel to the P&W Railroad tracks and guarded at its upstream end by a gate house, conveyed water from the New Pond to Mill No. 4. As built, short pony girder spans across the piers on the spillway carried the railroad tracks and gate lift mechanisms. A short Warren pony truss spanned the river's main channel just downstream of the gate. The railroad siding on the dam was active until 1954, when the structure was damaged by a hurricane. The spillway gates were removed and impoundment drained shortly after. The bridge superstructure was removed sometime after 1984. As part of the construction of the Blackstone Greenway, the existing steel Pratt pony trusses were erected across the spillway and a new concrete deck was built atop the gate (Kennedy 1984; Kierstead 2003:13-14; Kulik and Bonham 1978:72, 102).

The Pratt/Lonsdale Dam and Railroad Bridge is described in Section 7 of the Lonsdale Historic District nomination form. However, the accompanying boundary map is incorrectly drawn and inadvertently excludes the dam. Therefore, the accompanying results map, is approximate with respect to the National Register boundaries adjacent to this resource and had been drawn to follow the footprint of the dam structure (Kennedy 1984:7.9).

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Historic Resources

The Phase I reconnaissance survey identified two historic properties listed in the National Register of Historic Places within the OU2 project area/APE: the Lonsdale Historic District "Old Village" and the Blackstone Canal. Two contributing elements within these districts, the Pratt/Lonsdale Dam and Railroad Bridge and the earthen ramp and stone abutment (Blackstone Canal Feature 1A) are also located within the OU2 project area/APE (see Figure 5-35).

Three historic aboveground resource areas older than 50 years within the OU2 project area/APE are assessed as not eligible for listing in the National Register: Lenox Street Well, Quinnville Well Field, and the Nunes Parcel Transfer Station (see Figure 5-35). No additional historic aboveground survey is recommended for these three resources.

Archaeological Resources

The Phase I reconnaissance survey identified archaeologically sensitive areas within the Quinnville Well Field, J.M. Mills Landfill, Unnamed Island, and Nunes Parcel property units as well as the Blackstone River channels, wetlands, ponds, and inlet within the OU2 project area/APE (see Figure 5-7). The sensitive areas are identified on the basis of regional/local site predictive models that take into account the project area land use histories, historic map reconstructions, and a review of available environmental geotechnical data in the form of test trenches, test pits, and soil borings/samples as described in detail in Chapters 4 and 5 of the report. The potential sensitive strata for Native American sites consist of natural alluvium identified at varying depths within the Project APE (see Figure 5-7). For the J.M. Mills Landfill, the natural alluvium would be present below the waste in the 100-ft thick delineated landfill mass and below 9-15 ft around the perimeter of the landfill mass up to and along the river's edge (riparian buffer). For the Unnamed Island the natural alluvium extend below 6-16 ft in the delineated waste and fill materials, but could be present beginning at the ground surface along the river and pond edges outside of the waste materials. On the Nunes Parcel the natural alluvium extend below 1.5-13.5 ft in the areas of delineated waste and fill materials, but could be present beginning at the ground surface along the railroad easement and the pond/river edges. The remaining river/pond/wetland areas could contain sensitive natural alluvial strata that begin at the river/pond/wetland bottoms. Based on the general surficial geology characteristics of the overall Peterson-Puritan-OU2 study area (see Chapter 3 discussion), the upper 20 ft of natural alluvial deposits would have the highest potential for Native American cultural deposits. The age of the natural alluvial deposits as well as their precise horizontal and vertical location below and adjacent to waste and fill materials, however, is currently unknown without radiocarbon dating of any organic remains (e.g., wood charcoal, shell, peat) that may be present in these natural strata.

The types of Native American cultural deposits that would be expected in any alluvial deposits dating to the pre-contact, contact, and early historic periods in the project floodplain setting include habitation/resource procurement sites (e.g., fishing and hunting stations), dugout canoes in river and pond sediments, and possible burials in areas of naturally higher ground away from inundated, flood prone

landforms. Based on the known database of sites for the Blackstone River Valley in northern Rhode Island, these sites would date from the Middle Archaic through Woodland periods, but could extend into the Contact and early historic periods. No evidence of Native American resources was noted in the environmental soil borings and trench/test pit profiles reviewed as part of the Phase I survey; however, these subsurface investigations were not conducted or monitored by a professional archaeologist.

Post-contact period EuroAmerican archaeological resource areas are identified on the Nunes Parcel and on the north and east sides of Pond F. These resources include the documented gatehouse/power trench beneath and adjacent to the existing transfer station building in the eastern part of the Nunes Parcel and the newly identified Hunt Dam archaeological site remains that extend along the north side of Pond F just east of the Blackstone Canal towpath (bike path). Both of these resource areas are associated with the historical operations of the Lonsdale Mills, but are outside of the Lonsdale Historic District boundaries as currently mapped. These two identified archaeological resources have the potential to be contributing elements in the historic district; however, information needed to make evaluations of site significance and National Register eligibility would require more in-depth archaeological investigations (Phase I intensive, Phase II site evaluation), which may be outside the areas of likely remedial actions.

Native American Concerns

In accordance with Section 106 and the RIHPHC state archaeological permit special conditions, consultation with local Native American tribes was undertaken for the OU2 project area/APE. In June and July 2010 Arcadis staff, on behalf of EPA, contacted three members of the Seaconke Wampanoag Tribe, based in Warwick, Rhode Island. The Seaconke Tribe is not listed in the Bureau of Indian Affairs (BIA) or National Congress of American Indians (NCAI) as a federally or state recognized tribe in the Northeast. However, the tribe is the current owner of Plat #14, Lot #23 and Plat 34, Lot #249, which includes the J.M. Mills Landfill. Robert "Swift Owl" Cooper indicated that Senechataconit [sic] was an area comprised of locations in current Cumberland and Lincoln that were set aside for Native Americans in an agreement made with Thomas Willet recorded in a land deed in Plymouth land records. Mr. Cooper stated the deed is known as the Rehoboth North Purchase. He further noted that the area in the vicinity of the landfill was a former major Wampanoag village known as Mamantapit. The area in the vicinity of where the Blackstone River bends was known as Wawatain or Sugarloaf. Mr. Cooper indicated that the tribe has maps that depict these areas, although no maps have been provided to the EPA to date. Peter "Thinking Bear" Bauer is the tribe's historian and confirmed that he is possession of the historic maps that depict the village of Mamantapit, but he was unable to provide them at that time. Chief Wilfred "Eagle Heart" Greene provided similar information to Arcadis staff, but provided no mapping support.

David Balfour, Chair of the Cumberland Historic District Commission and town historian, confirms that the area of present-day Cumberland was included in the Rehoboth North Purchase. However, he has not been able to find any early maps associated with the land evidence records on file in Rehoboth or Plymouth, Massachusetts. Mr. Balfour communicated to PAL that he has heard the same rumors that such maps exist and he agrees that they would be most beneficial to understanding Native American occupation in the Cumberland-Lincoln section of the Blackstone River Valley at the time of European settlement (D. Balfour, personal communication 2012).

Arcadis staff also attempted to contact the Nipmuc Tribe in Rhode Island, which also is not listed in the BIA or NCAI lists of federally or state recognized Native American tribes in the Northeast, but the Nipmucs have a documented presence in the Blackstone River Valley. Joan Luster, President of the Nipmuc Indian Association of Connecticut, was reached instead, and she suggested contacting the Narragansett Indian Tribal Historical Preservation Office (NITHPO) for further information.

Arcadis staff spoke to John Brown of the NITHPO based in Narragansett, Rhode Island. Mr. Brown stressed that the Narragansett Tribe is the only federally recognized tribe in Rhode Island. PAL's archaeological permit issued by the RIHPHC included a special condition for contact and consultation with the NITHPO because of their federal recognition. Mr. Brown designated Doug Harris of the NITHPO to meet with the EPA, RIHPHC, PAL, and the PRPs' representative (Ground Water Consultants, Inc.) to discuss the OU2 project area. At the meeting held in Cumberland on February 29, 2012, Mr. Harris indicated the Tribe's concerns regarding the presence of Native American sites, in particular human burials on the Unnamed Island. Mr. Harris requested that EPA's consultants, PAL, conduct a review of available geotechnical data to provide a better understanding of the project area's geology. The results of this review have been incorporated into the Phase I survey results and recommendations presented in the report.

Recommendations

EPA will be shortly evaluating cleanup plans for the OU2 portion of the Peterson-Puritan, Inc. Superfund Site, which is expected to be released within the next year. The cleanup will likely include the placement of a synthetic cap covering the entire area of waste for the J.M. Mills Landfill and Nunes Transfer Station Parcel. It is possible that the removal of contaminated soils in the Quinnville Well Field and on the Unnamed Island may also occur to some degree. The lack of specific work plans at this point in the Superfund process that identify direct project impact areas related to cleanup activities such as construction staging, access, and remediation areas precludes an assessment of the project's potential for effect to the identified historic properties and potential archaeologically sensitive areas as shown on Figures 5-7 and 5-35.

PAL therefore recommends that the EPA and its remediation design team continue to consult with the RIHPHC and Native American tribes and other interested parties including the Cumberland and Lincoln historical associations to avoid, minimize, and/or mitigate direct and indirect (e.g., visual) impacts to historic properties and potential archaeologically sensitive areas. As work locations and cleanup activities are defined, additional cultural resource studies including combined Phase I(c) and Phase II archaeological investigations may be required to understand the potential direct and indirect impacts of the remediation activities on the identified properties and to provide an assessment of effect. The Phase I(c)/Phase II archaeological investigations would include subsurface hand testing outside of delineated waste areas to determine the presence and depths of potentially significant deposits buried within and below alluvium and other non-waste overburden sediments. In sensitive areas of deeply buried waste and overburden materials, including the historic gate house and mill power trench in the Nunes Parcel, archaeological monitoring of the soil removal/demolition activities may be warranted to document and record any belowground cultural deposits and structural remains.

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List of Informants

David Balfour, Chairperson, Cumberland Historic District Commission, Cumberland, RI.

Joanna Doherty, Community Planner, John H. Chafee Blackstone River Valley National Heritage Corridor, Woonsocket, RI.

John Faile, Manager, Lincoln Water Commission, Lincoln, RI.

Albert Klyberg, local historian and ranger, Wilbur Kelly House Museum, Lincoln, RI.

Kevin Klyberg, park ranger, John H. Chafee Blackstone River Valley National Heritage Corridor, Woonsocket, RI.

APPENDIX A

PROJECT CORRESPONDENCE INCLUDING RIHPHC ARCHAEOLOGICAL PERMIT

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
HISTORICAL PRESERVATION & HERITAGE COMMISSION
Old State House • 150 Benefit Street • Providence, R.I. 02903-1209
TEL (401) 222-2678 FAX (401) 222-2968
TTY (401) 222-3700 Website www.preservation.ri.gov

3 December 2010

David J. Newton, RPM
U.S. Environmental Protection Agency
5 Post Office Square, Suite 100
Boston, Massachusetts 02109-3912

Re: Peterson/Puritan, Inc. Superfund Site
Cumberland and Lincoln, Rhode Island

Dear Mr. Newton:

Thank you for your letter dated 9 November 2010 regarding the above-referenced project. As you are aware, the protection of the historic resources in the cleanup area is a significant concern for this office. We look forward to receiving information from and working with the Environmental Protection Agency throughout the course of this important project.

Regarding your request for information about cultural resources which may be present in the immediate area of the site, enclosed please find a map which we have prepared to show the approximate boundaries of historic resources in the area of the site.

These comments are provided in accordance with Section 106 of the National Historic Preservation Act. If you have any questions, please contact Jeffrey Emidy, Project Review Coordinator of this office.

Very truly yours,

Edward F. Sanderson
Executive Director
State Historic Preservation Officer

enclosure

101203.05jde

PAL
Public Archaeology Laboratory

December 7, 2011

Edward F. Sanderson
Executive Director
State Historic Preservation Officer
150 Benefit Street
Providence, Rhode Island 02903

Re: Peterson/Puritan, Inc. Superfund Site-Operable Unit 2, Cumberland and Lincoln
Phase I Reconnaissance Survey
PAL #2679

ATTN: Jeffrey Emidy, Project Review Coordinator

Dear Mr. Sanderson:

Enclosed please find an application for a permit to conduct a Phase I reconnaissance survey for the Peterson/Puritan, Inc. Superfund Site-Operable Unit 2 project area in Cumberland and Lincoln, Rhode Island. The project area is located on the Attleboro, Massachusetts USGS topographic quadrangle. We are prepared to begin the field investigations upon issuance of the permit. Thank you in advance for your time and attention to this matter.

If you have any questions or need further information, please do not hesitate to contact Suzanne Cherau, Principal Investigator, or me at your convenience.

Sincerely,

Deborah C. Cox

Deborah C. Cox, RPA
President

Enclosure

cc: David Lang Ground Water Consultants, Inc. (w/encl.)

210 Lonsdale Avenue Pawtucket, RI 02860 | 401.728.8780 Main | 401.728.8784 Fax
palinc.com

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS RHODE ISLAND HISTORICAL PRESERVATION AND HERITAGE COMMISSION

Application for permission to conduct archaeological field investigations (pursuant to the Antiquities Act of Rhode Island, G.L. 42-45 and the R.I. Procedures for Registration and Protection of Historic Properties)

1. Applicant's name and address

   A. Principal Investigator(s): Suzanne Cherau
   B. Field Supervisor(s): John Daly

2. Previous experience (attach vita): *On File*

3. Beginning date of project: December 12, 2011

4. Duration of project: 3 months

5. Location of project: *Please See Attached*

6. Ownership:

7. Scope of project (refer to applicable scope in Survey Standards): Phase I reconnaissance survey

8. Research design (present research problems, formulate hypotheses, discuss how hypotheses will be tested with data, discuss how data will be manipulated and hypotheses evaluated).

   Attach extra sheets: *Please See Attached*

9. Attach budget: *Please See Attached*

10. Specify repository: The Public Archaeology Laboratory, Inc.
    210 Lonsdale Avenue
    Pawtucket, Rhode Island 02860
    Estimated No. of Artifact (Document) Boxes: 1

11. Projected completion of final report and date when a draft review copy will be submitted to RIHP&HC:

   A. Draft: February 2012

   B. Final: February 2012

I, Suzanne Cherau , (**archaeologist**) certify that the information contained in this application is correct, and that I will comply with applicable federal and state legislation, regulations and standards, and any special conditions appended to this application. I understand that any change to the specifications of this permit, the research design, or project scope of work, without the approval of the RIHP&HC, may result in the revocation of this permit and the cessation of archaeological investigations. I also understand that should I fail to satisfy the conditions of this permit (items 7,8,9,10,11) the RIHP&HC may decide not to issue me, or my employer, permits for future projects until the deficiencies under this permit are resolved.

I, David J. Lang (**Project Coordinator, Peterson Puritan OU-2 Superfund Site, project proponent,**) agree to comply with applicable federal and state legislation and special conditions attached to this permit. I also agree to maintain adequate security at the project area, and, if determined necessary by the RIHP&HC, will take steps, as required by the RIHP&HC, to prevent trespassers or other unauthorized individuals from causing harm to the archaeological site or sites under investigation.

Suzanne J. Cherau
Applicant(s)

Permit Effective Date

David J. Lang
Property Owner or Project Proponent

Approved By
Rhode Island Historical Preservation
and Heritage Commission

Reviewed By: _____, RIHP&HC Staff Archaeologist

See below for any attached Special Conditions that may apply to this permit:

1.) Native American Special Condition Yes _____ No _____

2.) Other Special Conditions Yes _____ No _____

The RIHP&HC reserves the right to amend the terms and conditions of this permit based on new information received in the course of the project.

Form Revised 10/98

PN ## - Project

Public Archaeology Laboratory

Technical Proposal
Peterson/Puritan, Inc. Superfund Site – Operable Unit 2
Cumberland and Lincoln, Rhode Island

Phase I Reconnaissance Survey

December 6, 2011

Submitted to:

Ground Water Consultants, Inc.
2 Fosters Point
Beverly, Massachusetts 01915

Ground Water Consultants, Inc. is assisting the property owners with site remediation work for the Peterson/Puritan, Inc. Superfund Site–Operable Unit 2 (OU2) (United States Environmental Protection Agency [EPA] ID #RID055176283) in Cumberland and Lincoln, Rhode Island. In compliance with Section 106 of the National Historic Preservation Act (NHPA) of 1966 as amended, the EPA, as the lead federal agency for the superfund site, has requested that a Phase I reconnaissance survey be conducted of the OU2 project area. The objective of the Phase I reconnaissance survey will be to locate and identify any previously recorded and visible historic and archaeological resources and sensitive areas within the OU2 project area.

The OU 2 project area is just over one mile long along the Blackstone River at the Cumberland and Lincoln town line (Figure 1). It is comprised of several private properties that total approximately 200 acres in size. These parcels include the 36-acre J.M. Mills Landfill and the Lenox Street Municipal Well on the east side of the Blackstone River; and a 30-acre unnamed island to the south of the landfill and the 24-acre Quinnville Municipal Wellfield to the north of the landfill on the west side of the Blackstone River.

PAL has been retained by Ground Water Consultants, Inc. to conduct the Phase I reconnaissance survey for the OU2 project area. The following Technical Proposal describes the research framework along with the research design and field methodology involved in conducting the Phase I survey. The work products and schedule for the completion of the survey are also included.

Research Framework-Cultural Context

The OU2 project area is located along the Blackstone River in the towns of Cumberland and Lincoln, Rhode Island. It lies within the John H. Chafee Blackstone River Valley National Heritage Corridor (JHCBRVNHC), which stretches 46 miles from Providence, Rhode Island to Worcester, Massachusetts. Pre-contact period settlement of the Blackstone River drainage is well documented in the archaeological record. Native American sites dating from the earliest PaleoIndian Period (12,000-10,000 B.P. [years before present] through the Late Woodland and Contact periods (1000-300 B.P.) are recorded in this area. Sites are concentrated along tributary stream settings extending from elevated uplands to riverine and wetland zones. They represent generally small, temporary campsites where resource procurement and processing, stone tool repair and maintenance, and other subsistence-related activities were carried out by small groups of people. The lithic assemblages from most of these sites suggest they were occupied during only one or two episodes. At the time

of initial contact between European explorers and Native American groups inhabiting Narragansett Bay, a group of southern New England Algonquian speakers known as the Narragansett inhabited all of western Narragansett Bay and held influence over the entire region. Narragansett country was bordered to the north and west by the Nipmuck, to the north and east by the Massachusetts, to the east by the Pokanoket (or Wampanoag), and to the west by the Pequots and Mohegans. Smaller tribes tributary to Narragansett influence also were settled within Narragansett territory during the early seventeenth century.

Since the beginning of the American industrial revolution at Slater's Mill in Pawtucket, Rhode Island in the 1790s, the Blackstone River supported the majority of the region's water-powered mills and its tributaries enabled industrialization to spread throughout the watershed. The historic manufacturing industries were almost entirely devoted to textile production and allied industries such as machinery and tools. The Blackstone Canal was constructed between 1824 and 1828 and operated until 1848. The canal served as the primary transportation route for the movement of agricultural products, raw materials, manufactured goods, and passengers between Worcester and Providence. It was a major stimulus to the growth and commercial development of communities along its route in the early to mid-nineteenth century. When the canal closed in 1848 mills along its route acquired water rights, or reclaimed rights taken by the canal. The canal trench was converted to power canals for existing and new mills in many locations, creating a new wave of industrial construction in the Blackstone River Valley. While most of the late nineteenth-century industries ceased operations throughout the course of the twentieth century, the Blackstone Valley continues today to be a working landscape characterized by a number of natural and historic resource types including mill villages, urban centers, rural agricultural land and open space, and at its core the Blackstone River and Blackstone canal.

Historic resources that are listed or determined eligible for listing in the National Register (NR) of Historic Places within the JHCBRVNHC and in proximity to the OU2 study area include:

- Berkeley Village Historic District, Cumberland – NR Listed
- Blackstone Canal Historic District, Cumberland and Lincoln – NR Listed
- Lonsdale Mill Village Historic District, Cumberland and Lincoln – NR listed

Phase I Reconnaissance Survey Methodology

The goal of the Phase I reconnaissance survey will be to locate and identify previously recorded and visible historic and archaeological resources and sensitive resources within the OU2 project area. The survey methodology employed by PAL follows the scope of work set forth in *Performance Standards for Archaeological Projects, Rhode Island Historical Preservation and Heritage Commission* (RIHPHC 2011). The Phase I survey will consist of two primary tasks, archival research and field investigations, as described below.

Archival Research

Research for the Phase I reconnaissance survey will examine primary and published sources, historic views, and maps, including any building and/or National Register nomination forms for the OU2 project area on file at the RIHPHC, which will serve as the primary information source for this research. Any town survey building, National and State Register forms, and archaeological site forms on file at RIHPHC will be collected and supplemented as needed with documents on file at the following state and local repositories: Rhode Island State Archives, Rhode Island Department of

Environmental Management, Rhode Island Historical Society, the Blackstone Valley Historical Society, the Blackstone River Valley Heritage Corridor Commission, the Cumberland Historic District Commission; the Lincoln town government; and the Lincoln Water Commission. Interviews with local persons knowledgeable about the prehistory and history of the area, including member of local historical commissions/societies and the Wilbur Kelly House Museum in Lincoln and landowners may also be conducted.

A review of local geography, geology, ecology, soils, historical maps (town survey and atlas maps, aerial maps, topographical maps) and town histories will also be conducted to assist with the development of cultural contexts used to evaluate the significance of identified resources. The development of cultural contexts also assists in the archaeological sensitivity assessment for Native American and EuroAmerican archaeological resource potential and the formulation of predictive statements for the types and locations of any such deposits.

Field Investigations

A walkover survey will be conducted to examine the existing conditions of the OU2 project area. The walkover survey will include a close ground surface inspection to locate and record any recorded and visible historic and archaeological resources within the project area. Previously identified historic resources including the Pratt Dam, P&W Railroad, and stone walls and wooden structures at Pond F will be included in the survey. Notes will be taken on the physical attributes of these and any other identified resources along with digital photographs. The results of the walkover/existing conditions survey will be analyzed in the context of the historical research to provide an assessment of the current condition of identified historic resources as well as the archaeological sensitivity of the project area and potential for unrecorded cultural deposits.

No subsurface testing will be conducted and no artifacts will be collected during the walkover survey. Should any artifacts be observed, their nature and location will be photographed, described, and indicated on project maps.

Technical Report

Upon completion of the research and field investigations, PAL will prepare a technical Phase I reconnaissance survey report that will include the following information: survey methodology including information sources; research framework (environmental setting, cultural contexts-precontact, contact, post-contact periods, and site(s) land use history); results-inventory of known and potential historic and archaeological resources within the project area and archaeological sensitivity assessment; and management recommendations regarding the significance and National Register eligibility of identified resources and any further Phase I or Phase II cultural resource studies that may be needed.

The technical report will follow the guidelines established by the National Park Service in the *Recovery of Scientific, Prehistoric, Historic, and Archeological Data* (36 CFR Part 66 Appendix A) and the RIHPHC's *Performance Standards and Guidelines for Archaeological Projects* (2011). Draft and final copies of the report will be prepared by PAL for distribution to the project proponent and consulting parties.

Personnel

The key PAL staff assigned to the project will be Suzanne Cherau, Principal Investigator/Senior Archaeologist; and John Daly, Industrial Historian. The assigned PAL staff has over 25 years of combined experience in the field of New England cultural resources management, with an emphasis on historic dam/mill sites, environmental (superfund) remediation projects, and dam removal projects in Connecticut, Massachusetts, Rhode Island, New Hampshire, and Vermont. All PAL staff meet the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation.

Schedule

The research and walkover survey tasks will take approximately two weeks to complete, and will begin once the RIHPHC state archaeological permit is received and the EPA has approved the PAL HASP. The walkover survey needs to be done with no snow cover so that the ground surface is visible for archaeological sensitivity assessment purposes, in accordance with the RIHPHC's Cold Weather Policy for Archaeological Survey and Excavation (2011). The draft technical report will be submitted for review within 45 days of the completion of the research and field tasks.

Cost

A separate cost estimate to conduct the Phase I reconnaissance survey is attached.

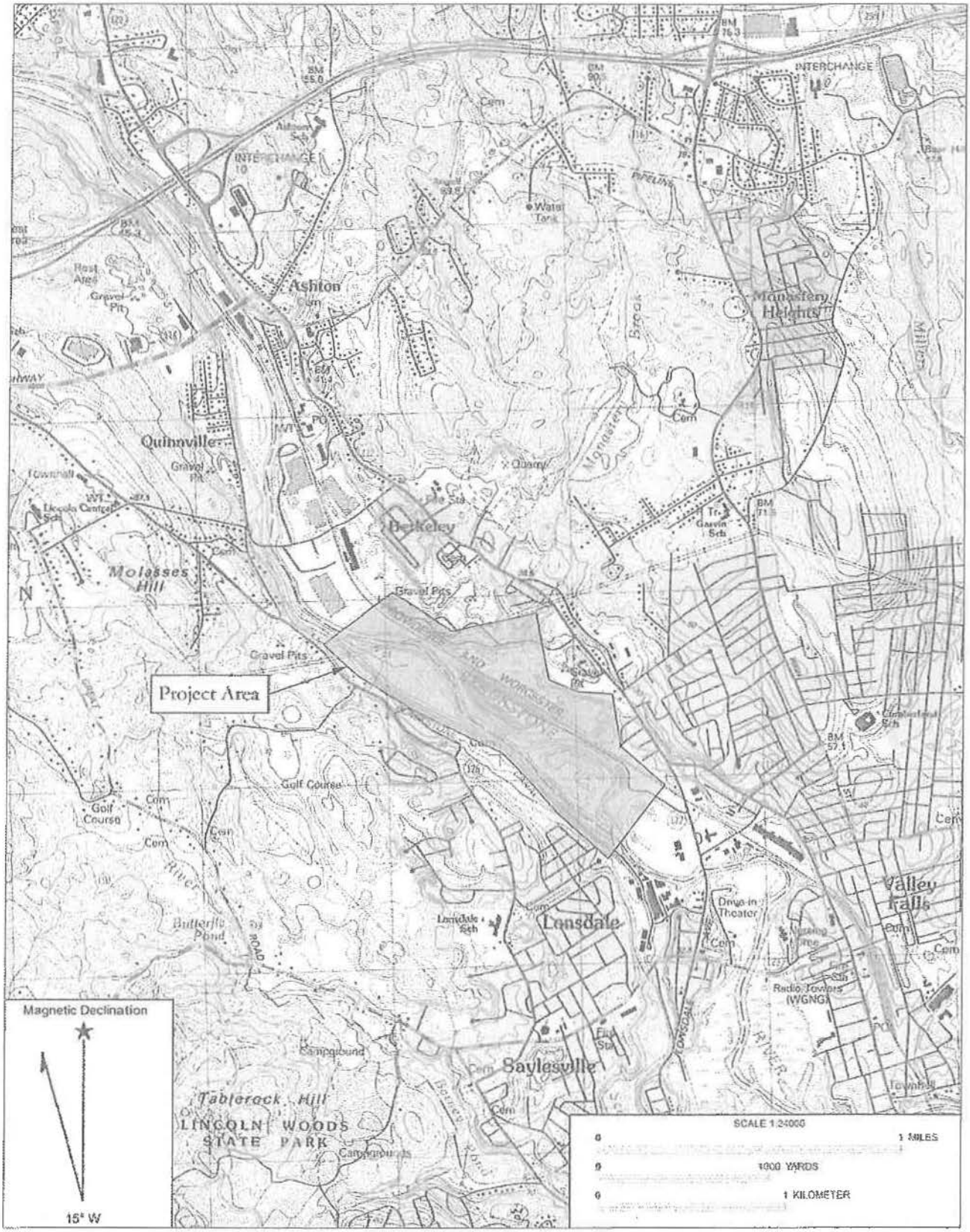


Figure 1. Location of the Peterson/Puritan, Inc. Superfund Site - Operable Unit 2 project area on the Attleboro, MA USGS topographic quadrangle, 7.5 minute series.

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
HISTORICAL PRESERVATION & HERITAGE COMMISSION
Old State House • 150 Benefit Street • Providence, R.I. 02903-1209
Preservation (401) 222-2678 FAX (401) 222-2968
Heritage (401) 222-2669 TDD (401) 222-3700

DATE 12/21/11

TO Suzanne Cheran

COMPANY PAL

FACSIMILE TELEPHONE NUMBER 728784

VOICE TELEPHONE NUMBER

SENT BY

Peterson / Punta Pennit

TOTAL NUMBER OF PAGES INCLUDING COVER SHEET 3

RIHPHC Archaeological Permit: 11-27
Effective date: 11/12/19 – 12/31/12
Project: Phase I Peterson/Puritan Superfund Site-Operable Unit 2, Cumberland and Lincoln

Native American Special Condition

The Narragansett Indian Tribal Historic Preservation Officer has stated an interest in this project and in accordance with the RIHPHC's *Survey Standards* the following items apply:

1. The RIHPHC will send a copy of the permit application to the NITHPO.

2. The project archaeologist shall seek the input of the NITHPO in carrying out the work. The RIHPHC encourages archaeologists and the NITHPO to maintain cooperative and collegial relationships and to share information about work in progress.

3. The project archaeologist shall inform the NITHPO when fieldwork will begin.

4. The project archaeologist shall send copies of the draft and final report or management memo to the NITHPO.

5. The RIHPHC will notify the NITHPO when the archaeological report or management memo is accepted and what further work (if any) the RIHPHC has required.

RIHP&HC, Permit Application
Page - 2 -

I, Suzanne Cherau , (archaeologist) certify that the information contained in this application is correct, and that I will comply with applicable federal and state legislation, regulations and standards, and any special conditions appended to this application. I understand that any change to the specifications of this permit, the research design, or project scope of work, without the approval of the RIHP&HC, may result in the revocation of this permit and the cessation of archaeological investigations. I also understand that should I fail to satisfy the conditions of this permit (items 7,8,9,10,11) the RIHP&HC may decide not to issue me, or my employer, permits for future projects until the deficiencies under this permit are resolved.

I, David J. Lang (Project Coordinator, Peterson Puritan OU-2 Superfund Site, project proponent,) agree to comply with applicable federal and state legislation and special conditions attached to this permit. I also agree to maintain adequate security at the project area, and, if determined necessary by the RIHP&HC, will take steps, as required by the RIHP&HC, to prevent trespassers or other unauthorized individuals from causing harm to the archaeological site or sites under investigation.

#11-27 12/20/11 - 12/31/12
Permit Effective Date

Suzanne J. Cherau
Applicant(s)

Approved By
Rhode Island Historical Preservation
and Heritage Commission

David J. Lang
Property Owner or Project Proponent

Reviewed By: _____, RIHP&HC Staff Archaeologist

See below for any attached Special Conditions that may apply to this permit:

1.) Native American Special Condition Yes ✓ No _____

2.) Other Special Conditions Yes _____ No _____

The RIHP&HC reserves the right to amend the terms and conditions of this permit based on new information received in the course of the project.

Form Revised 10/98

PN ## - Project

Public Archaeology Laboratory

January 10, 2012

John Brown
Narragansett Indian Tribal Historic Preservation Officer
P.O. Box 350
Wyoming, Rhode Island 02898

Re: Peterson/Puritan, Inc. Superfund Site-Operable Unit 2, Cumberland and Lincoln
Phase I Reconnaissance Survey
PAL #2679

Dear Mr. Brown:

PAL has been retained by Ground Water Consultants, Inc. of Beverly, Massachusetts to conduct a Phase I historic and archaeological reconnaissance survey for the Peterson-Puritan Superfund Site-Operable Unit 2 in Cumberland and Lincoln. The survey area is situated along the Blackstone River and includes the 36-acre J.M. Mills Landfill and the Lenox Street Municipal Well on the east side of the river, and a 30-acre manmade unnamed island and 24-acre Quinnville Municipal Wellfield on the west side of the river. The superfund site is regulated by the U.S. Environmental Protection Agency, which is overseeing soil remediation work.

The goal of the Phase I historic and archaeological survey is to locate and identify any significant cultural resources within the Operable Unit 2 portion of the superfund site. The locations of any such resources will be taken into account as part of the soil remediation efforts under Section 106 of the National Historic Preservation Act of 1966 as amended. By this letter we are requesting your office's assistance in identifying areas of concern to the Narragansett and would solicit the Tribe's involvement in the project. PAL conducted a site visit of the property in December 2011 and is available to meet with you or your designated Tribal representative to conduct a site visit at your earliest convenience. I have included a copy of PAL's scope-of-services with this correspondence for your records.

Please do not hesitate to contact Deborah Cox or me at your convenience if you have any questions or require any additional information. I can be reached through PAL's main office line, direct line (401) 288-6311, or by cell phone (401) 477-4654. I look forward to communicating with you on this project.

Sincerely,

Suzanne J. Cherau

Suzanne Cherau, RPA
Senior Archaeologist

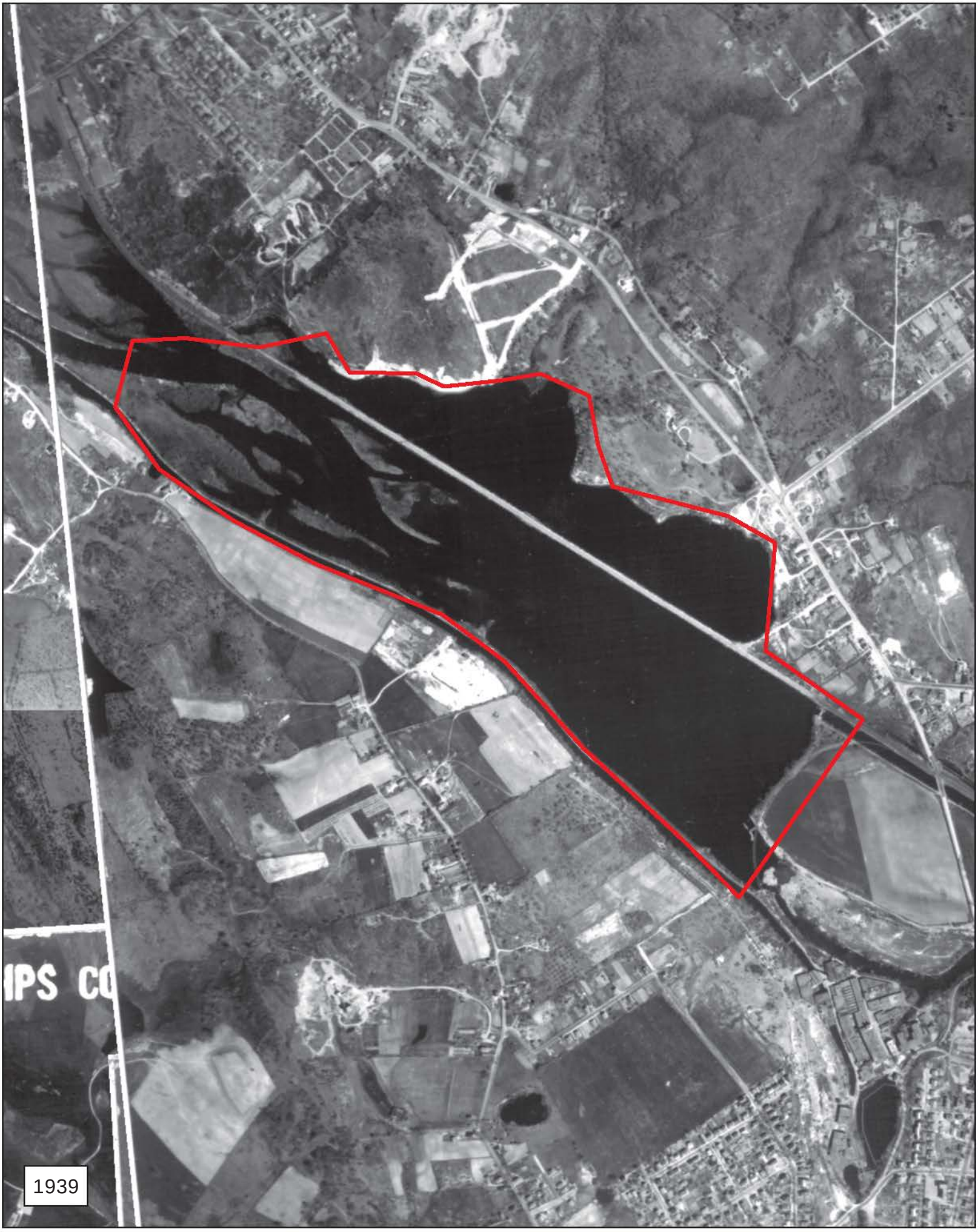
Enclosure

cc: David Land, Ground Water Consultants, Inc. (w/o encl.)

210 Lonsdale Avenue Pawtucket, RI 02860 | 401.728.8780 Main | 401.728.8784 Fax
palinc.com

APPENDIX B

RIGIS AERIAL PHOTOGRAPHS OF THE OU2 PROJECT AREA AND VICINITY



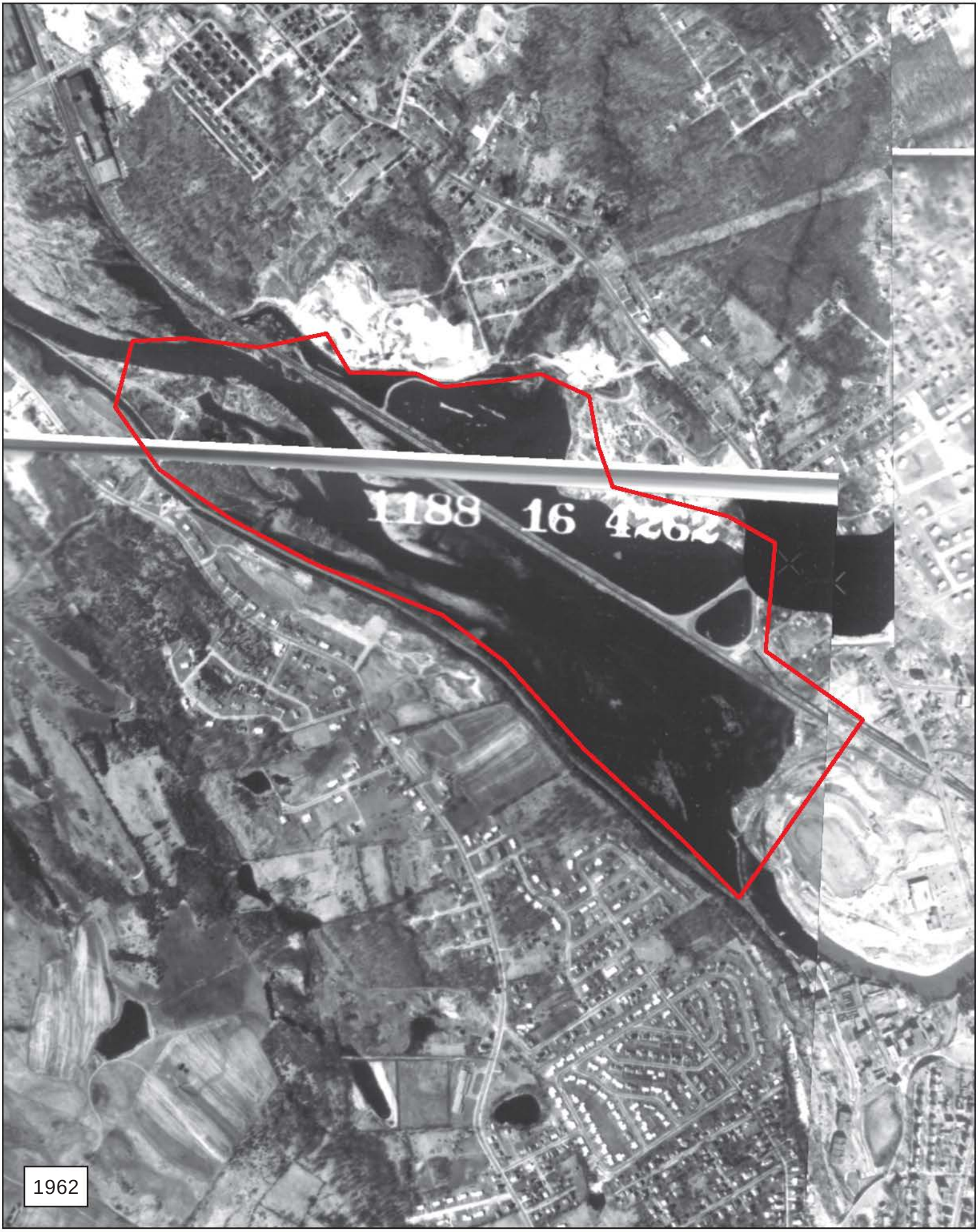
2679 Peterson/Puritan Superfund OU2. Project area and historic aerials (JM printed 1-20-12).

1 cm = 100 meters



2679 Peterson/Puritan Superfund OU2. Project area and historic aerials (JM printed 1-20-12).

1 cm = 100 meters



2679 Peterson/Puritan Superfund OU2. Project area and historic aerials (JM printed 1-20-12).

1 cm = 100 meters



2679 Peterson/Puritan Superfund OU2. Project area and historic aerials (JM printed 1-20-12).

1 cm = 100 meters



2679 Peterson/Puritan Superfund OU2. Project area and historic aerials (JM printed 1-20-12).

1 cm = 100 meters

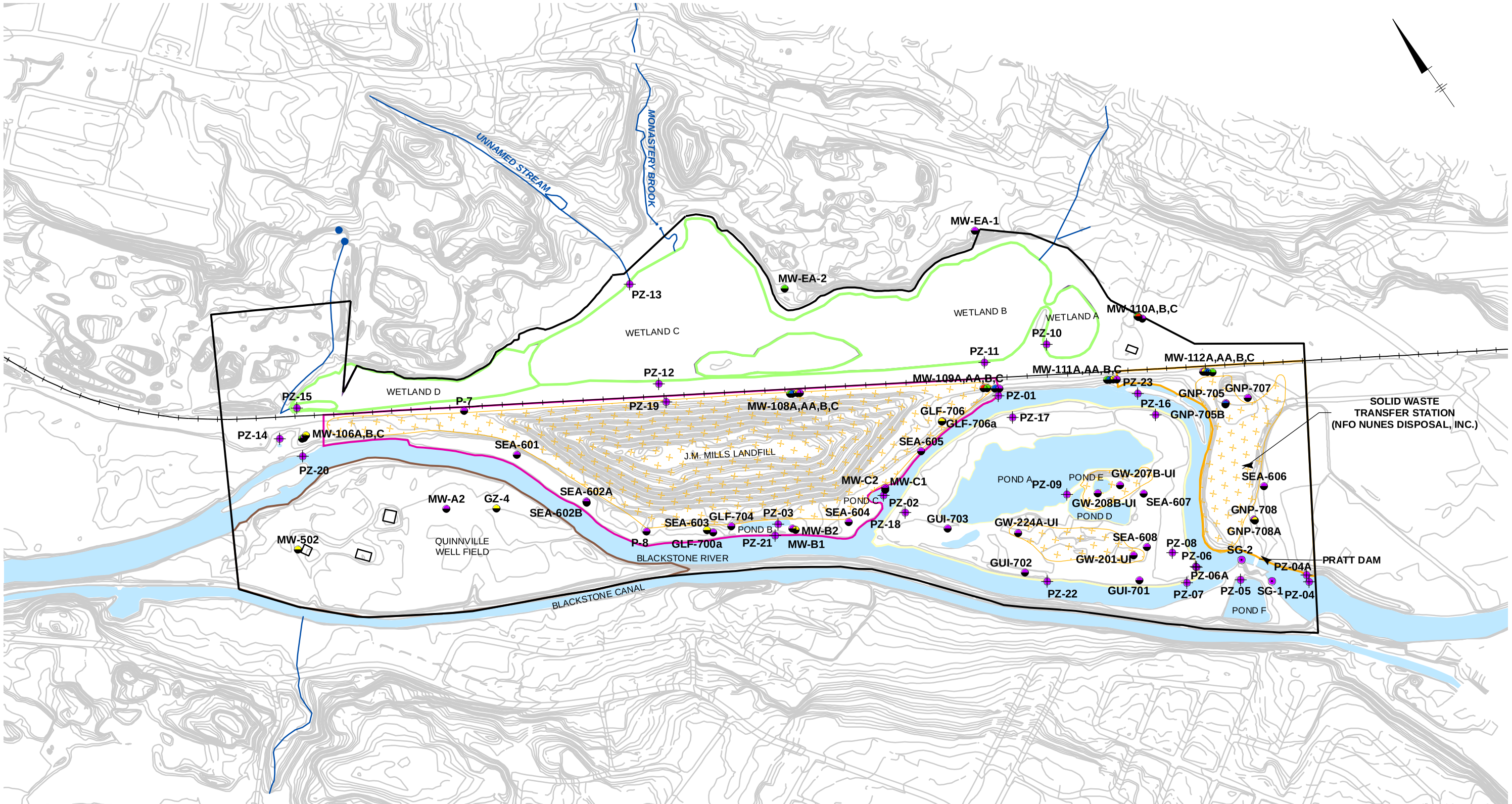


2679 Peterson/Puritan Superfund OU2. Project area and historic aerials (JM printed 1-20-12).

1 cm = 100 meters

APPENDIX C

GEOTECHNICAL TESTING AND SAMPLING LOCATIONAL MAPS FOR THE OU2 PROJECT AREA, REPRODUCED FROM THE REMEDIAL INVESTIGATION REPORT (ARCADIS 2012)



LEGEND:

- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE

FORMATION

- SHALLOW UNCONSOLIDATED UNIT
- INTERMEDIATE UNCONSOLIDATED UNIT
- TILL
- DEEPER UNCONSOLIDATED UNIT
- BEDROCK

- OU2 BOUNDARY
- WETLAND (INTERMITTENTLY WET)
- BURIED WASTE
- SURFACE WATER
- UNNAMED ISLAND
- J.M. MILLS LANDFILL
- SOLID WASTE TRANSFER STATION (NOW OR FORMELY OWNED BY NUNES DISPOSAL, INC.)
- QUINNVILLE WELL FIELD
- WETLAND

0 500 1,000 Feet

GRAPHIC SCALE

NOTES:
1) ONLY WELLS SAMPLED AS PART OF THE OU2 RI ARE SHOWN ON THIS FIGURE.

DRAFT

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND
REMEDIAL INVESTIGATION REPORT

MONITORING WELLS, PIEZOMETER AND STAFF GAUGES

ARCADIS

FIGURE 2-1

Appendix C-1

CITY: (CLE) DIV/GROUP:(ENV/GIS) DB:(LGREENE) LD:() PIC:() PM:() TM:(JROBERTS)
PROJECT: PETERSON PURITAN PATH: O:\GIS\Peterson Puritan\Cumberland RI\RemedialInvestigationReport\mxd\201201 UpdatesWells.mxd

CITY: (CLE) DIV/GROUP: (ENV/GIS) DB: (LGREENE) LD: () PIC: () PM: () TM: (J.ROBERTS)
PROJECT: PETERSON PURITAN PATH: Q:\GIS\Peterson_Puritan\Cumberland_RI\RemedialInvestigationReport\mxd\201201_Updates\SoilSampPhase1aand1b-topobasemap_update.mxd

WETLAND A
WETLAND B
WETLAND C
WETLAND D
POND A
POND B
POND C
POND D
POND E
POND F
POND I
POND N
POND P
BLACKSTONE RIVER
BLACKSTONE CANAL
(BACKWATER)
PRATT DAM
SO-W09-DF
SO-W08-DF
SO-047-DF
SO-W07x-DF
SO-W07-DF
SO-048-DF
SO-049-DF
SO-023-LF
LOU-001
SO-026-LF
SO-025-LF
SEA-601
SO-027-LF
SO-045-QW
SO-046-DF
SO-005-BG
SO-004-BG
LQW-011
SO-075-QW
LQW-014
SO-076-QW
SO-001-BG
SO-003-BG
LQW-010
SO-044-QW
LQW-017
SO-002-BG
LQW-013
LQW-009
LQW-016
LQW-012
LQW-018
LQW-015
SEA-602B
SO-028-LF
SO-029-LF
SO-032-LF
SO-030-LF
SO-041-LF
SEA-603
SO-042-LF
SO-024-LF
SO-022-LF
SEA-604
LLF-002
SO-020-LF
LLF-003
SO-021-LF
LLF-004
SO-019-LF
SEA-605
SO-W06-DF
SO-W05-DF
LUI-006
SO-081-UI
SO-043-LF
SO-082-UI
SO-078-UI
SO-224A-UI
SO-225A-UI
SO-014-UI
SO-079-UI
LUI-005
SO-220-UI
SO-080-UI
SO-223F-UI
SO-064-BR
SO-016-UI
SO-065-BR
SO-215-UI
SO-216-UI
SO-066-BR
SO-067-BR
SO-063-WT
SO-062-WT
SO-061-WT
SO-060-WT
SO-059-WT
SO-018-LF
SO-218-UI
SO-217-UI
SO-084-UI
SO-013-UI
SO-219-UI
SO-012-UI
SO-085-UI
SO-083-UI
SO-015-UI
SO-207A-UI
SO-207B-UI
SO-208B-UI
SO-077-UI
SO-227B-UI
SO-226A-UI
SO-006-UI
UI-TT-06
SO-228-UI
SO-007-UI
SO-222-UI
SO-205-UI
SO-088-UI
SO-068-BR
SO-069-BR
SO-214-UI
SO-070-BR
SO-213-UI
SO-071-BR
SO-101-NP
SO-100-NP
SO-102-NP
SO-058-WT
SO-053-NP
SO-017-NP
SO-054-NP
SO-052-NP
SO-037-NP
SO-103-NP
LNP-008
SO-104-NP
SO-036-NP
SO-051-NP
SO-011-UI
SO-050-NP
SO-212-UI
UI-TT-03
SO-035-NP
SO-009-NP
SO-055-NP
SO-086-UI
SO-034-NP
LNP-007
SEA-606
SO-206-UI
SO-105-NP
SEA-607
SO-211-UI
SO-210B-UI
SO-033-NP
SO-107-NP
SO-087-UI
SO-204-UI
SO-056-NP
SO-203-UI
SO-106-NP
SO-010-UI
UI-TT-10
SEA-608
SO-201-UI
SO-108-NP
SO-057-NP
SO-008-NP
SO-200-UI
SO-209-UI
UI-TT-01,02
SO-227B-UI
SO-226A-UI
SO-224A-UI
SO-225A-UI
SO-220-UI
SO-223F-UI
SO-222-UI
SO-205-UI
SO-214-UI
0
400
800
Feet
GRAPHIC SCALE

LEGEND:

- SO-029-LF ● PHASE 1A SURFACE SOIL SAMPLE LOCATION
- SEA-602B ● PHASE 1A SUBSURFACE SOIL SAMPLE LOCATION
- SO-033-NP ● PHASE 1A SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- LQW-009 ■ PHASE 1B SURFACE SOIL SAMPLE LOCATION
- SO-105-NP ■ PHASE 1B SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- SO-101-NP ■ PHASE 1B SUBSURFACE SOIL SAMPLE LOCATION
- SO-209-UI ▲ SUPPLEMENTAL INVESTIGATION SURFACE SOIL SAMPLE LOCATION
- SO-227B-UI ▲ SUPPLEMENTAL INVESTIGATION SUBSURFACE SOIL SAMPLE LOCATION
- SO-200-UI ▲ SUPPLEMENTAL INVESTIGATION SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION

- HISTORICAL POND
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION (NFO NUNES DISPOSAL, INC.)
- RAILROAD
- OU2 BOUNDARY
- HISTORICAL ACCESS ROAD
- WATER

DRAFT

NOTES:

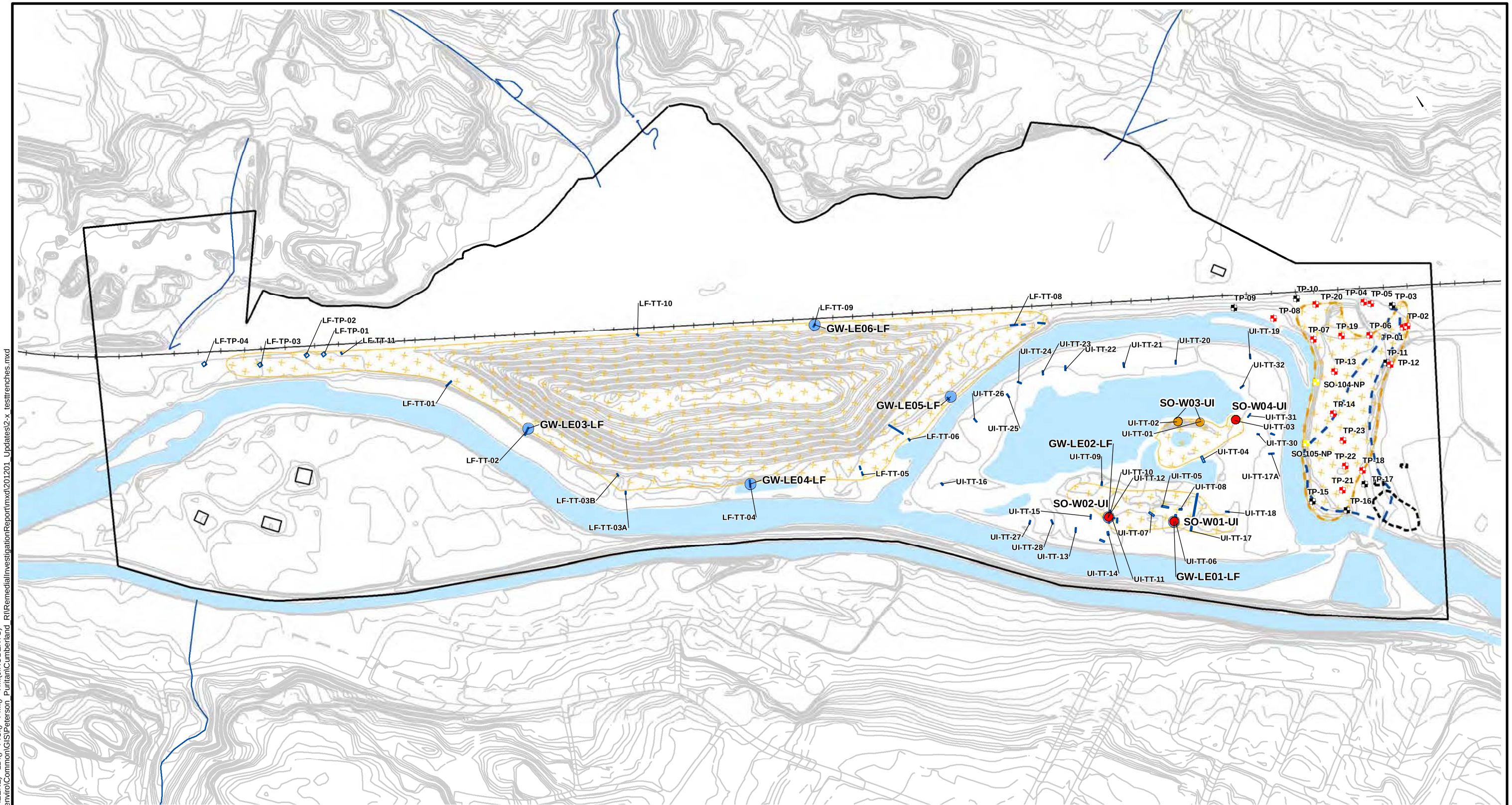
1. SAMPLE LOCATIONS AND BASEMAPPING ARE IN THE COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD 83 FEET. LOCATIONS RECORDED IN THE FIELD USING GPS.
2. LOCATIONS WITH MULTIPLE LABELS (E.G., SO-023-LF AND LOU-001) REPRESENT STATIONS WHERE SAMPLING RETURNED TO THE SAME LOCATION IN 2005 DURING THE PHASE IB INVESTIGATION AND COLLECTED AN ADDITIONAL SURFACE SOIL SAMPLE TO BE ANALYZED FOR DIOXIN/FURANS.
3. SUBSURFACE SOIL LOCATIONS CAN HAVE MULTIPLE DEPTH INTERVALS COLLECTED. SAMPLE IDs FOR SOIL SAMPLES COLLECTED AT DEPTH DIFFER FROM THEIR SAMPLE STATION ID.
4. NFO - NOW OR FORMERLY OWNED BY

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND
REMEDIAL INVESTIGATION REPORT

SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-2



LEGEND:

- PHASE 1A (TEST TRENCH ONLY) SOIL SAMPLE LOCATION (SHIELD)
- PHASE 1A COMPOSITE (TEST TRENCH ONLY) SOIL SAMPLE LOCATION (SHIELD)
- PHASE 1A GRAB WATER SAMPLE LOCATION (SHIELD)
- 2007 NUNES AREA TEST PIT LOCATION - SAMPLE(S) COLLECTED
- 2007 NUNES AREA TEST PIT LOCATION - NO SAMPLES COLLECTED
- 2007 NUNES AREA SOIL BORING LOCATION - HAND AUGERED (UNABLE TO EXCAVATE TEST PIT)
- PHASE 1A TEST TRENCHES (SHIELD)
- AREA OF EXCAVATION COMPLETED BY RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT (RIDEM)
- PHASE 1A PROJECTED BOUNDARY OF BURIED SOLID WASTE IN NUNES PARCEL
- REVISED PHASE 1B PROJECTED BOUNDARY OF BURIED SOLID WASTE IN NUNES PARCEL
- LIMITES OF BURIED WASTE

NOTE:

1. SAMPLE SO-W03-UI IS A COMPOSITE SAMPLE TAKEN FROM TEST TRENCHES UI-TT-01 AND UI-TT-02
2. GRAB WATER SAMPLES WERE COLLECTED FROM OPEN TEST TRENCHES
3. PHASE 1A TRENCH LOCATIONS WERE EXCERPTED FROM SHIELD PLATE 3, FEBRUARY 2006.

0 400 800 Feet

GRAPHIC SCALE

DRAFT

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

REMEDIAL INVESTIGATION REPORT

TEST TRENCH AND ASSOCIATED SOIL AND GRAB WATER SAMPLE LOCATIONS

ARCADIS

FIGURE
2-2a

CITY: (CLE) DIV/GROUP:(ENV/GIS) DB:(LGREENE) LD:() PIC:() PM:() TM:(J.ROBERTS)
PROJECT: PETERSON PURITAN PATH: G:\enviro\Common\GIS\Peterson_Puritan\Cumberland_RI\RemedialInvestigationReport\mxd\201201_Updates\2-x_testtrenches.mxd

APPENDIX D

GEOTECHNICAL SAMPLING LOGS, REVIEWED BY PAL FOR THE OU2 PROJECT AREA.

SHIELD
Environmental Associates, Inc.
2456 Fortune Drive, Lexington KY 40509

FIELD TEST TRENCH LOGS

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **8/21/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- LF-TT-01

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Lower tier of landfill; Large pieces of concrete debris on surface	
0 - 2		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	NA
2 - 15		Grayish brown Silty Sand and Gravel, loose, dry, no odor. Debris: concrete, bricks, scrap metal, glass bottles, paper, insulation, wood, plastic garbage bags.	
> 15		Grayish brown poorly sorted Sand and Gravel, loose, wet.	

Note: Final dimensions: 30' long x 4' wide x 16' deep. Northeast edge of test trench is within the lower tier of the landfill north of SEA-601. Waste found in first tier and ends at edge of the slope. Photo-documented by Mike Morris. Air monitoring conducted by Chad Kelly.
* No waste or leachate samples collected from LF-TT-01

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **8/21/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- LF-TT-02

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Lower tier of landfill; brush, scattered surface debris	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor (cover material).	GW-LE03-LF
1 - >15		Buried waste including: Hose, wood, plastic bags, plastic strips. Waste buried to > 15 feet - Excavator could not reach to bottom of waste.	

Note: Final dimensions: 36' long x 4' wide x 16' deep. Northeast edge of test trench is within the lower tier of the landfill between SEA-601 and SEA-602. Waste found in first tier and ends at edge of the slope. Photo-documented by Mike Morris. Ground water leachate (GW-LE03-LF) sample collected from LF-TT-02. Air monitoring conducted by Chad Kelley.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **8/21/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- LF-TT-03

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Lower tier of landfill; Scattered surface debris	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	NA
2 - 13		Buried waste including: blue plastic strips, dried paint, tires, hose, plastic jugs, and piping/conduits. Water encountered within the buried waste at a depth of approximately 6 feet below the ground surface.	

Note: Trench 3 split in two parts on the north and south sides of the haul road in the vicinity of monitoring well P-8. Final dimensions: North side: 12 feet x 4 feet x 13 feet deep. South side: 12 feet x 4 feet x 13 feet deep. Edge of waste encountered at south end of trench. No waste or leachate samples collected from test trench. Photo-documented by Mike Morris. Air monitoring conducted by Chad Kelley.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **8/21/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- LF-TT-04

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Northern edge of Pond B; Overgrowth, brush and scattered miscellaneous surface debris such as tires and scrap metal	
0 - 3		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	NA
3 - 8		Buried waste including: plastic, brick, and scrap metal on north end of test trench. Poorly sorted sand and gravel encountered within Pond B on south side of test trench. Water was encountered at a depth of approximately 4 feet from the surface.	

Note: Final Dimensions: 30' long x 4' wide x 8' deep. Waste encountered on north side of test trench adjacent to Pond B. Waste was not encountered within Pond B. Photo-documented by Mike Morris. Air monitoring concucted by Chad Kelley.
* No waste or leachate samples collected for analysis from LF-TT-04

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **8/21/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- LF-TT-05

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		South side of haul road near retaining wall; scattered debris invicinity (tires, scrap metal, etc)	
0 - 2		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	
3 - 9		Section 1: Buried waste including: plastic, nylon strips, hose, plastic bags. Section 2: Buried waste consisting predominantly of buried concrete. Water was encountered at a depth of approximately 6 feet from the surface.	NA
9-12		Grayish brown poorly sorted Silt and Sand, loose, wet.	NA

Note: Final Dimensions: Section 1 (north side) 10' long x 4' wide x 12' deep. Section 2 (south side) 15' long x 4' wide x 12' deep. Industrial/municipal wastes encountered in Section 1; Concrete (demolition debris) encountered in Section 2. Photo-documented by Mike Morris. Air monitoring concucted by Chad Kelley.
* No waste or leachatate samples collected from LF-TT-05.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **8/21/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- LF-TT-06

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Adjacent to haul road in the vicinity of MW-C1 and MW-C2 - Scattered debris on surface (tires, scrap metal)	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	NA
3 - 9		Section 1: Buried waste including: plastic bags, glass containers, plastic bottles, tires. Section 2: Buried waste consisting predominantly of plastic bags, glass and plastic bottles; syringes found in Section 2 on south side of haul road near MW-C1. Water was encountered at a depth of approximately 8 feet from the surface.	

Note: Final Dimensions: Section 1 (north side of haul road) 70' long x 4' wide x 9' deep. Section 2 (south side of haul road) 10' long x 4' wide x 9' deep. Industrial/municipal wastes encountered in Section 1; Industrial/municipal wastes including medical waste encountered in Section 2. Photo-documented by Mike Morris. Air monitoring conducted by Chad Kelley.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **8/22/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- LF-TT-07

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Adjacent to haul road in the vicinity of SEA-605 - Scattered debris on surface (tires, scrap metal, USTs). Located within the area of Debris Field 4.	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	GW-LE05-LF
3 - 12		Buried waste including blue plastic/nylon strips, hose, and wood. Depth to water approximately 10 feet below the ground surface. Depth of waste approximately 11-12 feet below ground surface. Waste extends to river side of haul road.	
> 12		Poorly sorted Sand and Gravel, loose, wet, mild odor	

Note: Final Dimensions: 14' long x 4' wide x approximately 14' deep. Photo-documented by Mike Morris. Air monitoring conducted by Chad Kelley.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **8/22/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- LF-TT-08

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Adjacent to haul road near the south gate and in the vicinity of MW-109 - Scattered debris on surface (railroad ties, scrap metal, USTs).	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	NA
3 - >15		Buried waste including plastic bags, wood, plastic food containers. Depth of waste greater than 15 feet below ground surface. Waste extends to river side of haul road near MW-109.	

Note: Final Dimensions: 100' long x 4' wide x approximately 15' deep. Photo-documented by Mike Morris. Air monitoring conducted by Chad Kelley.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **8/22/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- LF-TT-09

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Located on the north side of the landfill near MW-108. Vegetation and surface debris (railroad ties).	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	GW-LE06-LF
3 - 12		Buried waste including plastic bags, hose, tires, carpeting, cable, bottles, wood, cardboard. Depth of waste greater than 10 feet below ground surface. Ground water encountered at approximately 10 feet below the ground surface. Waste extends to fence line.	

Note: Final Dimensions: 12' long x 4' wide x approximately 12' deep. Ground water leachate sample collected from trench with trackhoe bucket. Photo-documented by Mike Morris. Air monitoring conducted by Chad Kelley.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **8/22/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- LF-TT-10

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Located on the north side of the landfill near PZ-19. Vegetation and surface debris (railroad ties).	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	NA
3 - 10		Buried waste including plastic bags, hose, tires, bottles, wood. Depth of waste greater than 10 feet below ground surface. Ground water encountered at approximately 10 feet below the ground surface. Waste extends to fence line.	

Note: Final Dimensions: 8' long x 4' wide x approximately 10' deep. Photo-documented by Mike Morris. Air monitoring conducted by Chad Kelley.

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EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- LF-TT-11

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Located on the north side of the landfill at the north gate. Large concrete slabs in the vicinity of Trench 11	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	NA
3 - 5		Buried waste including plastic bags, bottles, and wood.	

Note: Final Dimensions: 8' long x 4' wide x approximately 5' deep. Ground water leachate sample collected from trench with trackhoe bucket. Photo-documented by Mike Morris. Air monitoring conducted by Chad Kelley.

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LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Pit- LF-TP-01

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Vegetation and large concrete slabs on surface.	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	NA
3 - 5		Buried waste including plastic bags, bottles, and wood.	

Note: Final Dimensions: 5' long x 4' wide x approximately 5' deep. Air monitoring conducted by Chad Kelley.

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EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Pit- LF-TP-02

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Vegetation and large concrete slabs on surface.	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	NA
3 - 5		Buried waste including plastic bags, bottles, and wood.	

Note: Final Dimensions: 5' long x 4' wide x approximately 5' deep. Air monitoring conducted by Chad Kelley.

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LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Pit- LF-TP-03

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Vegetation and large concrete slabs on surface.	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	NA
3 - 5		Buried waste including large volume of Silly Putty eggs.	

Note: Final Dimensions: 5' long x 4' wide x approximately 5' deep. Photo documentation and descriptions conducted by Mike Morris. Air monitoring conducted by Chad Kelley.

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EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Pit- LF-TP-04

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Vegetation and large concrete slabs on surface.	
0 - 1		Grayish brown poorly sorted Silt and Sand, loose, dry, no odor.	NA
3 - 7		Poorly sorted, yellowish brown Sand and Gravel; loose, dry. No buried waste encountered in test pit.	

Note: Final Dimensions: 5' long x 4' wide x approximately 7' deep. Photo documentation and descriptions conducted by Mike Morris. Air monitoring conducted by Chad Kelley.

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EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Stephen Scheidt**
SIGNATURE:

Test Trench- UI-TT-01

Depth Interval (ft bgs)	Interval Top Elevation (ft MSL)	Description	Lab Sample ID
Ground Surface		Mounded area above ground surface covered with vegetation. Silty sand and gravel, dry. Littered with surface debris such as scrap metal.	
0 - 5		Dark gray to brown silty sand and gravel, loose, dry, no odor. Debris: bricks, pipe, scrap metal, glass bottles, chain link fence, hose, electrical wire insulation, floor grating and unidentified white fibrous material.	SO-W03-UI*
5 - 8		Dark gray to brown (with some black mottling) silty sand and gravel, loose, dry, no odor. Debris SAA. Additional debris: burnt wood fragments, ceramic electric wire mounts, & a locker door.	

Note: Final dimensions: 18' long x 7' wide x 8' deep. Oriented northeast/southwest. Northeast edge of test trench is 17' from Pond A. Photo-documented by Mike Morris & Steve Scheidt. Air monitoring conducted by Chad Kelly.
* Composited with sample collected from UI-TT-02; VOC sample collected at UI-TT-01.

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EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Stephen Scheidt**
SIGNATURE:

Test Trench-UI-TT-02

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Mounded area above ground surface covered with vegetation. Silty sand and gravel, dry. Littered with surface debris such as scrap metal, pipe, & tires.	
0 - 5	Dark gray to brown silty sand and gravel, loose, dry, no odor. Debris: bricks, pipe, scrap metal, glass bottles, hose, and electical wire insulation.	**SO-W03-UI***
5 - 8	Dark gray to brown (with some black mottling) silty sand and gravel, loose, dry, no odor. Debris SAA. Additional debris: burnt wood fragments and ceramic electric wire mounts.	
8 - 10	Light gray sandy river gravel with cobbles, poorly sorted, fine to coarse, rounded, loose, saturated, no odor or staining. Below water table.	NA

Note: Final dimensions: 20' long x 7' wide x 10' deep. Oriented northeast/southwest. Northeast edge of test trench is 10' from Pond A. Photo-documented by Mike Morris & Steve Scheidt. Air monitoring conducted by Chad Kelly.
* Composited with sample collected from UI-TT-01; VOC sample collected at UI-TT-01.

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SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **8/14/2003 - 8/15/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Stephen Scheidt**
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Test Trench- UI-TT-03

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Mounded area above ground surface covered with vegetation. Large amount of surface debri is present: scrap metal, rusted household appliances such as refrigerators and stoves, rusted/crushed 55 gal drums, and tires.	
0 - 8	Brown silt and fine sand, well sorted, loose, moist, no odor/staining noted. Debris similar to surface debris, but in addition: metal piping, bricks, wire, car parts, large pieces of concrete, cinder blocks, and large tank (estimated to be 250 gal. Tank was not removed.)	**SO-W04-UI**
> 8	Below tank, similar materials, water table present. Excavation ceased; debris extended to top of water table.	NA

Note: Final dimensions: 27' long x 8' wide x 8' deep. TT3 is located at the southeast end of Pond A where it meets the old access road, and is oriented in the northeast/southwest direction. On 8/15, TT3 was extended approximatedly another 20' in the west/southwest direction. Additional debris found included a water heater, railroad ties, pipe, and small tanks. Buried debris appeared to extend under the currently used access road between TT1 and TT3. The lateral extend of buried waste was explored in this area. Photo-documented by Mike Morris & Steve Scheidt. Air monitoring conducted by Chad Kelly.

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LOGGED BY: **Steve Scheidt**
SIGNATURE:

Test Trench- UI-TT-04

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetated mound of soil/debris consisting mostly of tires. Brown silt and sand, loose, moist, no odor/staining noted. Pond E ground surface littered with tires.	
0 - 8	Dark grey to brown silty sand and gravel, loose, dry, no odor. Similar demolition debris found (see TT1 - TT3): pipe, brick, tires, scrap metal, car parts, bed springs and a heater tank.	NA
8 - 12	Buried waste extends below water table. Soil SAA & saturated. Side of TT4 extending into low area southwest of Pond E; below water table are a large number of tires. Central area adjacent to Pond E was dug into and more tires were found, approximately 3 - 4' deep.	NA

Note: The ground surface in and around Pond E is littered with tires, and exploratory digging yields buried tires at least 3 - 4' bgs, and extends below water table. Entire Pond E area appears to hold buried tires and debris. The ground surface visibly "bounced" throughout the Pond E area when driven over by the excavator. Photo-documented by Mike Morris & Steve Scheidt. Air monitoring conducted by Chad Kelly.

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Test Trench- UI-TT-05

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Large vegetated mounded area. Aerosol cans of "Cough whip" dated 1965 and a needleless syringe plunger were found in the area.	
0 - 6	Light grey/brown Silt and fine Sand, loose, dry, no odor/staining.	NA
6 - 10	Grey/brown Silt and Sand, loose, moist, no odor/staining noted. Debris: plastics, wires, glass, plastic doll parts, pipe, unidentified cohesive, white granular material, plastic bag labeled "Union Carbide - Polyethylene," and unidentified metal machine parts.	NA
10 - 15	Dark grey Silt and Sand, loose, moist, strong organic/decay odor and black/purple staining. Additional debris: rubber, tires, machine parts, string, unidentified burned material, wire/cable insulation, glass vials, glass bottles, and syringe needles. Glass vials labeled "Abbot Laboratories" and "Sterile Sodium Chloride for Injection." A chunk of of material was closely investigated consisted of rust stained deteriorated plastic bags, material, and an aggregate of hollow-point needles.	NA

Notes: Final dimensions: 30' long x 6' wide x 15' deep. Trench is located on the berm of the depression southeast of the abandoned excavator. Photo-documented by Mike Morris & Steve Scheidt. Air monitoring conducted by Chad Kelly.

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Test Trench- UI-TT-06

Depth Interval (ft bgs)		Description	Lab Sample ID
Ground Surface		Surface littered with rusted appliances and scrap metal. Covered with vegetation. Berm opposite TT5.	
0 - 2		Brown Silt/Sand, loose, no odor/staining. Debris present.	NA
2 - 8		Municipal waste, bottles, paper, tires, strips of material, rubber and hose, plastic bags and wood debris in black sediment, saturated with water. Waste extends below water table. Strong odors: hydrocarbon, H_2S, and decayed organics.	SO-W01-UI GW-LE01-UI

Note: Final dimensions after exploring the lateral extent of buried wastes: 30' long x 7' wide x 8' deep. Extent of waste extends into central depression between TT5, TT6, TT7 and TT8. Photo-documented by Mike Morris & Steve Scheidt. Air monitoring conducted by Chad Kelly.

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EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Steve Scheidt**
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Test Trench- UI-TT-07

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetated berm.	
0 - 2	Berm contains burnt and unburnt waste, plastics, cardboard, paper, wood, glass and metal scrap. Water table encountered at 2'.	NA
2 - 11	Area of TT7 extended towards central depression surrounded by TT5, TT6, and TT8. Little to no soil. Waste completely saturated with water. Depth of waste below 11 ft undetermined. Neoprene electrical wire insulation, clear plastic sheeting, rubber strips, garden hose, wooden 2 x 4's, tires, and wastes such as deodorant cans, shaving cream cans, and an old Tabasco sauce bottle. Strong odors: hydrocarbon H2S, and decayed organics. Leachate is dark grey color.	NA

Note: Extent of waste could not be determined in the north direction. Excavation of berm would break small ponded area on the other side. Final dimensions: Approximately 25' long x 7' wide x 11' deep. Photo-documented by Mike Morris & Steve Scheidt. Air monitoring conducted by Chad Kelly.

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Test Trench- UI-TT-08

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Moderate vegetation on small mounded berm. Debris such as wood, tires, and rusted appliances.	
0 - 5.5	Debris found: garden hose, plastics, tires, spray cans, vinyl tarp. Soil had strong odors: decayed organics, and similar to burnt plastics.	NA
5.5 - 8	Silt and Sand. Black staining.	NA
Note:	Final dimensions: 12' long x 6' wide x 8' deep. Extent of waste found on southeastern edge of trench. Photo-documented by Mike Morris and Steve Scheidt. Air monitoring by Chad Kelly.	

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LOGGED BY: **Stephen Scheidt**
SIGNATURE:

Test Trench- UI-TT-09

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Some surface debris noted: tire, crushed empty drum, and a pipe. Vegetated.	
0 - 9	Light brown Silt and Sand, loose, dry, no odor staining. Minimal debris: a tire, PVC pipe fragments and some wood pieces.	NA
9 - 12	Brown Silty Sand, moderately cohesive, moist, no odor, some light orange and dark grey banding/mottling or staining.	NA

Note: Final dimensions: 16' long x 5' wide x 12' deep. TT9 located 150' west/northwest from Pond A piezometer. Photo-documented by Stephen Scheidt. Air monitoring by Chad Kelly. Refer to S.S. field book for trenching activities log.

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EXCAVATOR: **TMC, Dick Hadley-Operator**
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Test Trench- UI-TT-10

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetated berm top. Little debris on surface.	
0 - 3	Light brown Silt and fine Sand, well sorted, loose, no odor staining. Some debris: pipe, wood, plastic, vinyl strips, and municipal waste items.	NA
3 - 16	Groundwater encountered at 4' BGS. Contents include plastic toys, pipe, wire, plastic sheeting, vinyl strips, rubber strips, electrical insulation, glass bottles, scrap metal, rubber garden hose, unidentified materials/objects, propane cylinder and wood. Waste saturated with water, gray leachate. Slight hydrocarbon odor, dark gray to reddish gray stained soil.	**SO-W02-UI** **GW-LE02-UI**

Note: Waste depth ranged from 4' to 16' bgs. TT10 consisted of several small test trenches and therefore do not have length and width measurements. Trenching was photo-documented by Steve Scheidt and air monitoring conducted by Chad Kelly. Refer to S.S. fieldbook for trenching activities log.

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EXCAVATOR: **TMC, Dick Hadley-Operator**
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Test Trench- UI-TT-11

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetated berm top. Some debris: pipe, scrap metal, and plastic.	
0 - 1	Light brown Silt and Sand, loose, dry, no odor, orange rust staining. Debris increasing with depth immediately upon excavation: rusted pipe and plastic.	NA
1 - 9	Debris and waste extending into water table 4' bgs. Rubber hose, rusted metal, pipe, car parts, cylinders, canisters, plastic, and paper.	NA

Note: TT11 adjecent to TT10 to the southwest. Dimensions: Approximately 20' long x 7' wide x 9' deep. Depth of buried waste could not be determined due to high groundwater in test trench. Trenching was photo-documented by Steve Scheidt and air monitoring conducted by Chad Kelly. Refer to S.S. fieldbook for trenching activities log. Leachate and waste samples collected from trench.

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Test Trench- UI-TT-12

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation, wood debris, bare light grey sandy soil, loose, dry, no odor/staining.	
0 - 3	Light gray Sand, loose, dry, no odor/staining. Some debris: tires, plastic, wood.	NA
3-10	Dark gray Silty Sand, loose, moist, reddish black staining, strong decayed organic odor.	NA

Note: TT12 used to delinate the edge of buried waste pit area near TT10, TT11, and TT13. Trenching was photo-documented by Steve Scheidt and air monitoring conducted by Chad Kelly. Refer to S.S. fieldbook for trenching activities log.

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Test Trench- UI-TT-13

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetated berm, gravel, sand and silt on surface.	
0 - 12	Light grey silt and sand, loose, dry, and some dark grey/black staining near the bottom of the trench. No waste encountered.	NA

Note: Final Dimensions: Approximately 20' long x 6' wide x 12' deep. Trenching was photo-documented by Steve Scheidt and air monitoring conducted by Chad Kelly. Refer to S.S. fieldbook for trenching activities log.

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Test Trench- UI-TT-14

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetated lowland area, loose Sand and Silt. Little debris.	
0 - 3	Light grey fine Sand, well sorted, loose, dry, and no odor or staining. Some light yellow/brown Sand.	NA

Note: TT14 is located in the depression northeast of the canal berm and between the canal berm and Pond A. Final dimensions: 15' long x 7' wide x 3' deep. Trenching was photo-documented by Steve Scheidt and air monitoring conducted by Chad Kelly. Refer to S.S. fieldbook for trenching

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Test Trench- UI-TT-15

Depth Interval	Description	Lab Sample ID
Ground Surface	Trace vegetation, organic/plant matter, Sand.	
0 - 7	Light grey fine Sand, well sorted, loose, dry, and no odor or staining. Some light yellow/brown Sand. No debris/waste found.	NA

Note: Trenching was photo-documented by Steve Scheidt and air monitoring conducted by Chad Kelly. Refer to S.S. fieldbook for trenching activities log.

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LOGGED BY: **Stephen Scheidt**
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Test Trench- UI-TT-16

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Light gray fine Sand, well sorted, loose, low moisture, no odor/staining.	
0 - 3	Light gray fine Sand, well sorted, loose, low moisture, no odor/staining.	NA
3 - 6	Dark brown silty Sand, well sorted, loose, moist, no staining, organic odor	NA
6 - 7	Gravel and cobbles, poorly sorted, rounded, hard, moist, no odor/staining. Not penetrated by excavator.	NA

Note: Final dimensions: 12' long x 5' wide x 7' deep. No debris found; no evidence of dumping. Trench located on northeast end of unnamed island. Trenching was photo-documented by Steve Scheidt and air monitoring conducted by Chad Kelly. Refer to S.S. fieldbook for trenching activities log.

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SIGNATURE:

Test Trench- UI-TT-17

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetated berm and slope into depression (suspected waste pit). Debris: woods planks and scrap metal from cars, appliances, tires, and cinder blocks	
0 - 3	Brown Silt and Sand, loose, low moisture, no odor/staining. Debris: tires, scrap metal, tires, plastics, paper, and wood debris.	NA
3 - 6	Dark grey Silty, Sandy mud, saturated, strong hydrocarbon, H_2S, and decayed organic odors. Mostly waste: rubber hose, plastics, scrap metal, strips of material, wood, pipe, and unidentified metal machine parts. Water table at 6' bgs.	NA
> 6	Same as above.	NA

Note: Trash is 6' thick in crest of berm, and slopes into depression where waste is found below water table. Waste at depth could not be determined due to the water table. Area between berms in this area shakes and vibrates with the movement of the excavator similar to Pond E tire pit area. Trenching was photo-documented by Steve Scheidt and air monitoring conducted by Chad Kelly. Refer to S.S. fieldbook for trenching activities log.

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DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-17A

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0 - 2	Yellowish brown sand.	NA
2 - 7.5	Dark gray Sand and Gravel. Organic odor.	0.8
7.5	Same as above. Ground water encountered	NA

Notes: Dimensions: 22' long, 4' wide, 7.5' deep. No buried waste observed in Trench 17A Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

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EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Stephen Scheidt**
SIGNATURE:

Test Trench- UI-TT-18

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Dense vegetation. Some debris, such as plastic doll parts.	
0 - 2	Brown Silt and Sand, well sorted, loose, moist, no odor detected, rust and black staining. Debris: plastics, paper, roofing tile, unidentified granular material (see photos)	NA
2 - 8	same as above, depth of waste undefined.	NA
> 8	same as above, depth of waste undefined.	NA

Note: Trench located near haul road built by ENPRO. Waste found on the northwest side; waste not found on southeast side. Trenching was photo-documented by Steve Scheidt and Mike Morris. Air monitoring conducted by Chad Kelly. Refer to S.S. field book for trenching activities.

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LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-18A

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0 - 6	Yellowish brown sand.	NA
6-7.5	Poorly sorted Sand and Gravel. Ground water encountered at approximately 7.5 feet below ground surface.	0.8

Notes: Dimensions: 17' long, 4' wide, 7.5' deep. No buried waste observed in Trench 18A Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

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EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-19

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-9	Well sorted yellowish brown Sand; loose, dry. Ground water encountered at approximately 9 feet below ground surface.	0

Notes: Dimensions: 19' long, 4' wide, 9' deep. No buried waste observed in Trench 19. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-20

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-8	Well sorted yellowish brown Sand; loose, dry. Mild organic odor.	NA

Notes: Dimensions: 16' long, 4' wide, 8' deep. No buried waste observed in Trench 20. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-21

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-8.5	Well sorted yellowish brown Sand; loose, dry.	NA

Notes: Dimensions: 19' long, 4' wide, 8.5' deep. No buried waste observed in Trench 21. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

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FIELD TEST TRENCH LOGS

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-22

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-7	Well sorted yellowish brown Sand; loose, dry.	0.3
7-8	Poorly sorted Sand and Gravel; loose, wet. Ground water encountered at approximately 8 ft below ground surface.	NA

Notes: Dimensions: 20' long, 4' wide, 8' deep. No buried waste observed in Trench 22. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-23

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-6	Well sorted yellowish brown Sand; loose, dry.	0.8
6-6.5	Poorly sorted Sand and Gravel; loose, moist.	NA

Notes: Dimensions: 17' long, 4' wide, 6.5' deep. No buried waste observed in Trench 23. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-24

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-8	Well sorted yellowish brown Sand; loose, dry.	0.4
8-9	Poorly sorted Sand and Gravel; loose, wet. Ground water encountered at approximately 8 ft. below ground surface.	NA

Notes: Dimensions: 17' long, 4' wide, 9' deep. No buried waste observed in Trench 24. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-25

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-7.5	Well sorted yellowish brown Sand; loose, dry.	0.8
7.5-8	Poorly sorted Sand and Gravel; loose, wet. Ground water encountered at approximately 8 ft. below ground surface.	NA

Notes: Dimensions: 17' long, 4' wide, 8' deep. No buried waste observed in Trench 25. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-26

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-7.5	Well sorted yellowish brown Sand; loose, dry.	0.0

Notes: Dimensions: 18' long, 4' wide, 7.5' deep. No buried waste observed in Trench 26. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

SHIELD
Environmental Associates, Inc.
2456 Fortune Drive, Lexington KY 40509

FIELD TEST TRENCH LOGS

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-27

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-7.5	Well sorted yellowish brown Sand with some Gravel; loose, dry.	0.0

Notes: Dimensions: 16' long, 4' wide, 8' deep. No buried waste observed in Trench 27. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-28

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-8.5	Well sorted yellowish brown Sand; loose, dry.	0.0

Notes: Dimensions: 18' long, 4' wide, 8.5' deep. No buried waste observed in Trench 28. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-29

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-5	Poorly sorted, yellowish brown Sand and Gravel; loose, dry.	0.0

Notes: Dimensions: 19' long, 4' wide, 5' deep. No buried waste observed in Trench 29. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

PROJECT/CLIENT: **Peterson/Puritan**
SHIELD PROJECT NO: **300-1821-0200**
SITE NAME/LOCATION: **Peterson/Puritan, Cumberland, Rhode Island**
DATE: **10/24/2003**
EXCAVATOR: **TMC, Dick Hadley-Operator**
LOGGED BY: **Michael E. Morris**
SIGNATURE:

Test Trench- UI-TT-30

Depth Interval (ft bgs)	Description	Lab Sample ID
Ground Surface	Vegetation. No surface debris observed.	
0-4	Well sorted reddish brown Sand; loose, dry. Mounded fill material with no buried waste.	0.0

Notes: Dimensions: 10' long, 4' wide, 4' deep. No buried waste observed in Trench 30. Trenching was photo-documented Mike Morris. Air monitoring conducted by Chad Kelly.

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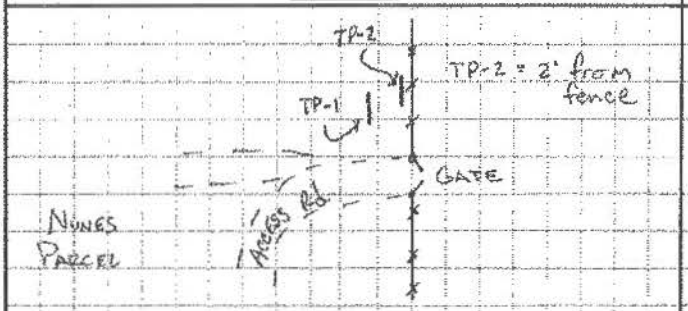
Test Pit Log

Test Pit ID: TP-1

Client:	PETERSON PURITAN	**Date/Day:**	10/31/06
Project:	NUNES PARCEL	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	40's A.M. Low 70's P.M.
Project #:	37902	**Wind:**	Light
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE SURVEY DATA	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View

Test Pit Dimensions:	12'L x 10'D x 3' W	**Total Depth:**	10'	**Depth to Water:**	N/A

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0 - 0.5		BR. VF-M Sand, Some f-SR Gravel, trace rootlets, dry. Surface debris in vicinity of TP (steel scrap, old metal drum).	N/A
0.5 - 3.0	0.0	Drk. Br. Soil mixed w/ wood chips, little metal scrap.	
3.0 - 10.0'	N/A	Drk Br. to Br. VF-M SAND mixed w/ rubber matting, foam, cloth/fabric.	
		12" Diam Concrete culvert encountered Running || to TP. Pipe filled in at least 3/4 of sediment although some H_2O did come out of pipe when it was inadvertantly disconnected. Possible old Stormwater pipe which is inactive.	
		* Hard to tell if H_2O coming in TP is from GW or the Gravel around the PVC pipe.	

Notes:

① Debris appeared to be at least as deep as the 12" pipe encountered. Could not see definite bottom since TP filled in w/ H_2O

Photograph Summary: - will confirm @ TP-5

#1	#1 Concrete Pipe (12")
#2	
#3	#3 Rubber, foam
#4	#4 Debris Around 8-10' bgs

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Test Pit Log

Test Pit ID: TP-2

Client:	PETERSON PURITAN	**Date/Day:**	10/31/06
Project:	NYMES PARCEL	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	40's A.M. / 70's P.M.
Project #:	37902	**Wind:**	Slight
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE Survey DATA	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View	Profile View
SEE TP-1 Plan View	

Test Pit Dimensions:	12'L x 10'D x 3'W	**Total Depth:**	10'	**Depth to Water:**	N/A

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-3.0'	0.0	Top Soil: Trace debris in 0-3' depth (woodchips w/ some fabric) Primarily Surficial debris.	N/A
3-7.5'	0.0	Lt. Br VF-m SAND, trace C-Sand & f-SR Gravel, dry	
7.5-10'	0.0	Brown VF-Sand, trace Clay, moist.	

Notes:

-TP used as Step-out from TP-1 were debris was encountered at greater depth and quantities.

Photograph Summary:

#1	#5 Trace debris in Top 3'
#2	#6 TP-2 facing N-NE
#3	#7 Spoil Pile on Plastic Sheeting
#4	#8 After Backfilling TP-1 & TP-2

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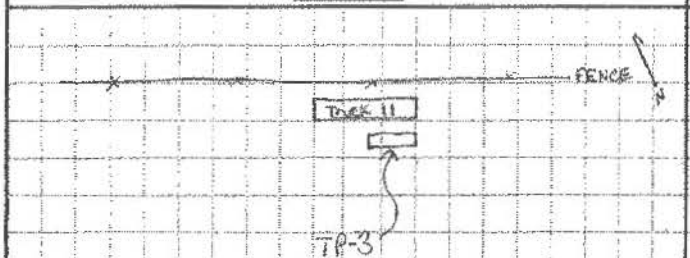
Test Pit Log

Test Pit ID: TP-3

Client:	Peterson Puritan	**Date/Day:**	10/31/06
Project:	Nunes Parcel	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	40's A.M. / 70's P.M.
Project #:	37902	**Wind:**	Slight
Logged By:	Shawn Wolf	**Subcontractor:**	MARCOR
Coordinates:	See Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View	Profile View



Test Pit Dimensions:	12' L X 13'D X 3'	**Total Depth:**	13'	**Depth to Water:**	57.4' AMSL

8.5' B.G.S.

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-1.5	0.0	Top Soil: Brown YF-M sand, trace f-SA Gravel, dry	SO-102-NP (0-1') @ 1035
1.5-1.9		Layer of wood chips.	
1.9-8.5	0.2	Bk. to drk. BR. f-M Sand, some Gravel, mixed with (partially burnt wood, metal sheeting Scrap pipe. Debris encountered to interface w/ water	SO-102-NP(2-8.5') @ 1110
8.5-13'	0.0	Fine to Coarse SR-R Gravel, some M-C Sand, wet.	

Notes:

#9 TP-3 Location of Surface Sample
#10 TP-3

Photograph Summary:

#1	#11
#2	#12 TP-3
#3	#13 Debris @ TP-3 (3.5-8.5')
#4	#14 Gravel/Cobbles @ TP-3

#15 TP-3 before backfilling - north side

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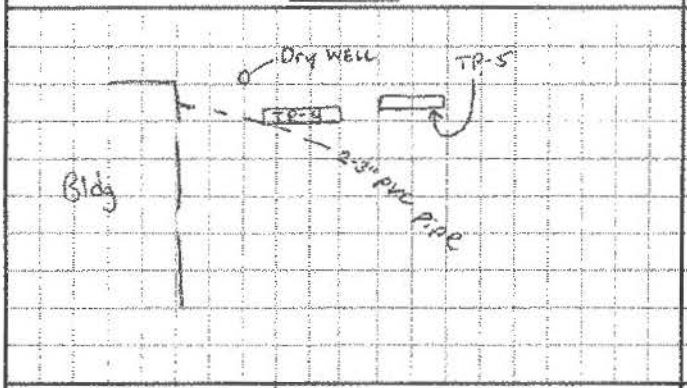
Test Pit Log

Test Pit ID: TP-4

Client:	PETERSON PURITAN	**Date/Day:**	10/31/06
Project:	NUNES PARCEL	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	40's a.m. / 70's P.M.
Project #:	37902	**Wind:**	Slight
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE Survey DATA	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View

Test Pit Dimensions:	10'L x 7'D x 6'W	**Total Depth:**	10'	**Depth to Water:**	

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-1'		Topsoil: Dark Brown f-m Sand, little f-Sc-Ang Gravel, dry	N/A
1-2'	0.0	Drk Brown VF-m SAND, Some f-c Angular Gravel, dry	
2-4'	2.4	Drk Gray to Drk Br. Silt & Angular Gravel, petroleum	
		like odor, however no Sheen observed when mixed w/ H_2O	
4-7'	0.3	Mix of Angular 2" Gravel and rounded Gravel,	
		WET. unable to see sides of TP at this depth due to H_2O filling in TP.	

Notes:

Photograph Summary:

#1	#16 3-4" PVC PIPE (sewer)
#2	#17 TP-4 FACING N(W (H2O filling in)
#3	#18 Gravel
#4	#19 Soil w/ petroleum like odor

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Test Pit Log

Test Pit ID: TP-5

Client:	Peterson Puritan	**Date/Day:**	10/31/06
Project:	Nunes Parcel	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	40's a.m. / 70's p.m.
Project #:	37902	**Wind:**	Slight
Logged By:	Shawn Wolf	**Subcontractor:**	MARCOR
Coordinates:	See Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View	Profile View
(See TP-4 Log)	

Test Pit Dimensions:	9'L x 6'D x 3'W	**Total Depth:**	6'	**Depth to Water:**	5'

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-1		Topsoil: Br. to Drk. Brown VF-m sand, dry.	N/A
1-4'	0.1	Dark Br. F-C SAND & rounded Gravel, Some brick & concrete fragments, little wood, dark gray Silt & VF-m SAND, moist	
4-6	0.0	SAND & Rounded F-C Gravel, Some Cobbles, wet. Appears to be native material.	
		TP terminated due to GW coming in Excavation.	

Notes:

- No odors observed here.
- Step out for TP-4

Photograph Summary:

#1	#20 Excavating @ TP-5
#2	#21 Water in TP-5
#3	#22 " "
#4	#23 Spoil Pile @ TP-5

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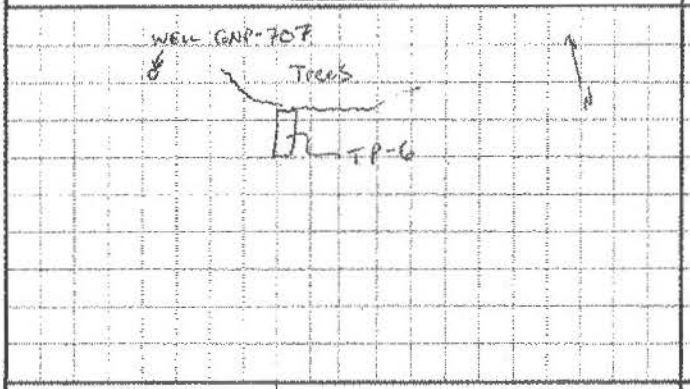
Test Pit Log

Test Pit ID: TP-6

Client:	PETERSON PURITAN	**Date/Day:**	10/31/06
Project:	NUNES PARCEL	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	40's AM / 70's P.M.
Project #:	37902	**Wind:**	Slight
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE SURVEY DATA	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View

Test Pit Dimensions:	12'L x 11'D x 3'W	**Total Depth:**	11'	**Depth to Water:**	N/A

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-6'		Lt. Br f-m SAND, occassional cobble & Boulder, dry [FILL]	N/A
5-6'		Trace debris (wood, bricks, plastic) Very thin layer of debris	
6-11'		Brown f-m SAND, trace Silt & f-c SR Gravel, dry (Appears Native)	

Notes:

Photograph Summary:

#1	#24 Fine layer of debris @ TP-6
#2	#25 TP-6 looking North
#3	#26 TP-6 looking N-NW
#4	#27 Spoil pile @ TP-6

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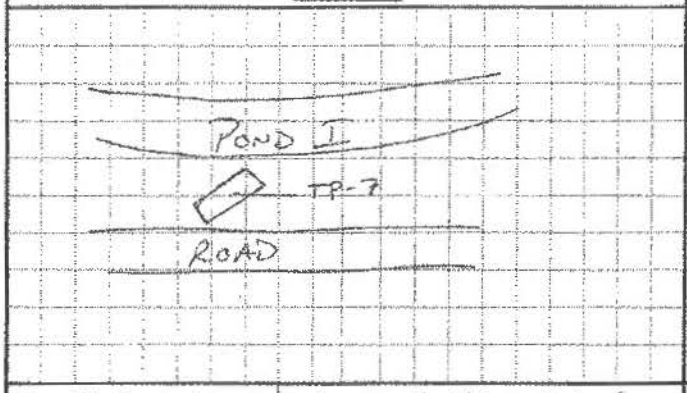
Test Pit Log

Test Pit ID: TP-7

Client:	Peterson Puritan	**Date/Day:**	11/1/06
Project:	Nynes Parcel	**Weather:**	50's cloudy
Location:	Cumberland, RI	**Temperature:**	
Project #:	37902	**Wind:**	Slight
Logged By:	Shawn Wolf	**Subcontractor:**	MARCOR
Coordinates:	See Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View

Test Pit Dimensions:	10'L x 11.5'D x 4'W	**Total Depth:**	11.5	**Depth to Water:**	10'

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-2'		Debris (concrete, bricks) observed on surface. Dark Brown Silt & VF-F sand, dry.	N/A
2-8'	0.0	Brown f-m sand, little Silt mixed w/ Concrete, bricks, Green Garden hose steel	
		wire & strapping, dry (majority of debris is between 2-4' bgs)	
8-11.5'	0.0	Dark Br. Silt, some clay, trace fine SAND, moist. Wet @ 10' bgs. Material	
		Appears to be native.	

Notes:

H_2O Coming in @ 10' bgs

Photograph Summary:

#1	#28 Debris found at TP-7
#2	#29 Rubber Hose
#3	#30 TP-7
#4	#31 TP-7
	#32 TP-7
	#33 After Backfill

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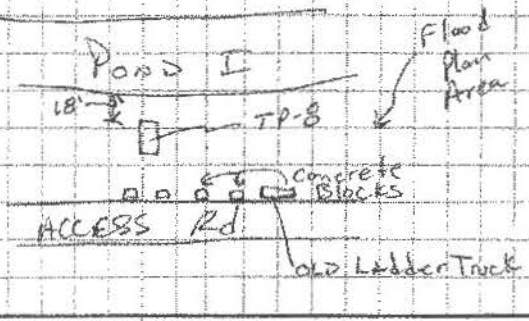
Test Pit Log

Test Pit ID: TP-8

Client:	Peterson Puritan	**Date/Day:**	11/1/06
Project:	Nunes Parcel	**Weather:**	Sunny 60's
Location:	Cumberland, RI	**Temperature:**	60's
Project #:	37902	**Wind:**	Slight
Logged By:	Shawn Wolf	**Subcontractor:**	MARCOR
Coordinates:	See Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View

Test Pit Dimensions:	9'L x 5'D x 3'W	**Total Depth:**	5'
Depth to Water:	4'		

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-4'	0.0	Brown f-M Sand & Silt, rootlets, moist	N/A
4-5'	0.0	Brown f-C Gravel & M-C Sand, wet.	

Notes:

- Did not Encounter Debris

Photograph Summary:

#1	#34: TP-8
#2	#35: Sidewall of TP-8
#3	#36: View of TP-8 w/ Pond I in Background
#4	#37: View of Excavator @ TP-8

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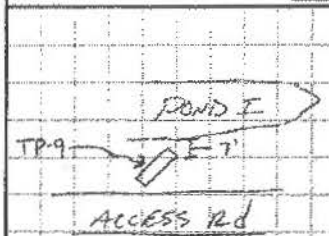
Test Pit Log

Test Pit ID: TP-9

Client:	Peterson Puritan	**Date/Day:**	11/1/06
Project:	Nunes Parcel	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	70's
Project #:	37902	**Wind:**	Slight
Logged By:	Shawn Wolf	**Subcontractor:**	MARCOR
Coordinates:	See Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View

Test Pit Dimensions:	12'L x 8'D x 3'W	**Total Depth:**	8'	**Depth to Water:**	7'

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-7'	0.0	Brown f-m sand, little silt, trace c-Sand & f-sm Gravel, rootlets, moist.	SO-100-NP(2-7')@ 1015
7-8'	0.1	Brown f-c Gravel, some m-c sand, wet. [Appears to be Native Material]	MS/MSD also collected.

Notes:

Approx 7' from H2O's Edge @ Pond I
No Debris Encountered.

Photograph Summary:

#1	#38 TP-9
#2	#39 " "
#3	#40 " "
#4	#41 Spoil Pile @ TP-9

#42 View of TP-9 w/ Pond I in Background.

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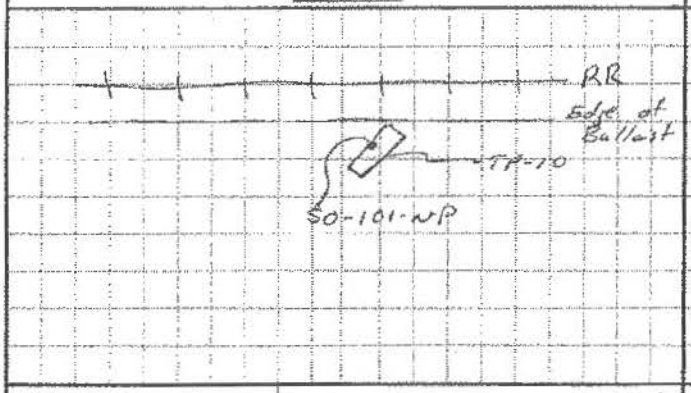
Test Pit Log

Test Pit ID: TP-10

Client:	PETERSON PURITAN	**Date/Day:**	11/1/06
Project:	NUNES PARCEL	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	70's
Project #:	37902	**Wind:**	Slight
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE Survey DATA	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View

Test Pit Dimensions:	16' L X 10.5' D X 3' W	**Total Depth:**	10.5	**Depth to Water:**	10.0'

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0 - 9.5'		Brown f-m SAND, some c-sand, little f-Rounded Gravel, dry. one old fire pond at 0.5' bgs	SO-101-NP(0-1') @ 1100
9.5 - 10		Dark gray Silt, little vf sand, trace Clay, moist to wet.	
10 - 10.5		Brown f-c sand & f-m Rounded Gravel, wet.	
			SO-101-NP(2-9') @ 1125
			(Just Above W.T.)

Notes:

No Debris found in Subsurface.

Photograph Summary:

#1	#43 Sidewall of TP-10
#2	#44 H2O seeping in @ TP-10
#3	#45 TP-10 w/ RR tracks in bkgrd.
#4	#46 Turtle

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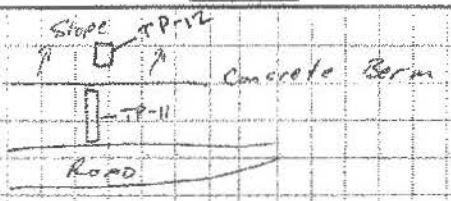
Test Pit Log

Test Pit ID: TP-11

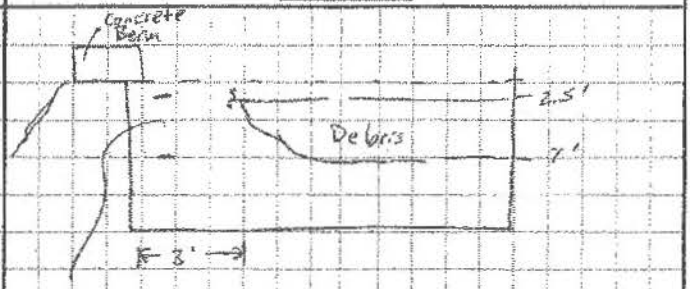
Client:	PETERSON PURITAN	**Date/Day:**	11/1/00
Project:	NUNES PARCEL	**Weather:**	Cloudy
Location:	Cumberland, RI	**Temperature:**	70's
Project #:	37902	**Wind:**	Slight
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE SURVEY DATA	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View



Test Pit Dimensions:	13'L x 11'D x 3'W	**Total Depth:**	11'	**Depth to Water:**	n/a

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-2.5	0.0	Brown f-m sand, some silt, little f-m SR to Rounded Gravel, dry	
2.5-7'	0.4	Dark Brown f-m sand & f-SR-SA Gravel mixed with Plastic Bags, tires, glass bottles, wire, wood that tappers off as you go towards concrete berm.	SO-103-NP(2-7') @ 1330
			↓
7-11'	0.0	Dark Br. to gray VF-F sand, some silt, trace f- Rounded gravel, dry	Approx 2' from concrete berm and 2' from debris.

Notes:

Debris Appears to stop ~ 3' From Concrete berm. TP-12 Excavated to confirm edge of debris.

Photograph Summary:

#1	#47 Debris Spoil Pile @ TP-11
#2	#48 " "
#3	#49 " "
#4	#50 TP-11

#51 Debris Tappering off @ TP-11
#52 Looking back towards ed @ debris
#53 debris Tappering off @ wall

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Test Pit Log

Test Pit ID: TP-12

Client:	Peterson Puritan	**Date/Day:**	11/1/00
Project:	Nyhes Parcel	**Weather:**	Cloudy
Location:	Cumberland, RI	**Temperature:**	70's
Project #:	37902	**Wind:**	Slight
Logged By:	Shawn Wolf	**Subcontractor:**	MARCOR
Coordinates:	See Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View	Profile View
See TP-11 Plan View	

Test Pit Dimensions:	7'L x 4'D x 3'W	**Total Depth:**	4'	**Depth to Water:**	

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-3'	N/A	Brown to Dk. Brown VF-F Sand, some Silt, trace Rounded Gravel, dry.	N/A
		Little Debris on Surface to 1' bgs. Appears to be primarily from debris going over Concrete Berm.	
3-4'	0.0	Dark Brown Silt & VF Sand, moist (Appears Native)	

Notes:

Approx. 6' from wall

Photograph Summary:

#1	#54
#2	#55
#3	
#4	

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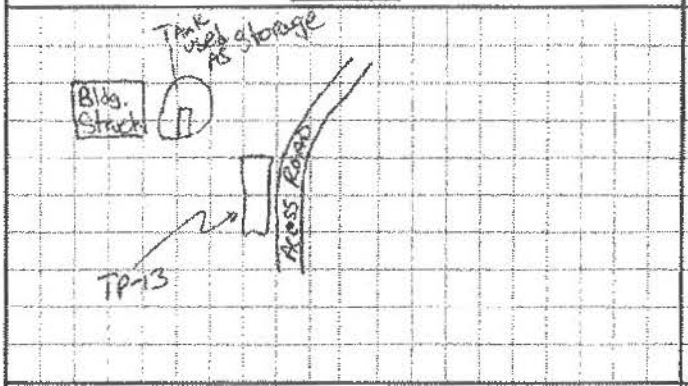
Test Pit Log

Test Pit ID: TP-13

Client:	Peterson Puritan	**Date/Day:**	11/1/06
Project:	Nunes Parcel	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	70's
Project #:	37902	**Wind:**	Slight
Logged By:	Shawn Wolf	**Subcontractor:**	MARCOR
Coordinates:	See Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View

Test Pit Dimensions:	12'L x 16'D x 4'W	**Total Depth:**	16'	**Depth to Water:**	10.1'

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-0.4	-	Asphalt (Right on Edge of Road) Asphalt Covered w/ some soil	N/A
0.4-2.5	0.2	Brown f-m SAND, some fine Rounded Gravel, dry (cover)	
2.5-16'	0.5	Dark Brown f-m Sand, some to little cobbles mixed w/ debris	
		Debris included: Large wooden spool ends, wood, rubber belts plastic sheeting & bags, fabric (both intact and	
	Sniffed around debris pile and did not observe any elevated PID Readings	Shredded) brick, wire, metal screens, glass bottles, cans, gas oven burner plate,	
		Newspaper (1977), phone book, pop cans, few tires, (6) metal drum lids (Bogus?) w/ what looks like red paint residue on inside of lids.	
	-	Reached full Extent of Excavators Reach. Did not encounter Bottom of waste.	

Notes:

#62	Drum Lids
#63	TP-13
#64	TP-13
#65	TP-13

#66 Debris Pile

Photograph Summary:

#1	#56 Excavating @ TP-13
#2	#57 White Sand layer @ TP-13
#3	#58 Debris Pile
#4	#59 Newspaper

#60 Debris Pile
#61 Debris Pile

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Test Pit Log

Test Pit ID: TP-14

Client:	PETERSON PURITAN	**Date/Day:**	11/1/06
Project:	NUNES PARCEL	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	70's
Project #:	37902	**Wind:**	Slight
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE Survey DATA	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View	Profile View
SEE Survey Data	

Test Pit Dimensions:	10'L x 13'D x 4'W	**Total Depth:**	13'	**Depth to Water:**	

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0 - 4'	0.0	Brown f-m Sand, little f-m Subrounded Gravel, trace Silt, dry.	N/A
4 - 10		Debris: Copper cable, electrical conduit, wood, cobbles, little plastic	
		water Seep @ 8' bgs	
10 - 13		Brown f-m SAND, little Silt, trace f-c SR Gravel, moist to wet.	

Notes:

Photograph Summary:

#1	photos 67 - 72
#2	
#3	
#4	

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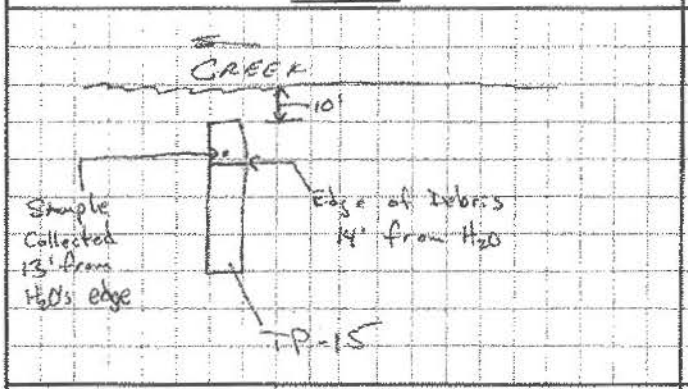
Test Pit Log

Test Pit ID: TP-15

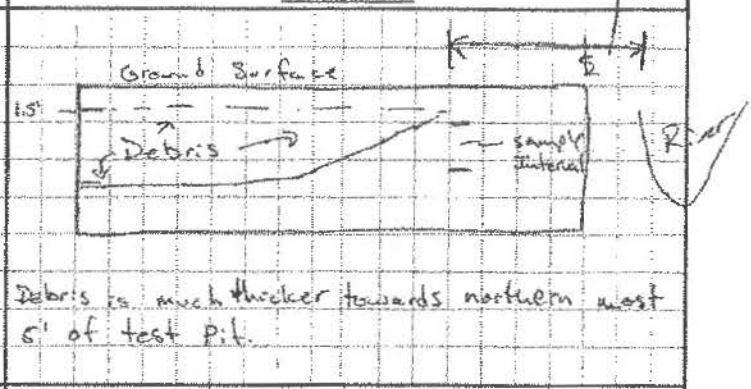
Client:	PETERSON PURITAN	**Date/Day:**	11/2/06
Project:	NUNES PARCEL	**Weather:**	Cloudy, Rain
Location:	Cumberland, RI	**Temperature:**	50's
Project #:	37902	**Wind:**	Slight
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View



Test Pit Dimensions:	10'L x 7'D x 3'W	**Total Depth:**	7'	**Depth to Water:**	6'

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-1.5	0.0	Some surface debris on surface (Bricks, old tires) Dark Brown Silt & VF-M Sand, roots, moist	
1.5-6	0.0	Br. f-m Sand, Some f-m SR Gravel mixed w/ Debris: Rubber fire hose, plastic netting, 2-3 tires, possible old rusty steel drum remenant (30gal), shredded fabric, cobbles, Bricks, concrete fragments,	SO-106-NP(2-5') @ 0915 ⇓ Sample Collected
		plastic sheeting and bags.	in interval above W.T.
6-7'	0.0	Brown f-c Gravel, Some f-c sand, wet.	
Debris Did not Appear to go Below W.T., however was right at the Interface.			

Notes:

#79 TP-15
80 Possible Drum Remanent @ TP-15?

Photograph Summary:

#1	# 73 TP-15
#2	# 74 TP-15
#3	# 75 Clean Sidewall @ TP-15
#4	# 76 TP-15 w/ Creek

#77 TP-15 Spoil pile
#78 Looking North @ TP-15

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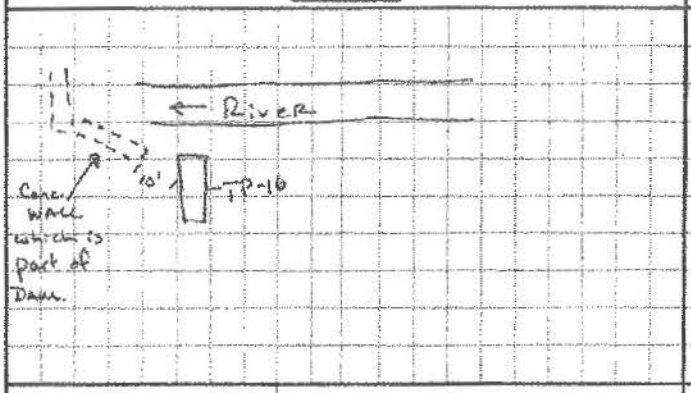
Test Pit Log

Test Pit ID: TP-16

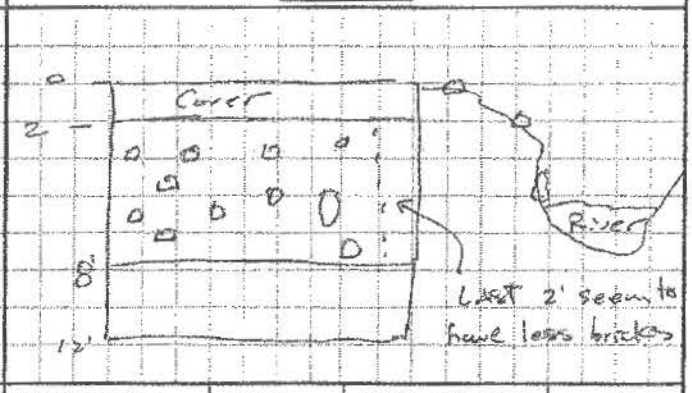
Client:	Peterson Puritan	**Date/Day:**	11/2/06
Project:	Nunes Parcel	**Weather:**	Rain
Location:	Cumberland, RI	**Temperature:**	50's
Project #:	37902	**Wind:**	Slight
Logged By:	Shawn Wolf	**Subcontractor:**	MARCOR
Coordinates:	See Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View



Test Pit Dimensions:	11'L x 12'D x 6'W	**Total Depth:**	12'D	**Depth to Water:**	N/A

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
		- Concrete Blocks on Surface.	
0-2'	0.0	Brown Silt & VF-f Sand, trace f-SR Gravel, dry.	SO-108-NP(3-8') @ 0940
2-8'	0.0	Brown f-m Sand mixed w/ a lot of Bricks, and concrete ~~chunks~~ pieces fragments. Test pit walls hard to keep open due to all of the bricks, etc.	
8-12'	0.0	Dark Brown to Brown Silt & VF-F Sand, moist	Only interval that could be composited due to sidewalls collapsing.

Notes:

Also collected duplicate Sample FD-110206 here.

Photograph Summary:

#1	Photos 81-87 - TP-16
#2	
#3	
#4	

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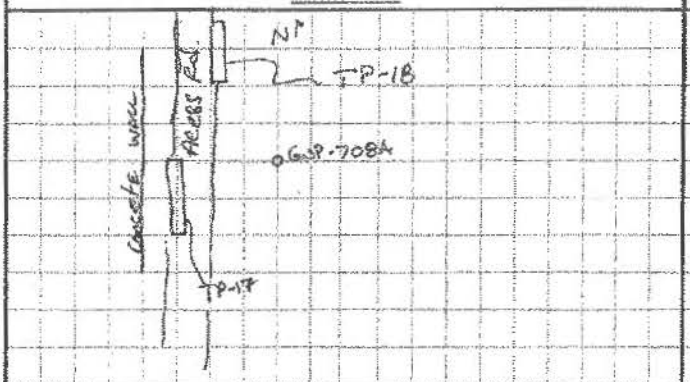
Test Pit Log

Test Pit ID: TP-17

Client:	Peterson Puritan	**Date/Day:**	11/2/00
Project:	Nunes Parcel	**Weather:**	cloudy
Location:	Cumberland, RI	**Temperature:**	50's
Project #:	37902	**Wind:**	Slight
Logged By:	Shawn Wolf	**Subcontractor:**	MARCOR
Coordinates:	See Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View

Test Pit Dimensions:		**Total Depth:**	11.5'	**Depth to Water:**	n/a

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0'-3.4'	0.0	Brown VF-F sand, little m-sand, trace C-Sand, dry.	SO-107-NP (0-1') @1230
0.0-0.2'	0.1	Dark Gray Silt & VF SAND, dry, trace f-sr Gravel. w/ Elevated Pb.	
		Checked several locations within the first 0-1' → sample collected from location w/in Test pit w/ highest Pb level.	
3.4-6'	0.0	Lt. Brown VF-M SAND, dry	SO-107-NP (2-10') @1300
6-11.5'	0.0	Brown VF-M SAND, some c-sand, dry to moist	
Test Pit was outside of was not	moved from fenced in located within	original location since the proposed location the RIDEM Excavation area.	was located Test Pit

Notes:

0-1'	Pb =	1,731 ppm
1-2'	Pb =	1,264 ppm
2-10'	Pb =	33 ppm
11-11.5	Pb =	17 ppm

Photograph Summary:

#1	#89	TP-17
#2	#89	" "
#3	#90	" "
#4	#91	" "
	#92	" "

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Test Pit Log

Test Pit ID: TP-18

Client:	PETERSON PURITAN	**Date/Day:**	11/2/06
Project:	NUNES PARCEL	**Weather:**	Cloudy
Location:	Cumberland, RI	**Temperature:**	50's
Project #:	37902	**Wind:**	Slight
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE Survey DATA	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View	Profile View
SEE TP-17 Plan View	

Test Pit Dimensions:	9'L X 11'D X 3'W	**Total Depth:**	11.0'	**Depth to Water:**	N/A

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-3'	0.0	Brown VF-F sand, little m-sand, trace C Sand, dry	N/A
3-6'	0.0	Lt. Brown to tan VF-m SAND, dry (Appears to be native)	
6-11	0.0	Brown VF-m SAND some C SAND, dry to moist (Appears to be native)	

Notes:

- Additional TP to Attempt to locate debris edge moving North of TP-17.

Photograph Summary:

#1	Photos 93-95 = TP-18
#2	
#3	
#4	

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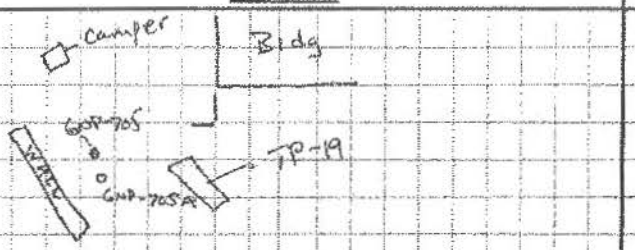
Test Pit Log

Test Pit ID: TP-19

Client:	PETERSON PURITAN	**Date/Day:**	11/2/06
Project:	NUNES PARCEL	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	mid 50's
Project #:	37902	**Wind:**	Slight
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View	Profile View



Test Pit Dimensions:	12'L x 15'D x 5'W	**Total Depth:**	15'	**Depth to Water:**	n/a

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-1'	N/A	Dark Brown Silt, sand, trace fine SR Gravel, dry.	N/A
1-10'	0.0	Lt. Brown to Gray fine SAND, little silt some fine Banded Gravel, dry [Fill]	
10-15'	0.1	Debris: wood, tires, plastic sheeting, plastic bags, rubber Strapping, vs. Customs Information Exchange Document (march 16, 1959)	
		Total Depth = 15' bgs - Could not get to bottom of the waste due to test pit collapse and tp too large.	
- TP Excavated to give better delineation between NE/northeast TP-7 and TP-13			

Notes:

Extra TP outside of shield define debris area.

Photograph Summary:

#1	#96 TP-19 @ 11' deep - Start of waste
#2	97 Spec: pile
#3	98 " "
#4	99 TP-19

100 " "
101 Paper Document

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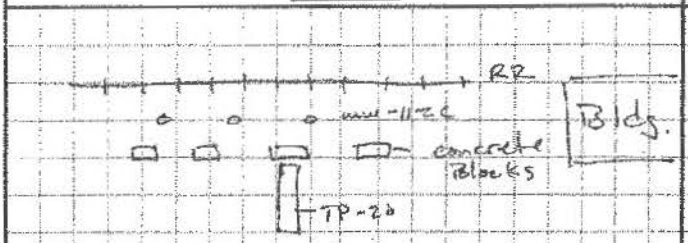
Test Pit Log

Test Pit ID: TP-20

Client:	PETERSON PURITAN	**Date/Day:**	11/3/06
Project:	NUNES PARCEL	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	40's
Project #:	37902	**Wind:**	-
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE SURVEY DATA	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View

Test Pit Dimensions:	10'L x 11.5'D x 3'W	**Total Depth:**	11.5
Depth to Water:	11'		

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0 - 1.5'	0.0	Brown f-m SAND, little C-sand, trace f. GRAVEL, dry.	N/A
1.5 - 8.5'	7.5	Debris: Rubber strapping, steel scrap, plastic, piano-like wire, pizza box, plastic bags, light bulb, bricks, blue tarp. Primarily Industrial-like debris w/ some debris being characteristic of municipal-like.	
8.5 - 11.5	1.0	Dark Brown to gray f-m SAND, some f-c sand & Rounded Gravel, little Silt, trace cobbles, moist wet @ 11.0' bgs.	

Notes:

Photograph Summary:

#1	Photos 102 - 106
#2	
#3	
#4	

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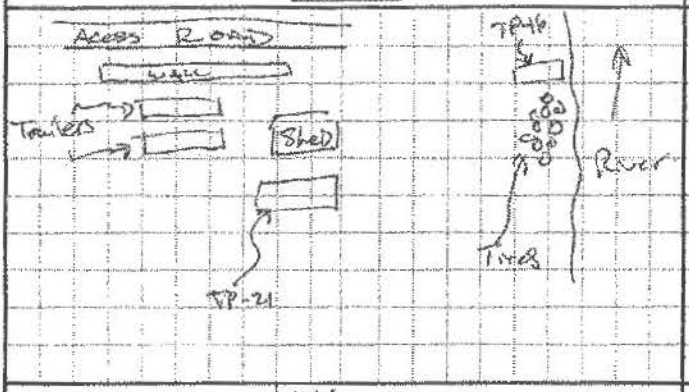
Test Pit Log

Test Pit ID: TP-21

Client:	Peterson Puritan	**Date/Day:**	11/3/06
Project:	Nunes Parcel	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	40's
Project #:	37902	**Wind:**	Slight
Logged By:	Shawn Wolf	**Subcontractor:**	MARCOR
Coordinates:	See Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View



Profile View

Test Pit Dimensions:	10'L x 12'D x 5'W	**Total Depth:**	12'	**Depth to Water:**	N/A

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-3.8'	N/A	Dark Brown to Brown vf-m SAND, some f-SA to SR Gravel, roots, dry	N/A
3.8-6'	0.1	Dark Brown Silt & vf sand, mixed w/ wood & Ash like material (Burnt wood like)	
6-12'	0.0	Brown Silt & vf sand, Appears to have some wood debris and trace bricks on side wall, but difficult to determine if it is from collapse from upper portion of TP.	
		Red Bricks, some partially Burnt wood, cobbles, trace steel mesh	

Notes:

Step in location for TP-16 since nothing other than Brick & concrete was found @ ~~TP-16~~ TP-16, M&E suggested location.

Photograph Summary:

#1	Photos 107 - 111 = TP-21
#2	
#3	
#4	

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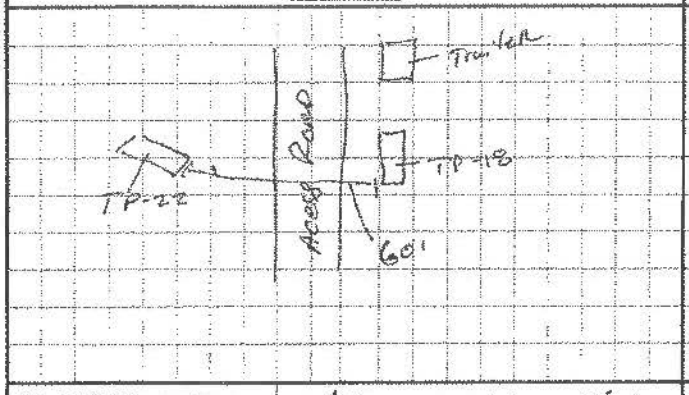
Test Pit Log

Test Pit ID: TP-22

Client:	PETERSON PURITAN	**Date/Day:**	11/3/06
Project:	NUNES PARCEL	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	40's
Project #:	37902	**Wind:**	—
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	See Survey Data	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View	Profile View



Test Pit Dimensions:	12'L x 19'D x 3'W	**Total Depth:**	19	**Depth to Water:**	18'

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-2	0.0	Dark Brown UF-F Sand, some f-c GR Gravel, dry	N/A
2-17.5	N/A	Red Bricks, wood, steel Scrap, plastic mold pieces that look similar to model car pieces, tree Stump, pineapple juice can	
		steel pipe.	
17.5-19'	N/A	Brown f-c Rounded Gravel, Some f-c Sand, wet	

Notes:

Photo of Trancite wrapped in plastic under Trailer 4.
212 ppm Pb (wet)

Photograph Summary:

#1	Photos: 112 - 121
#2	
#3	
#4	

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Test Pit Log

Test Pit ID: TP-23

Client:	PETERSON PURITAN	**Date/Day:**	11/3/00
Project:	NUNES PARCEL	**Weather:**	Sunny
Location:	Cumberland, RI	**Temperature:**	High 40's
Project #:	37902	**Wind:**	—
Logged By:	SHAWN WOLF	**Subcontractor:**	MARCOR
Coordinates:	SEE Survey DATA	**Equipment:**	John Deere 200C Excavator

Sketch of Test Pit Layout:

Plan View	Profile View
Reference Survey Data	

Test Pit Dimensions:	12'L x 16'D x 3'W	**Total Depth:**	16'	**Depth to Water:**	5.5'

Depth Interval (feet)	PID Screening Result (ppm)	Description of Soil/Material	Samples Collected
0-4'		Dark Brown VF-F SAND, some M-C SAND, little F-M GR Gravel, dry	N/A
4-13'		Debris: Steel scrap, plastic string like material, fiberglass fragments, cobbles, one crushed drum, metal wire mixed w/ dark Brown to gray F-M Sand, trace C-Sand, little F-M GR Gravel.	
13-16'		Dark Brown to gray F-M SAND, little C-Sand, moist. wet @ 15.5'	

Notes:

Photograph Summary:

#1	Photos 122-124
#2	
#3	
#4	

SHIELD
Environmental Associates, Inc.
2456 Fortune Drive, Lexington KY 40509

FIELD BOREHOLE LOG
BOREHOLE # GP-1

PROJECT/CLIENT:	**Peterson/Puritan**	DATE/TIME DRILLED:	**09/05/03 14:00**
SHIELD PROJECT NO:	**300-1821-0200**	DRILLING COMPANY:	**Geologic Exploration, Inc.**
SITE NAME/LOCATN:	**Cumberland, Rhode Island**	RIG OPERATOR:	**Emil Schum**
BORING LOCATION	**Nunes Property**	RIG TYPE/METHOD:	**Track Mounted Geoprobe**
LOGGED BY:	**M. Morris**	SAMPLER DIAMETER:	**2 inches** LENGTH: **4 feet**
SIGNATURE:		TOTAL BORING DEPTH:	**8 feet BGS** GS ELEV. **Not Surveyed**

Depth (ft)	Graphic Symbol	USCS Class	Description	Sample ID	PID	% Recovery	Notes
0		ML	**0-8' Fill/Waste Material** 0-3' Very dark gray (10YR 3/1) SILT with some Sand; Stiff, no plasticity, no odors noted; Brick fragments present	**GP-1 (0-1')** **SO-033-NP**		100	
2				**GP-1 (1'-5')** **SO-W14-NP**	2.2	100	
4			3'5' Very dark gray (10YR 3/1) SILT; Soft, no plasticity, dry; No odors; Brick fragments throughout, glass fragments present at approximately 5 feet BGS.				
6			5'-8' Black (10YR 2/1) SILT with some sand; soft, no plasticity, wet at approximately 8 feet BGS. No odors noted. Brick fragments present throughout.	GP-1 (5'-8')	0.6	100	
8			Refusal encountered at 8 feet below ground surface				
10							
12							
14							
16							
18							
20							

Comments: * Samples in bold submitted to laboratory for analysis
BGS - Below Ground Surface

Date Start/Finish: 11/9/05 - 11/10/05
Drilling Company: Boart Longyear
Driller's Name: Jim and Justin
Drilling Method: Rotary Sonic
Bit Size: 5-1/2"
Casing Size: 5-1/2"
Rig Type: Track-Mounted Mini Sonic

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth: 70' bgs
Surface Elevation: NA

Geologist: Sara Klimek/Joseph Lisi

Well/Boring ID: GLF-700A

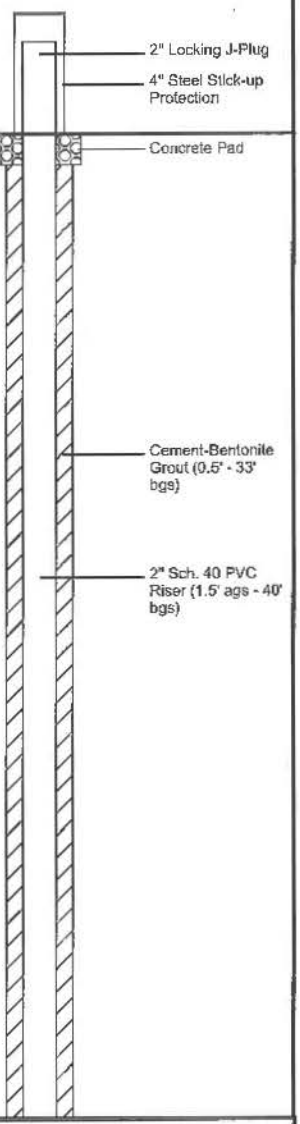
DRAFT

Client:
CCL Custom Manufacturing, Inc.
Best Foods (Formerly CPC International Inc.)
Waste Management

Location: Peterson/Puritan Superfund Site
Landfill Property
Cumberland, RI

DEPTH / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Vertical Profile Int.	Geologic Column	Stratigraphic Description
0 / 0							
0 / 0							Brown Silty fine SAND, some to little Organics (Roots, Wood), non-plastic, moist.
							Brown fine to coarse GRAVEL, little multicolored subrounded Cobbles and fine to coarse Sand, loose, non-plastic, moist.
							Color change to gray, wet below 3.6' bgs.
5 / -5	1	0-10	8.0	0.0	X		
10 / -10							Gray-brown fine to coarse SAND, little fine to coarse subrounded to subangular Gravel, non-plastic, wet.
	2	10-15	2.3	0.0			
15 / -15							
	3	15-20	0.0	0.0			

Well/Boring Construction



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engineers, scientists, economists

Remarks: a/bgs = above/below ground surface; NA = Not Applicable/Available; ND = Not Detected.

Client: CCL Custom Manufacturing, Inc.
Best Foods (Formerly CPC International Inc.)
Waste Management

Site Location:
Peterson/Puritan Superfund Site
Landfill Property
Cumberland, RI

Well/Boring ID: GLF-700A

Borehole Depth: 70' bgs

DRAFT

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Vertical Profile Int.	Geologic Column	Stratigraphic Description	Well/Boring Construction
		3	15-20	0.0	0.0			Gray-brown fine to coarse SAND, little fine to coarse subrounded to subangular Gravel, non-plastic, wet.	Cement-Bentonite Grout (0.5' - 33' bgs)
20	-20							Multicolored subangular to subrounded COBBLES, little fine to coarse subangular to subrounded Gravel, loose, non-plastic, wet.	2" Sch. 40 PVC Riser (1.5' ags - 40' bgs)
								Gray-brown fine to coarse SAND and fine to coarse GRAVEL, some subrounded Cobble, loose, non-plastic, wet.	
25	-25	4	20-30	1.5	0.0	X			
30	-30							Gray-brown fine to coarse SAND and fine to coarse GRAVEL, loose, non-plastic, wet. Increased Sand content from 31' - 32' bgs.	
		5	30-40	2.7	0.0				Bentonite Chips (33' - 38' bgs)
35	-35								

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Client: CCL Custom Manufacturing, Inc.
Best Foods (Formerly CPC International Inc.)
Waste Management

Site Location:
Peterson/Puritan Superfund Site
Landfill Property
Cumberland, RI

Well/Boring ID: GLF-700A

Borehole Depth: 70' bgs

DRAFT

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Vertical Profile Int.	Geologic Column	Stratigraphic Description
		5	30-40	2.7	0.0			Gray-brown fine to coarse SAND and fine to coarse GRAVEL, loose, non-plastic, wet.
40	-40							Gray-brown fine SAND, some Silt, medium dense, non-plastic, wet.
								Brown-gray fine to coarse SAND and multicolored fine to coarse subrounded to subangular GRAVEL, non-plastic, wet. Increased Sand content below 40.85' bgs.
								Brown-gray fine to coarse SAND, some fine Gravel and fine Sand, non-plastic, wet.
								Light brown fine to coarse SAND, non-plastic, wet. Grain size increases below 42.8' bgs.
								Color change to orange between 42.8' - 43' bgs.
45	-45	6	40-50	4.0	0.0			
50	-50							Brown fine to coarse SAND and multicolored fine GRAVEL, trace Silt, loose, non-plastic, wet.
								Brown Silty fine SAND, some medium to coarse Sand, little medium to coarse subrounded Gravel, non-plastic, wet.
								Brown fine to coarse subrounded GRAVEL, little fine to coarse Sand, trace Silt, non-plastic, wet.
		7	50-60	2.0	0.0			
55	-55							

Well/Boring Construction

- Bentonite Chips (33' - 38' bgs)
- 2" Sch. 40 PVC Riser (1.5' ags - 40' bgs)
- #0 Silica Sand Pack (38' - 51' bgs)
- 2" Sch. 40 PVC 0.010" Slot Screen (40' - 50' bgs)
- Bentonite Chips (51' - 52' bgs)
- Natural Collapse (52' - 70' bgs)

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Remarks: a/bgs = above/below ground surface; NA = Not Applicable/Available; ND = Not Detected.

Client: CCL Custom Manufacturing, Inc.
Best Foods (Formerly CPC International Inc.)
Waste Management

Site Location:
Peterson/Puritan Superfund Site
Landfill Property
Cumberland, RI

Well/Boring ID: GLF-700A

Borehole Depth: 70' bgs

DRAFT

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Vertical Profile Int.	Geologic Column	Stratigraphic Description	Well/Boring Construction
		7	50-60	2.0	0.0			Brown fine to coarse subrounded GRAVEL, little fine to coarse Sand, trace Silt, non-plastic, wet.	
60	-60							Brown fine to medium SAND, some coarse Sand, non-plastic, wet.	Natural Collapse (52' - 70' bgs)
								Brown coarse SAND and multicolored fine to coarse subrounded to subangular GRAVEL, little Silt and fine to medium Sand, trace subrounded Cobble, medium dense, non-plastic, wet.	
								Light gray SILT and CLAY, trace coarse Gravel, stiff, non-plastic, wet.	
65	-65	8	60-70	9.3	0.0			Light brown-gray fine to coarse subangular GRAVEL, little fine to coarse Sand, non-plastic, wet. Cobbles from 65.6' - 65.8' bgs.	
								Light gray-green SILT and fine SAND, some Clay, little fine to coarse Gravel, very dense, non-plastic, wet. Increased Gravel content and some maroon coloring below 66.4' bgs.	
						X		Brown fine SAND, some medium to coarse subangular Gravel, loose, non-plastic, wet. Interbedded layers of light green-gray Silt and fine Sand, some Clay and fine to coarse Gravel, very dense, non-plastic, wet.	
								Light gray to light blue SILT and very fine SAND, some fine subangular Gravel, trace Clay, dense, non-plastic, wet.	
70	-70								
75	-75								

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Remarks: a/bgs = above/below ground surface; NA = Not Applicable/Available; ND = Not Detected.

Appendix B1
Sample List - Soil

Field Sample ID	SO-001-BG	SO-002-BG
Date Collected	8/18/2003	8/18/2003
Location Name	QW	QW
Group Name	---	---
Station	SO-001-BG	SO-002-BG
RISP East (ft)	349023	349076
RISP North (ft)	305486	305415
Sample Location Description	QW, north of pumping stations	QW, north of pumping stations
Field QC Code	---	---
Other QC Code	MS/MSD	M&E split
Comments	---	---
Lab	Mitkem	Mitkem
SDG	B1309	B1309
Lab Sample ID	B1309-01	B1309-02
Lab Received	8/18/2003	8/18/2003
Analyses	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)
% Moisture	21	20
% Solids	79	80
Description	0-3" Brown SILT, some Organic Matter, soft, low plasticity, dry, no odor or staining; 3-12" Light brown to gray fine SAND, well sorted, medium dense, dry, no odor or staining	0-6" Brown SILT, some Organic Matter, soft, low plasticity, dry, no odor or stainingr; 6-12" Gray to light brown fine SAND, medium dense, dry, no odor or staining.

Appendix B1
Sample List - Soil

Field Sample ID	SO-003-BG	SO-004-BG
Date Collected	8/18/2003	8/18/2003
Location Name	QW	QW
Group Name	---	---
Station	SO-003-BG	SO-004-BG
RISP East (ft)	349158	349156
RISP North (ft)	305357	305535
Sample Location Description	QW, north of pumping stations	QW, north of pumping stations
Field QC Code	---	---
Other QC Code	---	---
Comments	---	---
Lab	Mitkem	Mitkem
SDG	B1309	B1309
Lab Sample ID	B1309-03	B1309-04
Lab Received	8/18/2003	8/18/2003
Analyses	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)
% Moisture	---	13
% Solids	---	87
Description	---	0-6" Brown SILT, some Sand, little quartz Gravel, soft, low plasticity, dry, no odor or staining; 6-12" Brown to light gray SILT, some light gray and yellow-orange quartz Gravel and fine Sand, soft, low plasticity, dry, no odor or staining

Appendix B1
Sample List - Soil

Field Sample ID	SO-FD01	SO-005-BG
Date Collected	8/18/2003	8/18/2003
Location Name	QW	QW
Group Name	---	---
Station	SO-004-BG	SO-005-BG
RISP East (ft)	349156	349102
RISP North (ft)	305535	305585
Sample Location Description	QW, same as SO-004-BG	QW, north of pumping stations
Field QC Code	FD	---
Other QC Code	---	---
Comments	---	---
Lab	Mitkem	Mitkem
SDG	B1309	B1309
Lab Sample ID	B1309-07	B1309-05
Lab Received	8/18/2003	8/18/2003
Analyses	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)
% Moisture	12	---
% Solids	88	---
Description	0-12" Very Dark brown (7.5YR 2.5/2) sorted, medium SAND, trace coarse Sand, trace fine to coarse Gravel, sub-angular, loose, dry, no odor or staining, metal and plastic debris	---

Appendix B1
Sample List - Soil

Field Sample ID	SO-044-QW	SO-045-QW
Date Collected	9/10/2004	9/10/2004
Location Name	QW	QW
Group Name	---	---
Station	SO-044-QW	SO-045-QW
RISP East (ft)	348682	349548
RISP North (ft)	305666	305519
Sample Location Description	QW, north end, north of GZ-1 above river bank	QW, on river bank
Field QC Code	---	---
Other QC Code	---	MS/MSD
Comments	---	---
Lab	Mitkem	Mitkem
SDG	C1116	C1116
Lab Sample ID	C1116-03	C1116-04
Lab Received	9/10/2004	9/10/2004
Analyses	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)
% Moisture	---	8
% Solids	---	92
Description	---	A - Brown fine SAND, some Silt, little coarse rounded Gravel, soft. B - Brown fine to medium SAND, poorly sorted, no odor. C - Brown fine to coarse SAND, some Silt, poorly sorted, soft, dry, no odor. D - Brown fine SAND, some Silt, well-sorted, dry, no odor.

Appendix B1
Sample List - Soil

Field Sample ID	SO-074-MF	SO-075-QW
Date Collected	9/10/2004	9/10/2004
Location Name	MF	QW
Group Name	---	---
Station	SO-074-MF	SO-075-QW
RISP East (ft)	346781	348876
RISP North (ft)	309152	305654
Sample Location Description	South end of Mackland Farms	QW, north of MW-502, toe of river bank
Field QC Code	---	---
Other QC Code	---	---
Comments	---	---
Lab	Mitkem	Mitkem
SDG	C1116	C1116
Lab Sample ID	C1116-05	C1116-02
Lab Received	9/10/2004	9/10/2004
Analyses	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)
% Moisture	3	8
% Solids	97	92
Description	0-12" Light olive brown (10YR 4/3) SILT and fine Sand, some Organic Matter, soft, dry, no odor or staining	0-12" Light olive brown (10YR 4/3) SILT and fine Sand, some Organic Matter, soft, dry, no odor or staining

Appendix B1
Sample List - Soil

Field Sample ID	SO-076-QW	SO-FD-13
Date Collected	9/10/2004	9/10/2004
Location Name	QW	QW
Group Name	---	---
Station	SO-076-QW	SO-076-QW
RISP East (ft)	348868	348868
RISP North (ft)	305613	305613
Sample Location Description	QW, north of MW-502, above river bank	QW, north of MW-502, same as SO-076-QW
Field QC Code	---	FD
Other QC Code	---	---
Comments	---	FD of SO-076-QW
Lab	Mitkem	Mitkem
SDG	C1116	C1116
Lab Sample ID	C1116-01	C1116-08
Lab Received	9/10/2004	9/10/2004
Analyses	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)
% Moisture	34	23
% Solids	66	77
Description	0-12" Dark brown (10YR 3/3) fine SAND and Silt, loose, dry, no odor or staining	Same as SO-046-DF

Appendix B1
Sample List - Soil

Field Sample ID	SO-058-WT	SO-059-WT
Date Collected	9/8/2004	9/9/2004
Location Name	WT	WT
Group Name	A	A
Station	SO-058-WT	SO-059-WT
RISP East (ft)	353022	352938
RISP North (ft)	303579	303887
Sample Location Description	River bank between MW-111and 112	Vacant land between Lenox Street Well and MW-110
Field QC Code	---	---
Other QC Code	---	M&E Split
Comments	---	---
Lab	Mitkem	Mitkem
SDG	C1099	C1106
Lab Sample ID	C1099-15	C1106-05
Lab Received	9/9/2004	9/10/2004
Analyses	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)	Percent Moisture Volatiles (OLM4.2) Semivolatiles (OLM4.2) PAHs (OLM4.2) Pesticides and PCBs (OLM4.2) Metals and Cyanide (ILM4.1)
% Moisture	21	16
% Solids	79	84
Description	0-6" Brown SILT, soft, low plasticity, dry; 6-12" Light brown SAND, loose, dry	See Log for GP-1

TABLE 2-1
SUMMARY OF WELL CONSTRUCTION INFORMATION

REMEDIAL INVESTIGATION REPORT
PETERSON PURITAN SITE - OPERABLE UNIT 2, CUMBERLAND AND LINCOLN, RHODE ISLAND

Well	Formation Code[(1)]	Date Installed	Well Diameter (inches)	Well Material	Screen Type	Total Boring Depth (feet bgs)	Well Screen Interval depth (feet bgs)	Ground Surface Elevation (feet NGVD)	Measuring Point Elevation (feet NGVD)	Well Screen Midpoint Elevation (feet NGVD)	Formation Material Screened
MW-106A	SH	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	18.0	7.5 - 17.5	66.79	68.61	54.3	FILL, SAND and GRAVEL
MW-106B	IN	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	43.2	32.7 - 42.7	66.79	68.55	29.1	SAND and GRAVEL
MW-106C	BR	Jul-87	1.5	Sch. 40 PVC	0.020" saw-slot	74.0	53.9 - 73.9	66.79	68.20	2.9	BEDROCK (schist)
MW-107A	SH	Apr-87	2.0	Sch. 40 PVC	0.010" factory slot	35.4	13.9 - 33.9	79.54	81.46	55.6	SAND, SAND and GRAVEL
MW-107B	IN	Apr-87	2.0	Sch. 40 PVC	0.010" factory slot	50.1	40.1 - 45.1	79.54	81.53	36.9	SAND and GRAVEL
MW-107C	BR	Apr-87	1.5	Sch. 40 PVC	0.020" saw-slot	75.0	49 - 69	79.54	81.55	20.5	BEDROCK (schist)
MW-108A	IN	Jun-87	2.0	Sch. 40 PVC	0.010" factory slot	45.0	33.7 - 43.7	67.41	69.00	28.7	SAND, fine to coarse
MW-108AA	SH	Jun-87	2.0	Sch. 40 PVC	0.010" factory slot	20.8	10.3 - 20.3	67.41	69.19	52.1	SAND, fine to medium
MW108B	DP	Jun-87	2.0	Sch. 40 PVC	0.010" factory slot	98.0	87 - 97	67.41	69.31	-24.6	SAND, fine to medium
MW-108C	BR	Jun-87	1.5	Sch. 40 PVC	0.020" saw-slot	140.7	117.4 - 117.4	67.41	69.26	-50.0	BEDROCK (orthoquartzite)
MW-109A	DP	Jun-87	2.0	Sch. 40 PVC	0.010" factory slot	87.2	76.6 - 86.6	67.16	68.64	-14.4	SAND and GRAVEL
MW-109AA	SH	Jun-87	2.0	Sch. 40 PVC	0.010" factory slot	21.7	11.2 - 21.2	67.16	67.77	51.0	SAND and GRAVEL
MW-109B	TL	May-87	1.5	Sch. 40 PVC	0.020" saw-slot	148.0	137.2 - 147.2	67.16	69.13	-75.0	Sandy TILL
MW-109C	BR	Apr-87	1.5	Sch. 40 PVC	0.020" saw-slot	179.0	158.5 - 178.5	67.16	69.30	-101.3	BEDROCK (orthoquartzite)
MW-110A	SH	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	17.5	6.8 - 16.8	65.89	66.91	54.1	SAND and GRAVEL
MW-110B	TL	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	65.0	54.4 - 64.4	65.89	67.50	6.5	TILL
MW-110C	BR	Jun-87	1.5	Sch. 40 PVC	0.020" saw-slot	100.0	78.1 - 98.1	65.89	67.93	-22.2	BEDROCK (schist/orthoquartzite)
MW-111A	IN	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	75.7	64.7 - 74.7	62.56	64.13	-7.1	SAND, fine
MW-111AA	SH	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	26.0	15.1 - 25.1	62.56	64.53	42.5	SAND and GRAVEL
MW-111B	DP	Jul-87	2.0	Sch. 40 PVC	0.010" factory slot	121.0	109.3 - 119.3	62.56	64.01	-51.7	SAND and GRAVEL
MW-111C	BR	Jul-87	1.5	Sch. 40 PVC	0.020" saw-slot	163.3	140.6 - 160.6	62.56	64.50	-88.0	BEDROCK (orthoquartzite)
MW-112A	IN	Aug-87	2.0	Sch. 40 PVC	0.010" factory slot	56.0	45.1 - 55.1	66.70	68.09	16.6	SAND and GRAVEL
MW-112AA	SH	Aug-87	2.0	Sch. 40 PVC	0.010" factory slot	21.0	9.3 - 19.3	66.70	68.59	52.4	SAND and GRAVEL
MW-112B	DP	Aug-87	2.0	Sch. 40 PVC	0.010" factory slot	82.4	71.7 - 81.7	66.70	68.20	-10.0	SAND, fine
MW-112C	BR	Aug-87	1.5	Sch. 40 PVC	0.020" saw-slot	120.0	99.6 - 119.6	66.70	68.09	-42.9	BEDROCK (orthoquartzite)
MW-501A	SH	---	2.0	Sch. 40 PVC	---	15.0	5 - 15	65.78	68.68	55.8	---
MW-501B	IN	---	2.0	Sch. 40 PVC	---	57.0	47 - 57	65.78	68.46	13.8	---
MW-501C	DP	---	2.0	Sch. 40 PVC	---	102.0	90 - 100	65.78	68.47	-29.2	---
MW-502	IN	---	2.0	Sch. 40 PVC	---	60.0	50 - 60	71.08	73.47	16.1	---
MW-A1	DP	Nov-80	1.5	Sch. 40 PVC	10-ft long saw-slot	85.0	75 - 85	63.23	64.79	-16.8	SAND, fine
MW-A2	SH	Nov-80	1.5	Sch. 40 PVC	10-ft long saw-slot	15.0	5 - 15	63.23	65.20	53.2	SAND, fine

APPENDIX G

WETLAND REPORT AND FLOODPLAIN MAP

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region 1
5 Post Office Square, Suite 100
Boston, MA 02109-3912

December 22, 2011

David J. Lang, LSP
Ground Water Consultants, Inc.
2 Fosters Point
Beverly, MA 01915

Re: EPA's Review Comments on Draft Technical Memorandum: Delineation of Wetland Boundaries and Waterways; Peterson Puritan Superfund Site - Operable Unit 2 Arcadis, October 2011

Dear Mr. Lang:

This letter is to inform you that the Agency has completed its review of the Draft Technical Memorandum: Delineation of Wetland Boundaries and Waterways, Peterson Puritan Superfund Site - Operable Unit 2 by Arcadis, October 2011. Based upon EPA's review, EPA approves this report subject to conditions. The conditions are that the PRP Group addresses the comments provided in the Enclosure, revise the document accordingly, and provide a final report as an appendix to, and in support of, the draft Feasibility Study.

Should you have any questions or concerns with regard to the comments provided, please feel free to call me at 617-918-1301, or David Newton, RPM at 617-918-1243.

Sincerely,

Larry Brill, Chief
OSRR 1 Branch

cc: David Newton, RPM
Mike Jasinski, Chief NH/RI SF Section
Michelle Lauterback, Enforcement Counsel
Paul Kulpa, RIDEM-OWM
Warren Diesl, AECOM

Enclosure

EPA's Review Comments:
Draft Technical Memorandum: Delineation of Wetland Boundaries and Waterways
Peterson Puritan Superfund Site - Operable Unit 2
Arcadis, October 2011

December 22, 2011

Note: Comments from The RI Department of Environmental Management are not included herein but may be forthcoming. Please feel free to communicate with Paul Kulpa directly but also inform EPA of any additional modifications in response to State comments.

General Comments

1. In several places, the memo states that the photo locations are shown on Figure 3; however, no photo locations could be found on Figure 3 or any of the other figures. In the final report, please add the missing information.

2. This report addresses areas within OU2 that may be considered to require remedial actions based on lead concentrations [only] (e.g., soil excavation in areas with lead concentrations above potential benchmarks, such as USEPA's RSLs of 400 mg/kg for residential and 800 mg/kg for industrial or RIDEMs ARAR of 150 mg/kg). However, both Figure 2 and 4 do not illustrate all of the OU2. Please correct these two (2) figures in the final report to represent the whole of OU2. Additionally, please also make note in the final report that that additional and more detailed delineations, as well as evaluations of impacts, may be required in the future as remedial actions are further defined.

3. It would be helpful if the sizes/acreages of the wetland and pond features were provided, where applicable. For example, it can be assumed from Figure 4 that Ponds B, C, and E do not have buffers because they are smaller than ¼-acre, but a table of actual/ approximate sizes of all wetland features would be a valuable addition and should be relatively easy to prepare for inclusion in the final report.

Specific Comments

1. **Background Information Review, p. 1, last paragraph:** Please provide a reference for the source of the 100-year floodplain boundary shown on Figure 1 (e.g. FEMA, [date]). [Note to Dave Lang/Keith Stang- On December 12, 2011 an email was forwarded to EPA from GWC and Arcadis –BBL which further explained the 100 year flood plain interpretation concerning the Quinnville Wellfield as shown on Fig. 1. This explanation is worth including in the final report. Additionally, some of the reviewers make note that there is not a good correlation of color codes with land/water features on Figure 1. This may simply be an issue with trying to match various CAD map resources onto one composite map. Potentially this could be explained in a note on the Figure (or elsewhere) expressing that this is a "best fit" interpretation of the data sets (or other explanation).]

2. **Delineation Results, Soil Lead Concentrations, and Associated Ecological Functions of Identified Wetlands, p. 7, first complete bullet:** The text states that the sampling points with lead concentrations between 150 and 500 mg/Kg in the eastern portion of the

Quinnville wellfield are within the buffer zone of the Blackstone River (assumed to be the 200 foot buffer zone). Two of the sampling locations with elevated lead concentrations (LQW-012 and -013) are more than 200 feet from the Blackstone, implying that they are not in the buffer zone for the river. However, on Figure 4, it appears that the 200 ft buffer zone may encompass all or part of the Quinnville wellfield. Please clarify if the 200 ft buffer zone (in which case all or part of the Quinnville wellfield and most of the known elevated lead locations would be within the 200 ft buffer zone of either the river or possibly the Blackstone canal). Please provide any clarifications in the text and figures of the final report.

3. **Delineation Results, Soil Lead Concentrations, and Associated Ecological Functions of Identified Wetlands, p. 7, *J. M. Mills Landfill*:** The wetlands (A, B, C, D) and Pond N north of the landfill should be evaluated to determine if they have buffer zones that could be impacted by future remediation activities at OU2. Please review and clarify in a final report.

4. **Attachment 1, Data Sheets:** Please revise to include vegetation scientific names with the common names.

5. **Attachment 1, Data Sheets, and Figure 4:** Typically wetland/upland data plots are paired along transects. DP5 (upland) and DP6 (wetland) are both adjacent to Pond A, but they are widely separated. If additional or more detailed delineations are done at Pond A in the future, data plots should be added so that each location includes a paired wetland/upland data plot.

GROUND WATER CONSULTANTS, INC.

October 31, 2011

David J. Newton, RPM
USEPA New England, Region 1
OSRR, NH/RI SF Section
1 Congress Street
Suite 1100 (HBO)
Boston, Massachusetts 02114-2023

Subject: Peterson/Puritan, Inc. Superfund Site – Operable Unit 2
Cumberland and Lincoln, Rhode Island
CERCLA Docket No. 1-87-1064
Technical Memorandum: Delineation of Wetland Boundaries and Waterways

Dear David:

Please find enclosed the *Technical Memorandum: Delineation of Wetland Boundaries and Waterways* for the Peterson/Puritan, Inc. Superfund Site – Operable Unit 2 located in the towns of Cumberland and Lincoln, Rhode Island.

If you have any questions, please feel free to contact me with questions or comments.

Sincerely,

David J. Lang /meh

David J. Lang, LSP
Ground Water Consultants, Inc.

DJL/meh
Enclosure

cc: Paul Kulpa (Rhode Island Department of Environmental Management)
Warren Diesl (Metcalf & Eddy, Inc.)
Andrew Schkuta (Metcalf & Eddy, Inc.)
Ken Finkelstein (National Oceanic and Atmospheric Administration)
Chau Vu (United States Environmental Protection Agency)
Bart Hoskins (United States Environmental Protection Agency)

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Technical Memorandum: Delineation of Wetland Boundaries and Waterways

Peterson/Puritan, Inc. Superfund Site – Operable Unit 2
Cumberland and Lincoln, Rhode Island

October 2011

This document is a DRAFT which has not received final USEPA approval.

Draft Technical Memorandum: Delineation of Wetland Boundaries and Waterways
Peterson/Puritan, Inc. Superfund Site – Operable Unit 2
Cumberland and Lincoln, Rhode Island

I. Introduction

This technical memorandum summarizes the results of background research and field activities for the delineation of wetland and waterway boundaries on the Peterson/Puritan, Inc. Superfund Site – Operable Unit 2 (OU2) located in the towns of Cumberland and Lincoln, Rhode Island (site). The field work was conducted between July 18 and July 21, 2011 on waters and wetlands immediately adjacent to Ponds A, B, C, D, E, F, I, and P. The objective of the wetland and waterway delineation was to identify areas of the site that may be impacted by future remediation (e.g., soil excavation in areas with lead concentrations above potential benchmarks, such as the United States Environmental Protection Agency's [USEPA's] Regional Screening Levels [RSLs] or the Rhode Island Department of Environmental Management's [RIDEM's] applicable or relevant and appropriate requirement [ARAR] of 150 milligrams per kilogram [mg/kg]). The USEPA RSLs for residential and industrial soil are 400 and 800 mg/kg, respectively.

II. Background Information Review

Prior to on-site activities, background information, including wetland maps and soil types, were reviewed to assist with the field effort. Specifically, wetland maps, including National Wetland Inventory (NWI) maps, Rhode Island Geographic Information System (RIGIS) wetland maps, and United States Geological Survey (USGS) national hydrography dataset (NHD) maps, were reviewed to identify potential wetland areas. NWI maps present the approximate location of wetlands that are mapped and evaluated over time by the United States Fish and Wildlife Service (USFWS) to monitor waterfowl habitat. RIGIS wetland maps are interpreted from 1988 aerial photography and described by the USFWS classification system (Cowardin et al., 1979). The USGS NHD maps are based on delineations of water features from topographic maps. Wetlands presented on these three map types (NWI, RIGIS, and NHD) provide preliminary information regarding the potential presence of wetlands at the site.

Figure 1 presents an overlay of the NWI, RIGIS, and NHD information for OU2. The NWI map for OU2 indicates the potential presence of freshwater emergent wetlands north of the railroad line that traverses the site; these locations correspond to Wetlands A, B, C, and D. The NWI map also indicates the presence of several freshwater ponds south of the railroad line (i.e., on the Unnamed Island, Quinnville Well Field, Nunes Parcel, and near Pratt Dam) and a freshwater pond north of the railroad line and east of Wetlands A, B, C, and D. The RIGIS map indicates various wetland types (e.g., emergent, scrub/shrub, forested) north of the railroad line (corresponding to Wetlands A, B, C, and D) and three wetland areas on the Quinnville Well Field. The RIGIS map also indicates open water on the Unnamed Island (corresponding to Ponds A, D, and E) and near Pratt Dam (corresponding to Pond F). Likewise, the NHD map shows swamp/marsh in the location of Wetlands A through D and ponds on the Unnamed Island and near Pratt Dam.

Figure 1 also presents the boundary of the 100-year floodplain, which delineates potential flood areas subject to inundation by the 1% annual chance flood, as identified by the Federal Emergency Management Agency. The 100-year floodplain for OU2 extends from the Blackstone Canal north to Wetlands A through D, and essentially encompasses the entire area of OU2. Therefore, the majority of the soil and sediment samples collected as part of the remedial investigation (RI) for OU2 were collected within the 100-year floodplain.

A review of the soil survey for the site location was performed to determine the presence of hydric soils, which are a preliminary indicator of wetlands. The soil survey map for the site (Figure 2) shows that soils mapped in the majority of the areas in the wetland assessment area consisted of either Dumps (Du) or open water (W). Dumps are defined in the soil survey as areas created by human transported material. Dump soils are classified as unknown hydric soils, as they can develop hydric soil characteristics under the proper environmental conditions.

III. Wetlands Regulation

Wetlands represent protected resources on both a federal and state level. Wetlands are protected on a federal level under several laws, most notably Section 404 of the Clean Water Act. Wetlands are protected on a state level under the RIDEM's Freshwater Wetlands Act (FWA). Rhode Island has three categories of wetlands: freshwater wetlands, freshwater wetlands in the vicinity of the coast, and coastal wetlands. Freshwater wetlands by definition include, but are not limited to, marshes, swamps, bogs, ponds, rivers, river and stream floodplains and banks, and areas subject to flooding or storm flowage. Freshwater wetlands are the focus of interest at OU2.

The RIDEM (2007) identifies two general kinds of wetland buffer zones for freshwater wetlands: perimeter and riverbank. A perimeter wetland is defined as an area of land within 50 horizontal feet (regardless of topography) of a freshwater wetland consisting in part, or in whole, of a bog, marsh, swamp, or pond. A riverbank wetland is defined as an area of land within 200 feet of the edge of any flowing body of water having a width of 10 feet or more, and an area of land within 100 feet of the edge of any flowing body of water having a width of less than 10 feet during normal flow. A floodplain is defined as land adjacent to a river or stream or other flowing water body that is, on average, likely to be covered with flood waters resulting from a 100-year frequency storm. Related to the floodplain is the floodway, which is the channel of a river or stream and any immediately adjacent areas that must be kept free of encroachment to allow 100-year flood waters to be carried without increase in flood heights or flows and without endangering life or property. The floodway is shown on Figure 1 in addition to the 100-year floodplain.

The 50-foot buffer zone (perimeter wetland) applies to the following wetland types:

- swamps greater than or equal to 3 acres in size
- marshes greater than or equal to 1 acre in size
- bogs of any size
- ponds greater than or equal to ¼ acre in size

The 100-foot buffer zone (riverbank wetland) applies to the following wetland types:

- streams and intermittent streams less than 10 feet wide
- rivers less than 10 feet wide

The 200-foot buffer zone (riverbank wetland) applies to the following wetland types:

- streams and intermittent streams greater than or equal to 10 feet wide
- rivers greater than or equal to 10 feet wide

Wetland types that are not considered to have a buffer zone include:

- forested wetlands less than 3 acres in size
- shrub wetlands less than 3 acres in size
- emergent plant communities less than 1 acre in size
- submergent plant communities less than ¼ acre in size
- special aquatic sites (i.e., body of open standing water) that do not meet the definition of a pond, but are capable of supporting and providing habitat for aquatic fauna (e.g., vernal pool)
- areas subject to storm flowage and/or flooding
- floodways
- floodplain wetlands

According to the RIDEM (2007), all wetlands, including the 50-foot perimeter and the 100-foot and 200-foot riverbank wetlands, must be avoided and protected. The goal of the RIDEM's FWA is no net loss of wetlands. To help achieve that goal, the RIDEM requires wetland permit applications to demonstrate that the proposed projects or activities do not include any random, unnecessary, or undesirable alterations of wetlands; that all alternatives to avoid and minimize wetland impacts have been pursued; and that the proposed project adheres to the technical permit review criteria.

IV. Delineation Methodology

Wetland boundaries were delineated in accordance with the multi-parameter approach presented in the 1987 *Corp of Engineers Wetland Delineation Manual* and the 2009 *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region*. Specifically, the identification of wetlands relies on field observations of vegetation, soils, and hydrology and involves the completion of wetland determination data forms. Observations of hydrophytic vegetation, hydric soils, and wetland hydrology are recorded at wetland sampling points, and observations of upland vegetation, soils, and hydrology are recorded at corresponding upland sampling points to delineate the wetland boundary. Field personnel also identified the ordinary high water (OHW) line of waterways associated with Ponds A, B, C, D, E, I, and P, as well as the Blackstone River and backwater channel of the river adjacent to Ponds B, C, I, and F based on observed field indicators, such as shelving, presence of litter and debris, and a natural

line impressed on the bank. In addition to delineation objectives, the resource boundaries identified under this effort also provide an update to the historic limits presented in previous reports within areas surveyed.

Due to the large size of the site, wetland delineation efforts focused on those areas of the site that were likely to contain wetlands (based on NWI, RIGIS, and NHD mapping) and also displayed relatively high lead concentrations in soil (e.g., above the RIDEM ARAR of 150 mg/kg). As shown on Figure 3, the highest lead concentrations generally occur within the southern portion of the Unnamed Island (near Ponds D and E), with the highest concentrations located to the east of Pond E. Lead concentrations in the range of 150 to 500 mg/kg are also present along the southern bank of the Blackstone River, across from the Unnamed Island; along the river shoreline adjacent to the Nunes Parcel; along the shoreline adjacent to the J.M. Mills Landfill; and in several locations within the Quinnville Well Field.

The area immediately adjacent to Ponds A, B, C, D, E, F, I, and P were evaluated for changes in the plant community and topography that indicate the potential presence of freshwater wetlands. Soil profiles were then evaluated for the presence of hydric soil field indicators (e.g., depleted matrix colors, redoximorphic features) in areas where vegetation and hydrology suggested the presence of wetland conditions. Soil profiles in adjacent upland areas were also evaluated to confirm the wetland boundary. Field data forms were completed at six locations (i.e., three in wetlands and three in uplands) to document the observed field indicators that were used to identify the wetland boundaries.

The identified wetland boundaries were flagged in the field with high-visibility flagging. In addition, the identified OHW line of waterways associated with Ponds A, B, C, D, E, F, I, and P were flagged in the field with different colored high-visibility flagging. The wetland boundaries, OHW lines, and data collection point locations were then surveyed by ARCADIS using a combination of global positioning system and traditional survey methods. The results of the delineation activities are discussed below for each subarea of the site.

V. Delineation Results, Soil Lead Concentrations, and Associated Ecological Functions of Identified Wetlands

Delineation activities centered around the on-site ponds and the areas of relatively high lead concentrations in soil. Figure 3 presents the soil lead concentrations. Figure 4 presents the identified extent of freshwater wetlands and open water immediately adjacent to Ponds A, B, C, D, E, F, I, and P. The RIDEM buffer zones are also shown on Figure 4 (i.e., 50-foot buffer around ponds greater than ¼ acre in size and 200-foot buffer from the river's edge). The surveyed OHW elevations that were identified in the field and the 100-year floodplain are also presented on Figure 4. Attachment 1 presents the field data forms for sampling locations DP-1 through DP-6; these sampling locations are shown on Figure 4. Attachment 2 presents representative photographs of the wetland areas.

The following discusses the identification of wetlands within each subarea of the site, ecological functions of these natural resources, and associated soil lead concentrations.

Unnamed Island

- Ponds A, D, and E are located in the center of the Unnamed Island and contained standing water at the time of the field activities (Figure 4). These ponds appeared to be isolated open water features that periodically receive hydrologic input from the Blackstone River during severe storm events or seasonally high water levels. During the RI investigations, there were several large floods that inundated the Unnamed Island (either in part or in entirety). During the fall 2005 flooding, high water marks on trees on the Unnamed Island indicated the flood stage was 3 to 4 feet above the Unnamed Island floor. Pond P is located adjacent to the Blackstone River and did not contain standing water, but evidence of potential ponding was observed (e.g., drift lines, sediment deposits). Pond P now appears to be an intermittent stream corridor that transports seasonal and severe storm flow from the backwater of the Blackstone River to Pond A (as shown on Figure 4). Pond P had been identified as an isolated intermittent pond in previous reports. It now appears that hydrologic inputs to this pond have been reduced from prior conditions. Pond E is located between Ponds A and D and contains a number of old tires (see photo #15 in Attachment 2).

- Identified freshwater wetlands associated with Ponds D, E, and P included forested communities. Wetlands associated with Pond A include a mixture of wet meadow/shrub, emergent, and forested wetland types. Several areas exhibiting mosaics of potential wetlands and uplands were identified on the Unnamed Island.

- Photographs of Pond A are included in Attachment 2 (see photos #1 and #2). Photograph locations are shown on Figure 3. The banks of portions of Pond A contain debris, and elevated lead was found in debris piles adjacent to Pond A.

- A potential vernal pool was identified to the southwest of Pond D and its approximate location is shown on Figure 4.

- Ecological functions likely associated with the wetlands and ponds on the Unnamed Island include wildlife habitat and flood control. The Unnamed Island is heavily vegetated, which provides valuable wildlife habitat. Mature trees and shrubs are present in some areas, which can provide habitat for arboreal fauna. The ponds, when inundated, may provide habitat to aquatic and semi-aquatic fauna, such as fish, amphibians, and reptiles. Upland habitats are likely valuable to terrestrial fauna (e.g., small and large mammals) for foraging, nesting, and/or cover. The ponds and wetlands on the Unnamed Island are frequently inundated, especially during high flow events associated with the Blackstone River. Therefore, these ponds and wetlands most likely also serve a function for flood control.

- Soil lead concentrations in the Unnamed Island range from 3.9 mg/kg (sample SO-222-UI) to 9,640 mg/kg (sample SO-208B-UI) (see Figure 3). The highest lead concentrations were observed near Pond E, and are generally restricted to the southeastern portion of the subarea. The majority of these sampling locations fall within mapped wetland/pond areas or buffer zones. Remedial action is likely in Pond E given the presence of debris (i.e., tires) and lead concentrations in surrounding soils.

Nunes Parcel

- Pond I is located along the shoreline of the Blackstone River, adjacent to the Nunes Parcel (Figure 4). This pond contained standing water at the time of the field activities and appeared to be a permanent backwater that is perennially connected to the Blackstone River. The wetland associated with Pond I is forested.

- Ecological functions likely associated with the wetlands and Pond I include wildlife habitat and flood control. Because Pond I is a backwater of the Blackstone River, one of the functions of this pond and its associated wetlands is to receive overflow from the river during flood and/or storm events. Similar to the remainder of the site, this area is heavily vegetated, and as such, likely provides habitat to local wildlife. Upland areas likely support populations of terrestrial fauna (e.g., avian and mammalian species), and the pond and wetland areas likely support aquatic and semi-aquatic fauna. These natural communities likely provide foraging, nesting, and/or shelter to wildlife.

- Soil lead concentrations in the Nunes Parcel range from 10 mg/kg (samples SO-103-NP and SO-107-NP) to 5,460 mg/kg (sample SO-033-NP) (Figure 3). The soil samples with the highest lead concentrations fall within a wetland/pond area or buffer zone (Figure 4) and are located within identified waste areas. The majority of these lead concentrations are between 150 and 500 mg/kg. However, there are a few locations with soil lead concentrations above 500 mg/kg, but these concentrations were generally observed below ground surface (see Figure 3). During the construction of the bike path, approximately 2,000 tons of lead-contaminated soils were excavated from the west end of the Nunes Parcel and disposed off site.

Quinnville Well Field

- Delineation activities did not focus on this subarea of the site because soil lead concentrations were relatively low here. Additionally, based on the RIGIS and NWI maps, the portion of the Quinnville Well Field with lead concentrations ranging from 151 mg/kg (sample SO-045-QW) to 460 mg/kg (sample LQW-010) (i.e., eastern portion of the subarea) did not contain mapped wetland areas (Figure 1). However, a site walkover of this subarea was performed to investigate the potential presence of wetland areas and gain a general understanding of the ecological habitats.

- Photographs of the Quinnville Well Field are presented in Attachment 2 (see photos #9 through #13). Photograph locations are shown on Figure 3. Photo #9 was taken on the bike path looking north toward the Quinnville Well Field subarea and shows a heavily vegetated area. Photos #12 and #13 were taken on the Quinnville Well Field access road and show the bike path in the distance. This area, as noted by high water marks and fresh debris, was flooded by Tropical Storm Irene in August 2011. A corrugated steel culvert pipe crosses the road and gives further evidence of the frequent flooding of this area.

- This subarea of the site is heavily vegetated with mature trees, shrubs, and herbaceous groundcover. There was evidence of flooding (e.g., drift lines, sediment deposits) along the access road that traverses the Quinnville Well Field (see photo #13 in Attachment 2). This subarea of the site likely

provides habitat to local wildlife, including terrestrial and semi-aquatic fauna. Flood control may also be another function of this area. The riverbank along the Quinnville Well Field drops off to the west and creates a depression or bowl where water tends to accumulate and settle after the river stage begins to decrease. Photo #10, with its sparser vegetation, was taken within this bowl area, which has likely accumulated trapped sediments from Blackstone River flood flows.

- Soil lead concentrations in the western portion of the Quinnville Well Field range from 11 mg/kg (sample LQW-017) to 123 mg/kg (sample SO-076-QW). There are several sampling points with lead concentrations in the range of 150 to 500 mg/kg, which are located in the eastern portion of the site. Concentrations here range from 190 mg/kg (sample LQW-013) to 460 mg/kg (sample LQW-010) (Figure 3). Although wetland delineation activities did not cover the Quinnville Well Field, these sampling locations do fall within the buffer zone of the Blackstone River.

J.M. Mills Landfill

- Ponds B and C are located along the toe of the former J.M. Mills Landfill (Figure 4). These ponds were dry at the time of observation, but contained saturated soils and appeared to be seasonally connected to the Blackstone River. As shown on Figure 4, relatively small, forested wetland areas are associated with these ponds. Surrounding areas in the vicinity of these ponds did exhibit mosaics of potential wetlands and upland areas, but delineation activities did not extend into other areas of the former landfill.

- Photographs of Ponds B and C are presented in Attachment 2 (see photos #3, #4, and #5). Photograph locations are shown on Figure 3.

- Ecological functions of Ponds B and C and their associated wetlands likely include wildlife habitat and flood control. These resources were characterized by mature trees, shrubs, herbaceous groundcover, and areas of suspected flooding. Therefore, these areas likely provide habitat to terrestrial, aquatic, and semi-aquatic fauna for foraging, nesting, and/or shelter. The proximity of these ponds to the Blackstone River suggests that these resources may also provide some flood control during storm and flood events.

- Soil lead concentrations in the vicinity of Pond B are less than 150 mg/kg. However, concentrations of lead in soils near Pond C are slightly higher, ranging from 161 mg/kg (sample SO-019-LF) to 206 mg/kg (sample SO-020-LF) (Figure 3). These sampling points are located in the vicinity of the mapped ponds and wetlands, as well as within the buffer zone of the Blackstone River.

Southern Bank

- Pond F is located along the Southern Bank, adjacent to the Pratt Dam (Figure 4). This pond did contain standing water at the time of observation. As shown on Figure 4, this pond is mostly surrounded by forested wetland areas that extend westward along the Southern Bank of the Blackstone River.

- Photographs of Pond F are presented in Attachment 2 (see photos #6, #7, and #8). Photograph locations are shown on Figure 3.

- Because this area of the site is heavily vegetated (similar to the remainder of the site), it likely provides wildlife habitat to local fauna. Mature trees may provide habitat to arboreal wildlife and shrubs, and herbaceous groundcover may provide foraging, nesting, and/or shelter to terrestrial and semi-aquatic species. Pond F may provide habitat to aquatic and/or semi-aquatic fauna. Due to its proximity to the Blackstone River, it is assumed that this area of the site may also provide flood control during storm and/or flood events.

- Soil lead concentrations in the vicinity of Pond F are less than 150 mg/kg (Figure 3). Soil lead concentrations along the Southern Bank are slightly higher, ranging from 156 mg/kg (sample SO-069-BR) to 221 mg/kg (sample SO-066-BR). However, these sampling locations fall within mapped wetland areas (see Figure 3).

VI. Summary

Freshwater wetlands are important natural resources for the production and diversity of local wildlife. Wetlands provide habitat for various terrestrial, aquatic, and semi-aquatic plant and animal species, and depending on size, can support local populations of these species. Local fauna that may use the identified wetlands at the OU2 site may include permanent residents, as well as migratory (seasonal) and transient individuals. Wetlands may serve local wildlife as travel corridors, nesting sites, foraging areas, nurseries, breeding sites, and shelter. In addition to wildlife value, another important function of the freshwater wetlands is flood control. Wetlands can protect surrounding areas from flooding by storing, retaining, and otherwise controlling flood waters following storm events. Furthermore, wetlands can control potential damage caused by flooding by dissipating erosional forces, providing frictional resistance to flood flows, and providing shoreline stabilization. Freshwater wetlands can also be an important source of recharge or discharge to surface-water and groundwater supplies. Water quality functions of wetlands may include nutrient cycling, processing of organic wastes, and reduction of suspended sediment.

The wetlands identified under this effort meet the federal criteria for wetlands and are, therefore, regulated under Section 404 of the Clean Water Act. As such, disturbances or permanent losses of wetlands must be avoided or minimized. Unavoidable disturbances or losses may require mitigation to offset the lost functions of the disturbed wetland. The identified wetlands also meet the definition of wetlands under the Rhode Island Freshwater Wetlands Act. In addition to the regulatory protection afforded to the wetlands, Rhode Island also regulates activities in adjacent wetland buffer zones (i.e., 50-foot-wide zone surrounding a bog, marsh, swamp, or pond of at least ¼ acre). Activities are also regulated at the federal and state level for activities conducted in waters of the United States and their floodplains. Section 10 of the Rivers and Harbors Act regulates all work below the OHW elevation of a stream or river. In addition, activities within the 100-year flood elevation of a river are required not to affect the 100-year stormwater elevation. Rhode Island also regulates a 200-foot-wide buffer adjacent to rivers that are greater than 10 feet in width, which would apply to the Blackstone River throughout OU2.

Potential remedial activities, such as soil excavation, would result in the loss of wetland vegetation, which in turn would affect wildlife value and flood control. Even with compensatory mitigation, soil excavation would result in short-term effects on these natural resources.

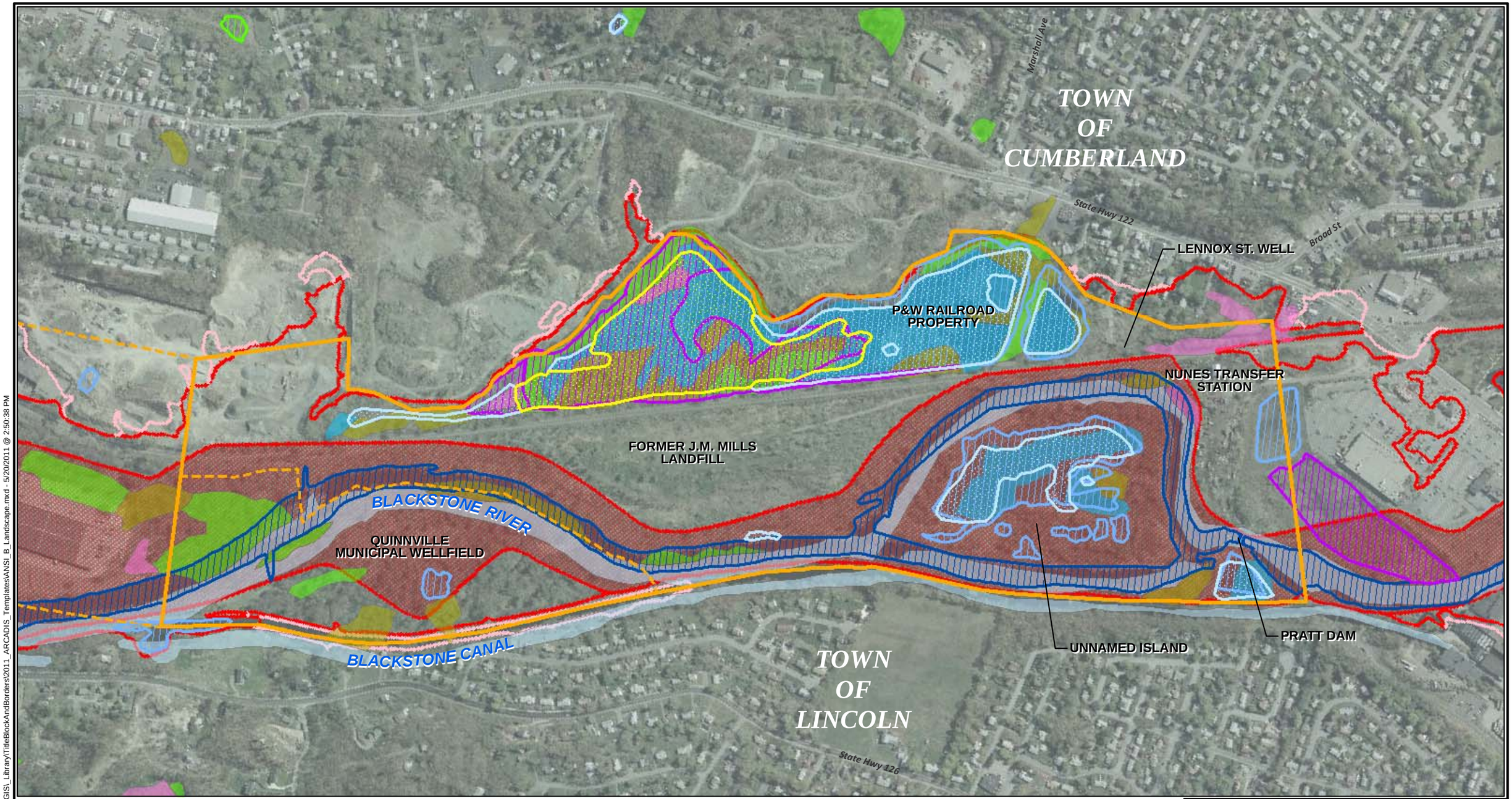
VII. References

Cowardin, L.M., V. Carter, E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. December 1979.

Rhode Island Department of Environmental Management. 2007. Office of Water Resources. Fact Sheet, Wetlands #9. Dated November 21, 2007. Available at http://www.dem.ri.gov/programs/benviron/water/wetlands/pdfs/wfs09.pdf.

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Figures



RHODE ISLAND GIS WETLANDS
- EMERGENT WETLAND: MARSH/WET MEADOW
- FORESTED WETLAND: DECIDUOUS
- PALUSTRINE OPEN WATER
- RIVERINE NONTIDAL OPEN WATER
- SCRUB-SHRUB SWAMP

USFWS NATIONAL WETLANDS INVENTORY
- FRESHWATER EMERGENT WETLAND
- FRESHWATER FORESTED/SHRUB WETLAND
- FRESHWATER POND
- RIVERINE

USGS NHD WATER BODIES
- LAKE/POND
- SWAMPMARSH

FEMA FLOOD ZONES
- FLOODWAY AREA
- 100-YEAR FLOOD ZONE
- AREA OF MODERATE FLOOD HAZARD, USUALLY THE AREA BETWEEN THE LIMITS OF THE 100-YEAR AND 500-YEAR FLOODS.

- APPROXIMATE BOUNDARY, OU 1
- APPROXIMATE BOUNDARY, OU 2

FEMA	FEDERAL EMERGENCY MANAGEMENT AGENCY
GIS	GEOGRAPHIC INFORMATION SYSTEMS
NHD	NATIONAL HYDROGRAPHY DATASET
USFWS	U.S. FISH AND WILDLIFE SERVICE
USGS	U.S. GEOLOGICAL SURVEY

0 500 1,000
SCALE IN FEET

PETERSON/PURITAN INC. SUPERFUND SITE
CUMBERLAND AND LINCOLN, RHODE ISLAND

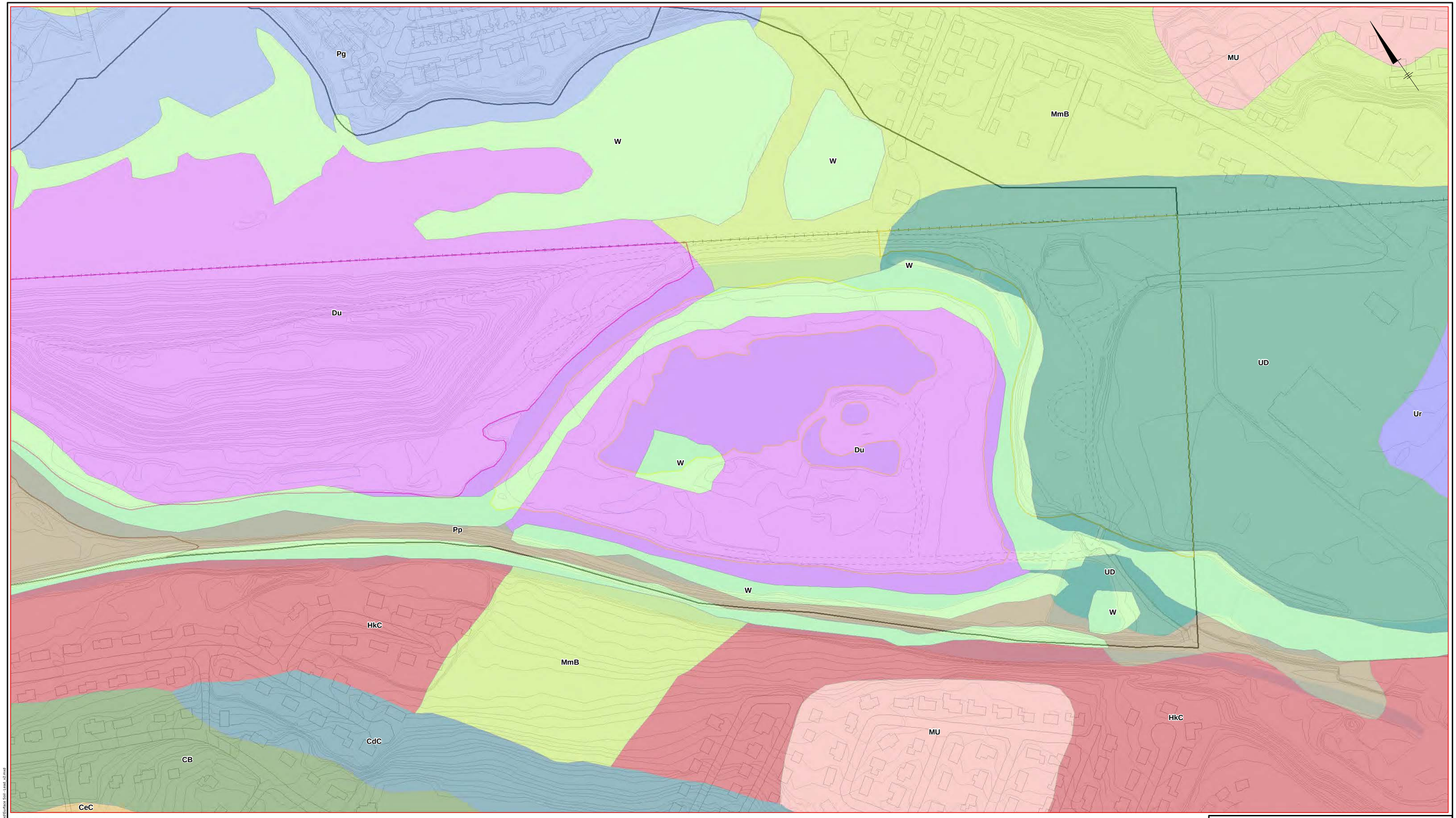
WETLAND DELINEATION REPORT

WETLANDS IN VICINITY OF OU2

ARCADIS

FIGURE
1

CITY: SF DIV/GROUP: (ENV/GIS) DB: K ERNST LD: S MAROTTA PIC: PM: TM:
PROJECT: B0037902.0000.00500 PATH: G:\GIS_Library\TitleBlockAndBorders\2011_ARCADIS_Templates\ANSI_B_Landscape.mxd - 5/20/2011 @ 2:50:38 PM



LEGEND

SSURGO UNITS

- CANTON-URBAN LAND COMPLEX
- CANTON AND CHARLTON FINE SANDY LOAMS, 8 TO 15 PERCENT SLOPES
- CANTON AND CHARLTON FINE SANDY LOAMS, VERY ROCKY, 3 TO 15 PERCENT SLOPES
- DUMPS
- HINCKLEY GRAVELLY SANDY LOAM, ROLLING
- MERRIMAC-URBAN LAND COMPLEX
- MERRIMAC SANDY LOAM, 3 TO 8 PERCENT SLOPES
- PITS, GRAVEL
- PODUNK FINE SANDY LOAM
- UDORTHENTS-URBAN LAND COMPLEX
- URBAN LAND
- WATER

- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- SOLID WASTE TRANSFER STATION
- RAILROAD
- HISTORICAL ACCESS ROAD
- OU2 BOUNDARY

0 300 600 Feet

GRAPHIC SCALE

NOTES:

1. SOIL SURVEY STAFF, NATURAL RESOURCES CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE. SOIL SURVEY GEOGRAPHIC (SSURGO) DATABASE FOR [SURVEY AREA, STATE]. AVAILABLE ONLINE AT HTTP://SOILDATAMART.NRCS.USDA.GOV. ACCESSED [08/23/2011].

2. BASEMAPPING SOURCE: ARCADIS; COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD 83 FEET.

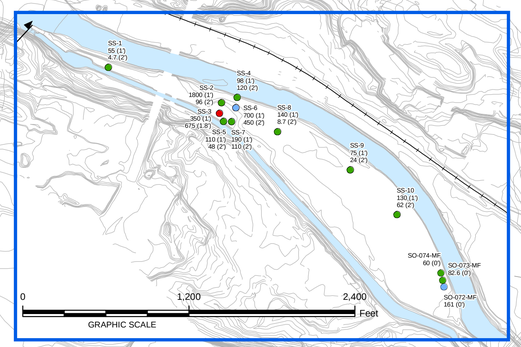
PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND
WETLAND DELINEATION REPORT

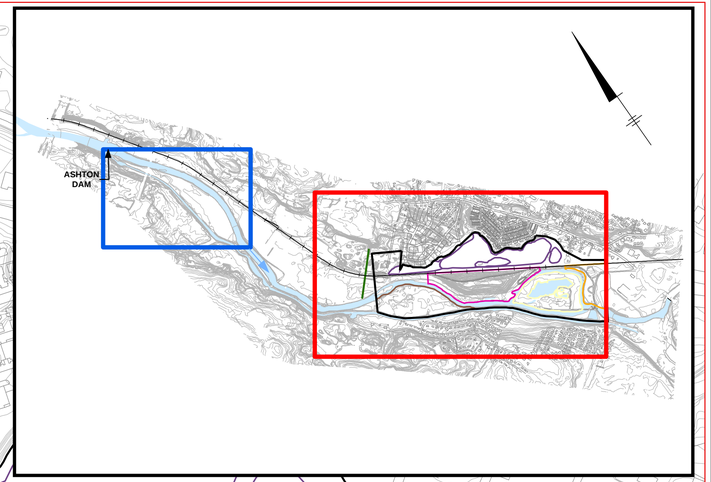
SOIL SURVEY (SSURGO) UNITS

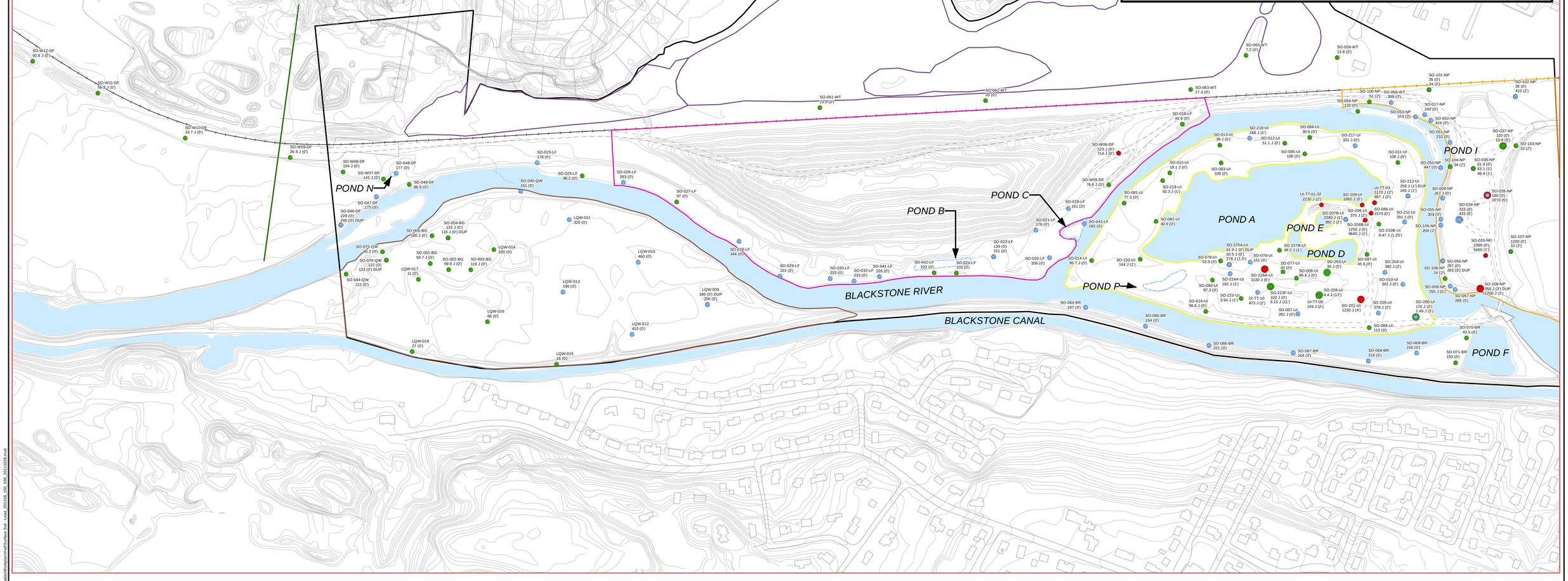
ARCADIS

FIGURE
2

62/607.SYR.65 MTK.EAB
Revised: 2012-03-28
Q:\Peterson_Puritan\Cumberland_RI\Remedialinvestigation\Report\mxd\Surface Soil - Lead_v2.mxd







LEGEND:

SOIL SAMPLE LOCATION CONCENTRATION (mg/kg)

- <=150 mg/kg
- >150 - 500 mg/kg
- >500 mg/kg

SAMPLE DEPTH

- <=2' BELOW GROUND SURFACE
- >2' BELOW GROUND SURFACE

- HISTORICAL POND
- J.M. MILLS LANDFILL
- UNNAMED ISLAND
- QUINNVILLE WELL FIELD
- WETLAND
- SOLID WASTE TRANSFER STATION
- RAILROAD
- OU2 BOUNDARY
- HISTORICAL ACCESS ROAD
- WATER
- DIRECTION OF SURFACE WATER FLOW

(NFO NUNES DISPOSAL, INC.)

NOTES:

1. SAMPLE LOCATIONS AND BASEMAPPING ARE IN THE COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD 83 FEET. LOCATIONS RECORDED IN THE FIELD USING GPS.
2. NFO - NOW OR FORMERLY OWNED BY
   BSC - BELOW SCREENING CRITERIA

0 400 800 Feet

GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

WETLAND DELINEATION REPORT

LEAD CONCENTRATIONS IN SOIL

ARCADIS

FIGURE 3

6/20/07 SYR 85 MTK EAB
Revised: 6/20/07 EAB
Path: O:\arp\Peterson_Puritan\Cumberland_RI\2011_Biomedia\Investigation\Work\plan\mxd\Surface Soil - Lead_20110628_150_000_20111028.mxd

WETLAND B

WETLAND A

WETLAND C

POND I

POND C

POND B

DP-6

DP-4

DP-3

POND A

POND E

POND D

DP-5

PRATT DAM

POND P

BLACKSTONE RIVER

Estimated Location of Vernal Pool Observed During Survey

BLACKSTONE CANAL

DP-1

POND F

DP-2

LEGEND:

WETLAND AND ORDINARY HIGH WATER DELINEATION

- ORDINARY HIGH WATER LINE
- WETLAND BOUNDARY
- CONCURRENT WETLAND/OHW LINES
- END OF SURVEY AREA
- POND
- WETLAND
- 100-YEAR FLOODPLAIN
- RIDEM 50 FOOT BUFFER AROUND 1/4 ACRE PONDS
- RIDEM 200 FOOT BUFFER FROM RIVER EDGE
- OU2 BOUNDARY
- WATER

NOTES:

1. BASEMAPPING SOURCE: ARCADIS; COORDINATE SYSTEM: STATE PLANE RHODE ISLAND NAD 83 FEET.

0 330 660 Feet

GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

WETLAND DELINEATION REPORT

WETLANDS, FLOODPLAIN AND ORDINARY HIGH WATER BOUNDARY DELINEATIONS

ARCADIS

FIGURE 4

6/24/07 SYR-RI, MTK,EAB
G:\Projects\Peterson Puritan\Cumberland, RI\Remedial\Investigation\Reports\mxd\Ecl\Arce Sold - Lead_v2.mxd

ARCADIS

Attachment 1

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Peterson Puritan City/County: Cumberland Sampling Date: 7/19/11

Applicant/Owner: State: RI Sampling Point: DP1

Investigator(s): GMM Section, Township, Range:

Landform (hillslope, terrace, etc.): Floor plain / base of hillslope Local relief (concave, convex, none): concave

Slope (%): Lat: Long: Datum:

Soil Map Unit Name: NWI classification:

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area within a Wetland?** Yes X No ____
Hydric Soil Present?	Yes X	No ____	If yes, optional Wetland Site ID: Wetland C
Wetland Hydrology Present?	Yes X	No ____	

Remarks: (Explain alternative procedures here or in a separate report.)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- X Sediment Deposits (B2)
- X Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- X Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- X Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- X Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No X	Depth (inches): ____
Water Table Present?	Yes ____	No X	Depth (inches): ____
Saturation Present? (Includes capillary fringe)	Yes ____	No X	Depth (inches): ____

Wetland Hydrology Present? Yes X No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: DP1 located in floodplain of Blackstone River

VEGETATION – Use scientific names of plants.

Sampling Point: DP1

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Fraxinus pennsylvanica	40	Y	FACW
2. Acer rubrum	10	N	FAC
3. Acer saccharinum	25	Y	FACW
4.			
5.			
6.			
7.			
	75	= Total Cover	

Sapling/Shrub Stratum (Plot size: 15')			
1. Fraxinus pennsylvanica	15	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
	15	= Total Cover	

Herb Stratum (Plot size: 1m²)			
1. clear weed	5	N	FACW
2. acer saccharinum	15	Y	FACW
3. yellow woodsorrel	5	N	NL
4. lady thumb	10	Y	FACW
5. path rush	5	N	FAC
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	40	= Total Cover	

Woody Vine Stratum (Plot size: 15')			
1.			
2.			
3.			
4.			
	0	= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:	
OBL species	x 1 =	
FACW species	x 2 =	
FAC species	x 3 =	
FACU species	x 4 =	
UPL species	x 5 =	
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- X Rapid Test for Hydrophytic Vegetation
- X Dominance Test is >50%
- ___ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No ___

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP-1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-2	10YR 5/2	80	10YR 5/6	20	C	M	sandy loam	
2-4	10YR 8/2	50 40	10YR 5/6	20	C	M	sandy loam	
2-4	10YR 4/1	50 40						
4-5	10YR 7/2	90	10YR 6/8	10	C	M	sandy loam	
5-6	10YR 4/1	90	10YR 5/8	10	C	M	sandy loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- X Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- X Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7) (**LRR R, MLRA 149B**)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- X Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Dark Surface (S7) (**LRR K, L**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- X Piedmont Floodplain Soils (F19) (**MLRA 149B**) not correct region
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes X No _____

Remarks:

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Peterson Pacific City/County: Cumberland Sampling Date: 7/19/11

Applicant/Owner: _____ State: RI Sampling Point: DP-2

Investigator(s): OMM Section, Township, Range: _____

Landform (hillslope, terrace, etc.): hill top Local relief (concave, convex, none): none

Slope (%): _____ Lat: _____ Long: _____ Datum: _____

Soil Map Unit Name: _____ NWI classification: _____

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil X, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes _____ No X

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** Yes _____ No X
Hydric Soil Present?	Yes _____	No X	If yes, optional Wetland Site ID: _____
Wetland Hydrology Present?	Yes _____	No X	

Remarks: (Explain alternative procedures here or in a separate report.)

area along hike paths @ top of slope upgradient of wetland C

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? Yes _____ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION – Use scientific names of plants.

Sampling Point: DP-2

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Norway maple	20	Y	NL
2. mulberry	25	Y	FACU
3. white birch	5	N	FACU
4. black cherry	5	N	FACU
5.			
6.			
7.			
	55	= Total Cover	

Sapling/Shrub Stratum (Plot size: 15')			
1. which hazel	15	Y	FAC
2. ~~bush~~ honeysuckle (tatarian)	10	Y	FACU
3. morus sp.	10	Y	FACU
4. norway maple	10	Y	NL
5.			
6.			
7.			
	45	= Total Cover	

Herb Stratum (Plot size: 1m²)			
1. stinging nettle	50	Y	FACU
2. path rush	10	N	FAC
3. crab grass	10	N	FACU
4. rough cinquefoil	<1	N	FACU
5. yellow woodsorrel	<1	N	NL
6. Dutch white clover	<1	N	OBL
7.			
8.			
9.			
10.			
11.			
12.			
	70	= Total Cover	

Woody Vine Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
		= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 7 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 14% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x 1 =
FACW species	x 2 =
FAC species	x 3 =
FACU species	x 4 =
UPL species	x 5 =
Column Totals: (A)	(B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ Rapid Test for Hydrophytic Vegetation

___ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes _____ No X

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP-2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-12	10YR 4/4	90					sandy loam	remainder fill material

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7) (**LRR R, MLRA 149B**)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Dark Surface (S7) (**LRR K, L**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ No X

Remarks:

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Peterson Puritan City/County: Cumberland Sampling Date: 7/20/11

Applicant/Owner: State: RI Sampling Point: DP3

Investigator(s): GMM/CLT Section, Township, Range:

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none):

Slope (%): Lat: Long: Datum:

Soil Map Unit Name: NWI classification:

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes X No

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____	No X	**Is the Sampled Area within a Wetland?** Yes ____ No X
Hydric Soil Present?	Yes ____	No X	If yes, optional Wetland Site ID:
Wetland Hydrology Present?	Yes X	No ____	

Remarks: (Explain alternative procedures here or in a separate report.)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- X Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- X Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No X	Depth (inches): ____
Water Table Present?	Yes ____	No X	Depth (inches): ____
Saturation Present? (includes capillary fringe)	Yes ____	No X	Depth (inches): ____

Wetland Hydrology Present? Yes X No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Drift location within 100yr floodplain but not flooded frequently or long enough to develop hydric soils or vegetation

VEGETATION – Use scientific names of plants.

Sampling Point: DP3

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. catalpa	30	Y	FAC
2.			
3.			
4.			
5.			
6.			
7.			
	30 = Total Cover		

Sapling/Shrub Stratum (Plot size: 15')			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
	0 = Total Cover		

Herb Stratum (Plot size: 1m²)			
1. japanese knotweed	100	Y	FACU
2. shaggy mattk	5	N	FACU
3. yellow wood sorrel	<1	N	FACU
4. bidens frondosa	<1	N	FACW
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	105 = Total Cover		

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	<1	x 2 =	0
FAC species	30	x 3 =	90
FACU species	105	x 4 =	420
UPL species	0	x 5 =	0
Column Totals:	135 (A)		510 (B)

Prevalence Index = B/A = 3.8

Hydrophytic Vegetation Indicators:

___ Rapid Test for Hydrophytic Vegetation

___ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes ___ No X

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP-3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-4	10YR 3/2	100					sandy loam	
4-16	10YR 3/2	97	5YR 4/6	3	C	PL	sandy loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7) (**LRR R, MLRA 149B**)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Dark Surface (S7) (**LRR K, L**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ No X

Remarks:

WETLAND DETERMINATION DATA FORM -- Northcentral and Northeast Region

Project/Site: Peterson Puritan City/County: Cumberland Sampling Date: 7/20/11

Applicant/Owner: _____ State: _____ Sampling Point: DP-4

Investigator(s): GMM / CLT Section, Township, Range: _____

Landform (hillslope, terrace, etc.): Vegetation Local relief (concave, convex, none): _____

Slope (%): _____ Lat: _____ Long: _____ Datum: _____

Soil Map Unit Name: _____ NWI classification: _____

Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes _____ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____	**Is the Sampled Area within a Wetland?** Yes X No _____
Hydric Soil Present?	Yes X	No _____	If yes, optional Wetland Site ID: _____
Wetland Hydrology Present?	Yes X	No _____	

Remarks: (Explain alternative procedures here or in a separate report.)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- X Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15)
- ___ Hydrogen Sulfide Odor (C1)
- X Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? Yes X No _____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION – Use scientific names of plants.

Sampling Point: DP4

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. cottonwood	20	Y	FAC
2. green ash	30	Y	FACW
3. box elder	20	Y	FAC
4. cutleaf	5	N	FAC
5.			
6.			
7.			
	75	= Total Cover	

Sapling/Shrub Stratum (Plot size: 15')			
1. green ash	30	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
	30	= Total Cover	

Herb Stratum (Plot size: 1m²)			
1. clearweed	60	Y	FACW
2. bidens frondosa	10	N	FACW
3. lady thumb	40	Y	FACW
4. yellow wood sorrel	<1	N	FACU
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	110	= Total Cover	

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
		= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 6 (A)

Total Number of Dominant Species Across All Strata: 6 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x 1 =
FACW species	x 2 =
FAC species	x 3 =
FACU species	x 4 =
UPL species	x 5 =
Column Totals: (A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- \ Rapid Test for Hydrophytic Vegetation
- X Dominance Test is >50%
- ___ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No ___

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP-4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-4	10YR 3/2	80	10YR 5/2	10	D	M	sandy loam	
			5YR 5/6	10	C	M/PL		
4-8	10YR 3/1	60	5YR 5/6	40	C	M	sandy loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7) **(LRR R, MLRA 149B)**
- ___ Polyvalue Below Surface (S8) **(LRR R, MLRA 149B)**
- ___ Thin Dark Surface (S9) **(LRR R, MLRA 149B)**
- ___ Loamy Mucky Mineral (F1) **(LRR K, L)**
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- X Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) **(LRR K, L, MLRA 149B)**
- ___ Coast Prairie Redox (A16) **(LRR K, L, R)**
- ___ 5 cm Mucky Peat or Peat (S3) **(LRR K, L, R)**
- ___ Dark Surface (S7) **(LRR K, L)**
- ___ Polyvalue Below Surface (S8) **(LRR K, L)**
- ___ Thin Dark Surface (S9) **(LRR K, L)**
- ___ Iron-Manganese Masses (F12) **(LRR K, L, R)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 149B)**
- ___ Mesic Spodic (TA6) **(MLRA 144A, 145, 149B)**
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes X No _____

Remarks:

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Peterson Pue tm Site City/County: Cumberland Sampling Date: 7/21/11

Applicant/Owner: _____ State: RI Sampling Point: DP5

Investigator(s): GMM, CLT Section, Township, Range: _____

Landform (hillslope, terrace, etc.): _____ Local relief (concave, convex, none): Convex

Slope (%): 0 Lat: _____ Long: _____ Datum: _____

Soil Map Unit Name: _____ NWI classification: _____

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? NO Are "Normal Circumstances" present? Yes X No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? NO (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____	**Is the Sampled Area within a Wetland?** Yes _____ No X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	If yes, optional Wetland Site ID: _____

Remarks: (Explain alternative procedures here or in a separate report.)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? Yes _____ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION – Use scientific names of plants.

Sampling Point: DP5

Tree Stratum (Plot size: 30 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. Silver Maple	25	Y	FACW
2. Green Ash	20	Y	FACW
3. Black Willow	5	N	FACW
4.			
5.			
6.			
7.			
	60 = Total Cover		30/12
Sapling/Shrub Stratum (Plot size: 15 ft)			
1. Catalpa	5	Y	FAC
2.			
3.			
4.			
5.			
6.			
7.			
	5 = Total Cover		
Herb Stratum (Plot size: 1m x 1m)			
1. Stinging nettle	10	N	FACW
2. Poison ivy	15	N	FAC
3. Deertongue panicum	25	Y	FAC
4. Mugwort	15	N	FACW
5. Rugosa/tomato goldenrod (S. rugosa)	25	Y	FAC
6. Lepidium virginicum	~~15~~ 5	N	FACW
7.			
8.			
9.			
10.			
11.			
12.			
	95 = Total Cover		48/19
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

- ___ Rapid Test for Hydrophytic Vegetation
- X Dominance Test is >50%
- ___ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No _____

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP5

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-11	10YR 3/3	100					Sandy loam	
11-15	10YR 2/2	100					Sandy loam	
15-20	10YR 3/3	100					Sandy loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7) (**LRR R, MLRA 149B**)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Dark Surface (S7) (**LRR K, L**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ No X

Remarks:

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Peterson Porter Site City/County: Cumberland Sampling Date: 7/21

Applicant/Owner: _____ State: RI Sampling Point: DP6

Investigator(s): GMM, CLT Section, Township, Range: _____

Landform (hillslope, terrace, etc.): _____ Local relief (concave, convex, none): Concave

Slope (%): 10 Lat: _____ Long: _____ Datum: _____

Soil Map Unit Name: _____ NWI classification: _____

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? No Are "Normal Circumstances" present? Yes X No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? NO (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____	**Is the Sampled Area within a Wetland?** Yes X No _____
Hydric Soil Present?	Yes X	No _____	If yes, optional Wetland Site ID: _____
Wetland Hydrology Present?	Yes X	No _____	

Remarks: (Explain alternative procedures here or in a separate report.)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- X Saturation (A3)
- X Water Marks (B1)
- ___ Sediment Deposits (B2)
- X Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- X Sparsely Vegetated Concave Surface (B8)
- X Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15)
- ___ Hydrogen Sulfide Odor (C1)
- X Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- X Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ___	No X	Depth (inches): _____
Water Table Present?	Yes ___	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes X	No ___	Depth (inches): 7

Wetland Hydrology Present? Yes X No _____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION – Use scientific names of plants.

Sampling Point: DP6

Tree Stratum (Plot size: 30 Ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. Cottonwood	40	Y	FAC
2. Black willow	5	N	FACW
3. Green ash	5	N	FACW
4.			
5.			
6.			
7.			
	50	= Total Cover	

Sapling/Shrub Stratum (Plot size: 15)			
1. Black willow	5	Y	FACW
2. Catalpa	<5	N	FAC
3.			
4.			
5.			
6.			
7.			
	7.5	= Total Cover	

Herb Stratum (Plot size: 1m x 1m)			
1. Green ash	15	Y	FACW
2. Silver maple	5	N	FACW
3. Water horehound (Lycopus americanus)	5	N	OBL
4. Lady's thumb	10	Y	FACW
5. Yellow woodsorrel	<5	N	NL
6. Black willow	<5	N	FACW
7. Virginia bugleweed (Lycopus virginicus)	<5	N	OBL
8. American elm	10	Y	FACW
9.			
10.			
11.			
12.			
	47.5	= Total Cover	24 / 9.5

Woody Vine Stratum (Plot size: NA)			
1.			
2.			
3.			
4.			
		= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x 1 =
FACW species	x 2 =
FAC species	x 3 =
FACU species	x 4 =
UPL species	x 5 =
Column Totals: (A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

___ Rapid Test for Hydrophytic Vegetation

___ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No ___

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP6

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-4	7YR 4/1	100					Sand	lots of root matter
4-7	7YR 4/1	95	7YR 4/4	5			Sandy loam	
7-16	10YR 4/1	97	2.5YR 3/6	3			Sandy loam	Saturated, very gritty

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7) (**LRR R, MLRA 149B**)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- X Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Dark Surface (S7) (**LRR K, L**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes X No _____

Remarks:

ARCADIS

Attachment 2

Attachment 2
Draft Technical Memorandum: Delineation of Wetland Boundaries and Waterways
Peterson/Puritan, Inc. Superfund Site – Operable Unit 2
Cumberland and Lincoln, Rhode Island



Photo #1: View of Pond A facing northeast from westernmost edge (connects to Photo #2)



Photo #2: View of Pond A facing east from westernmost edge (connects to Photo #1)



Photo #3: View of a segment of Pond B with no standing water



Photo #4: View of Pond C's path of connection to the Blackstone River



Photo #5: Emergent forested/shrub wetland vegetated areas around Pond C



Photo #6: View of Pond F and adjacent forested wetlands from bike path near Pratt Dam (connects to Photo #7)



Photo #7: View of Pond F and adjacent forested wetlands (connects to Photo #6)



Photo #8: View into forested wetland surrounding Pond F along access path to Unnamed Island from bike path



Photo #9: Typical vegetation looking north towards Quinnvillle Well Field



Photo #10: At southeast end of Quinnville Well Field, looking north toward sample locations LQW-011 and LQW-012



Photo #11: Near wells in Quinnville Well Field (northern portion of subarea), looking east toward sample location LQW-011



Photo #12: Access road along Quinnville Well Field, approximately 600 feet southwest of Blackstone River



Photo #13: Culvert pipe on access road along Quinnville Well Field; evidence of recent flooding



Photo #14: Looking north to J.M. Mills Landfill and Pond B, across Blackstone River from Town of Lincoln



Photo #15: View of Pond E and surrounding areas

FEMA-PREDICTED 100-YEAR FLOOD AREA AND ESTIMATED FLOOD ELEVATIONS IN THE PETERSON PURITAN OU2 AREA

Legend

- OU2 Boundary
- FEMA Delineated 100-year Flood Area
- Floodway
- 71 Base Flood Elevations (FEMA 2009)
- Water Features

Contour Elevation (ft)

- 52 - 66
- 68
- 70
- >70

0 250 500 1,000 1,500 2,000 Feet

AECOM

74 73 72 71 70 69 68 67 66 65 64

Notes:

1. FEMA Flood Elevations based on Flood Insurance Rate Map for Cumberland, RI, FEMA, March 2009.

2. In the Peterson Puritan OU2 area, FEMA Flood Insurance Study (March 2009) shows that the 500-year flood elevation is between 1 and 3 feet higher than the 100-year flood elevation presented .

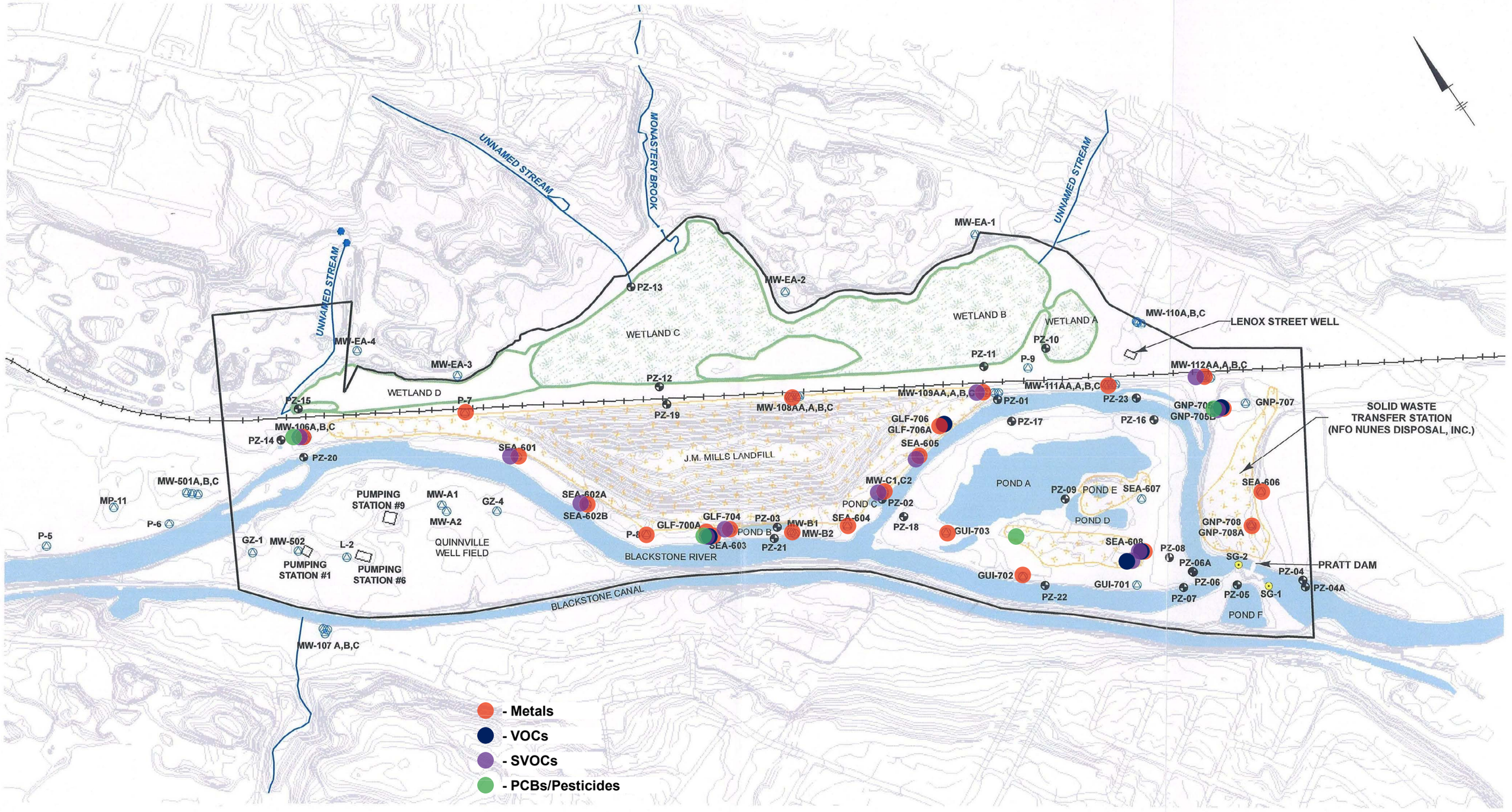
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APPENDIX H

GROUNDWATER PERFORMANCE STANDARD EXCEEDANCES

The following figures present groundwater results which exceeded Performance Standards (PSs) in at least one sampling event at the site (includes events in 2003, 2004, 2005, 2006, 2009, and 2012). Note that not all wells were sampled during each event, nor were all parameters. Furthermore, there were groundwater samples collected on the Unnamed Island while soil sampling – these wells are not labeled on the figures. However, if there were PS exceedances, a dot has been placed in the approximate location of the sampling point.

All PS exceedances considered to be site-related are shown. If there was a sampling event following an exceedance, those results are also presented to show any decreases in concentration. Due to space limitations, this was not fully completed on the figures for arsenic, iron, manganese, and thallium. In those cases, the only wells reviewed were those which would potentially/likely be near the outside of the proposed compliance boundary. Any detections/detection limits below the PS are shown in green font.



NOTES:

1. NFO - NOW OR FORMERLY OWNED BY
2. SOME OF THE MONITORING WELLS SHOWN WERE NOT SAMPLED DURING THE RI. SEE RI TEXT FOR A DESCRIPTION OF WHICH WERE SAMPLED AS PART OF THE 4 SAMPLING EVENTS DURING THE RI.

LEGEND:

- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- OU2 BOUNDARY **(RI Site Study Area)**
- BURIED WASTE
- WETLAND (INTERMITTENTLY WET)
- SURFACE WATER

0 500 1,000 Feet
GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

FIGURE GW-1. EXCEEDANCES OF HUMAN HEALTH GROUNDWATER PSs

6/15/07 SYR-85 EAB KEW MTK
Peterson/Puritan (37902.012)
O:\Peterson_Puritan\Cumberland_RI\RemedialInvestigationReport\mxd\Wells.mxd

UNNAMED STREAM
MONASTERY BROOK
UNNAMED STREAM
UNNAMED STREAM
MW-EA-1
MW-EA-2
PZ-13
MW-EA-4
MW-EA-3
WETLAND C
WETLAND B
WETLAND A
WETLAND D
MW-110A,B,C
LENOX STREET WELL
PZ-10
PZ-11
P-9
PZ-12
PZ-19
P-7
PZ-15
MW-106A
Chloroform – 0.47 - 2005
MW-106B
Chloroform – 0.81 - 2005
MW-106C
Chloroform – 0.72 - 2005
MW-106A,B,C
PZ-14
PZ-20
GLF-706a
Chloroform – 2.5 - 2005
MW-108AA,A,B,C
MW-112AA,A,B,C
MW-111AA,A,B,C
PZ-01
PZ-23
PZ-16
PZ-17
GNP-705B
Chloroform – 2.4 - 2005
GNP-705
GNP-705B
GNP-707
SOLID WASTE
TRANSFER STATION
(NEO NUNES DISPOSAL, INC.)
GLF-706
GLF-706A
SEA-605
SEA-601
J.M. MILLS LANDFILL
GNP-705
Benzene – 19 – 2005
Benzene – 20 - 2012
MW-501A,B,C
MP-11
P-6
P-5
PUMPING
STATION #9
MW-A1
MW-A2
GZ-4
SEA-602A
SEA-602B
GLF-704
Chloroform – 0.24 - 2005
MW-C1,C2
POND A
POND C
PZ-02
SEA-604
PZ-09
POND E
SEA-607
SEA-606
POND D
GNP-708
GNP-708A
GLF-704
PZ-03
MW-B1
MW-B2
GLF-700A
PZ-18
GUI-703
GZ-1
MW-502
L-2
PUMPING
STATION #1
PUMPING
STATION #6
QUINNVILLE
WELL FIELD
GLF-700a
Chloroform – 0.51 - 2005
P-8
POND B
SEA-603
PZ-21
BLACKSTONE RIVER
SEA-608
PZ-08
PZ-06A
SG-2
PRATT DAM
GW-201-UI
Benzene – 4.88 – 2009
(duplicate was above)
PZ-04
PZ-06
PZ-04A
PZ-05
SG-1
GUI-701
PZ-22
SEA-603
Benzene-1100 – 2003
Benzene- 675 – 2004
Benzene – 140 – 2005
Benzene – 0.25 - 2012
SEA-608
Benzene-7.85 – 2003
Benzene- 7.7 – 2006
Benzene – ND - 2012
POND F
BLACKSTONE CANAL
MW-107 A,B,C

PSs (ug/L)
Benzene – 5
Chloroform – 0.19

NOTES:

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2. SOME OF THE MONITORING WELLS SHOWN WERE NOT SAMPLED DURING THE RI. SEE RI TEXT FOR A DESCRIPTION OF WHICH WERE SAMPLED AS PART OF THE 4 SAMPLING EVENTS DURING THE RI.

LEGEND:

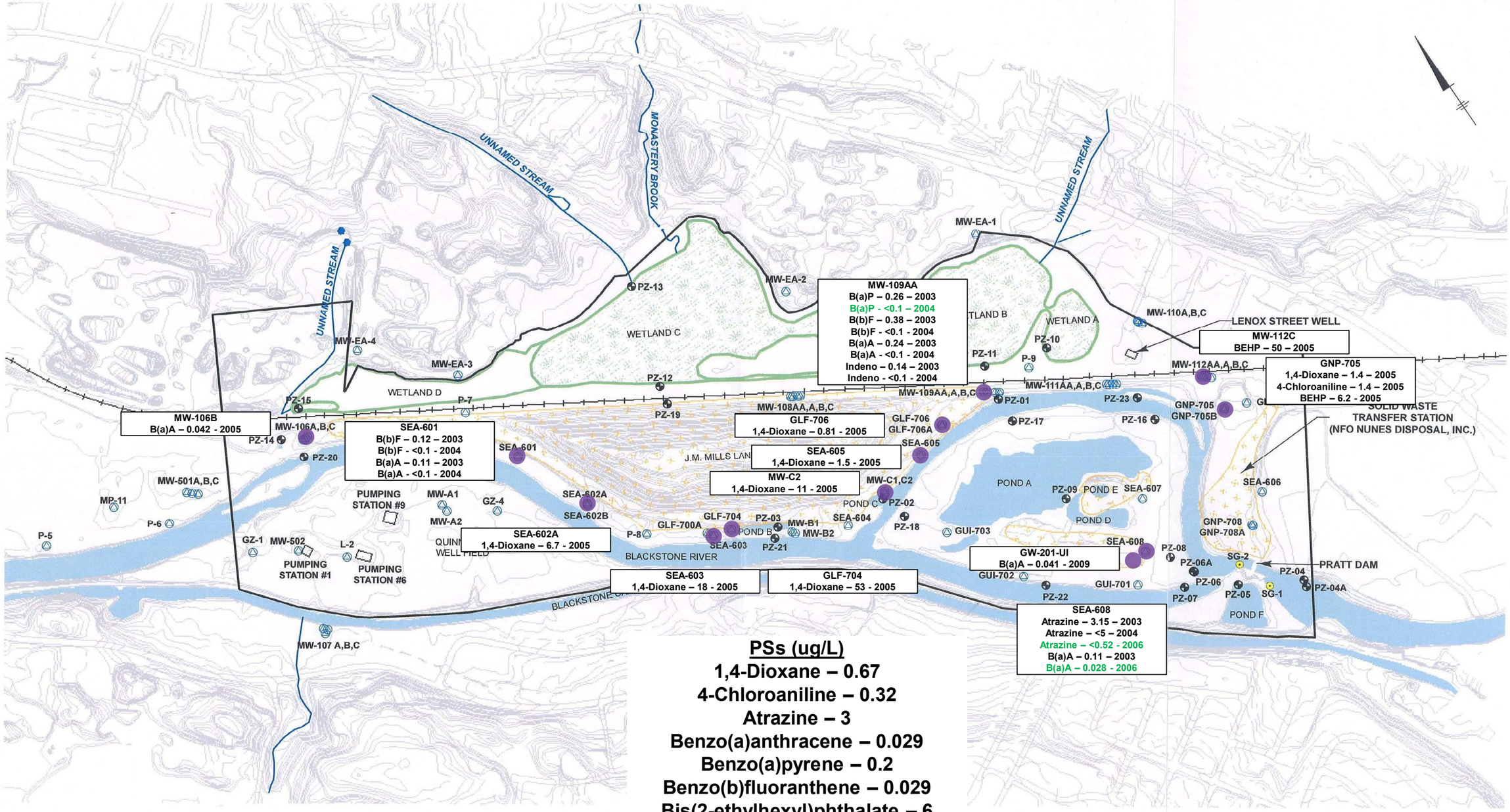
- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- OU2 BOUNDARY **(RI Site Study Area)**
- BURIED WASTE
- WETLAND (INTERMITTENTLY WET)
- SURFACE WATER

0 500 1,000 Feet
GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

FIGURE GW-2. EXCEEDANCES OF HUMAN HEALTH GROUNDWATER PSs VOCs

6/15/07 SYR-85 EAB KEW MTK
Peterson/Puritan (37902.012)
O:\Peterson_Puritan\Cumberland_RI\RemedialInvestigationReport\mxd\Wells.mxd



PSs (ug/L)

1,4-Dioxane – 0.67
4-Chloroaniline – 0.32
Atrazine – 3
Benzo(a)anthracene – 0.029
Benzo(a)pyrene – 0.2
Benzo(b)fluoranthene – 0.029
Bis(2-ethylhexyl)phthalate – 6
Indeno(1,2,3-cd)pyrene – 0.029

NOTES:

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2. SOME OF THE MONITORING WELLS SHOWN WERE NOT SAMPLED DURING THE RI. SEE RI TEXT FOR A DESCRIPTION OF WHICH WERE SAMPLED AS PART OF THE 4 SAMPLING EVENTS DURING THE RI.

LEGEND:

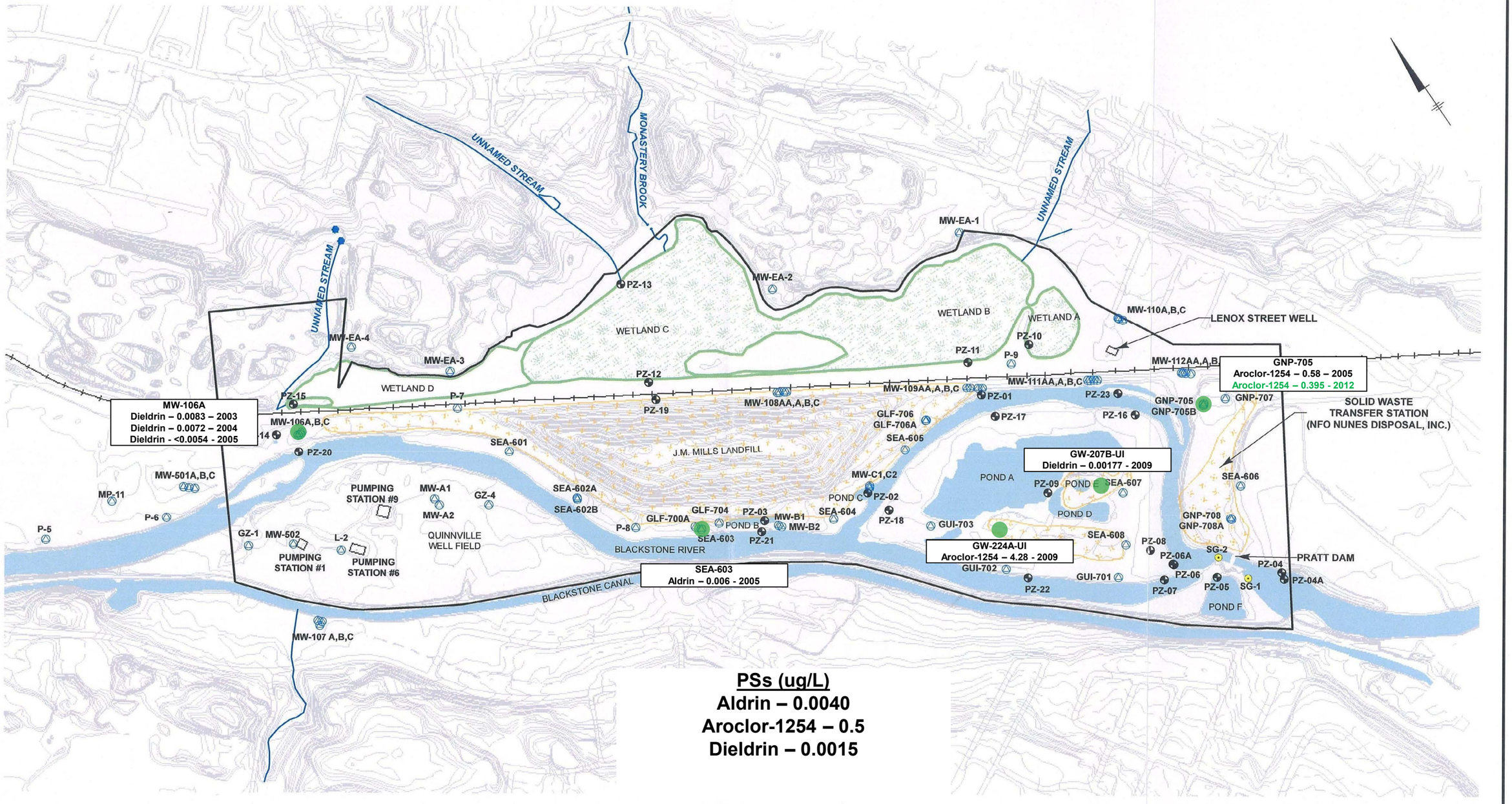
- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- OU2 BOUNDARY **(RI Site Study Area)**
- BURIED WASTE
- WETLAND (INTERMITTENTLY WET)
- SURFACE WATER

0 500 1,000 Feet
GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

FIGURE GW-3. EXCEEDANCES OF HUMAN HEALTH GROUNDWATER PSs SVOCs

6/15/07 SYR-85 EAB KEW MTK
Peterson/Puritan (37902 012)
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PSs (ug/L)
Aldrin – 0.0040
Aroclor-1254 – 0.5
Dieldrin – 0.0015

NOTES:

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LEGEND:

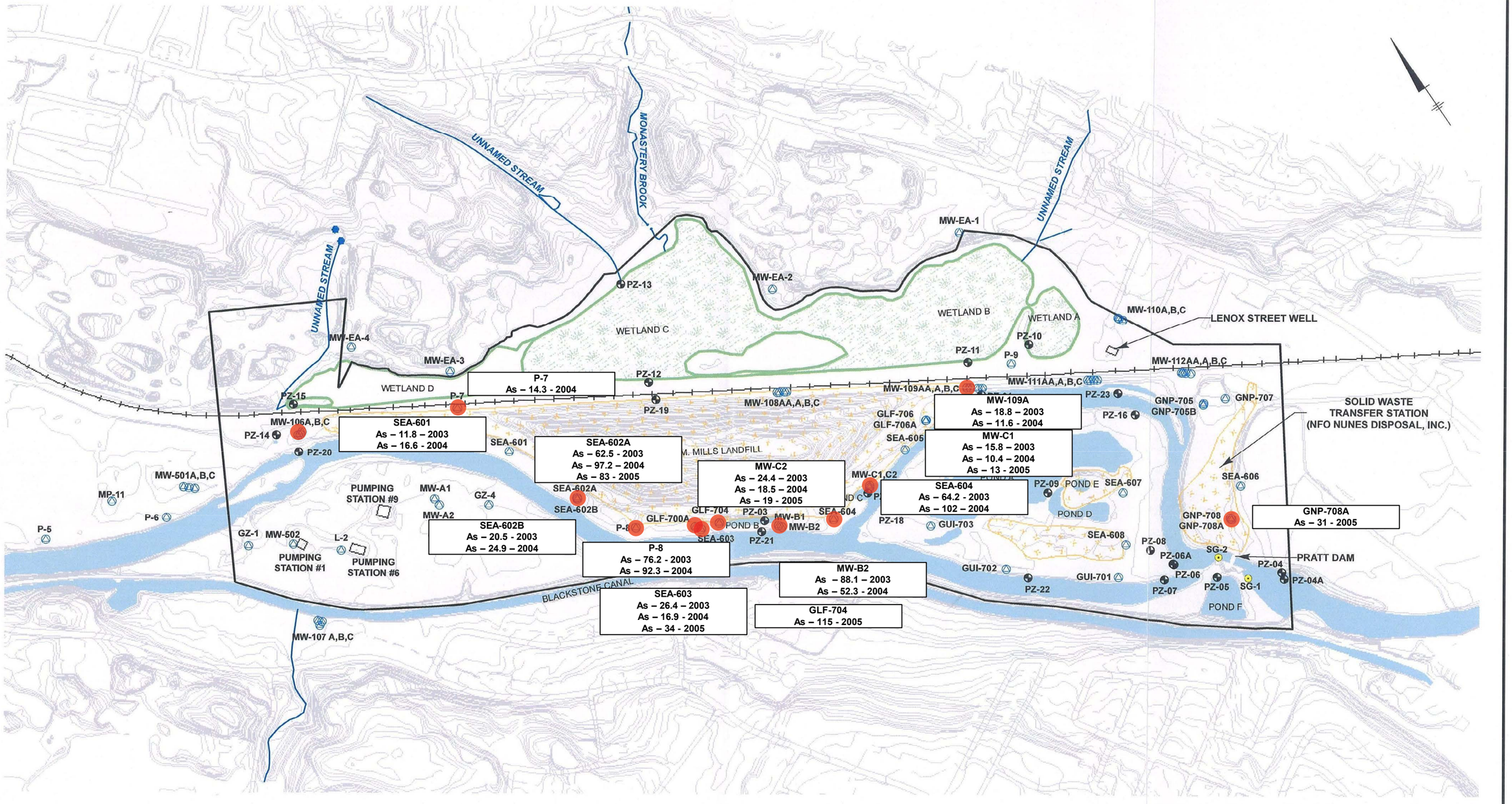
- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- OU2 BOUNDARY **(RI Site Study Area)**
- BURIED WASTE
- WETLAND (INTERMITTENTLY WET)
- SURFACE WATER

0 500 1,000 Feet
GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

FIGURE GW-4. EXCEEDANCES OF HUMAN HEALTH GROUNDWATER PSs PCBs/PESTICIDES

6/15/07 SYR-85 EAB KEW MTK
Peterson/Puritan (37902 012)
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NOTES:

1. NFO - NOW OR FORMERLY OWNED BY
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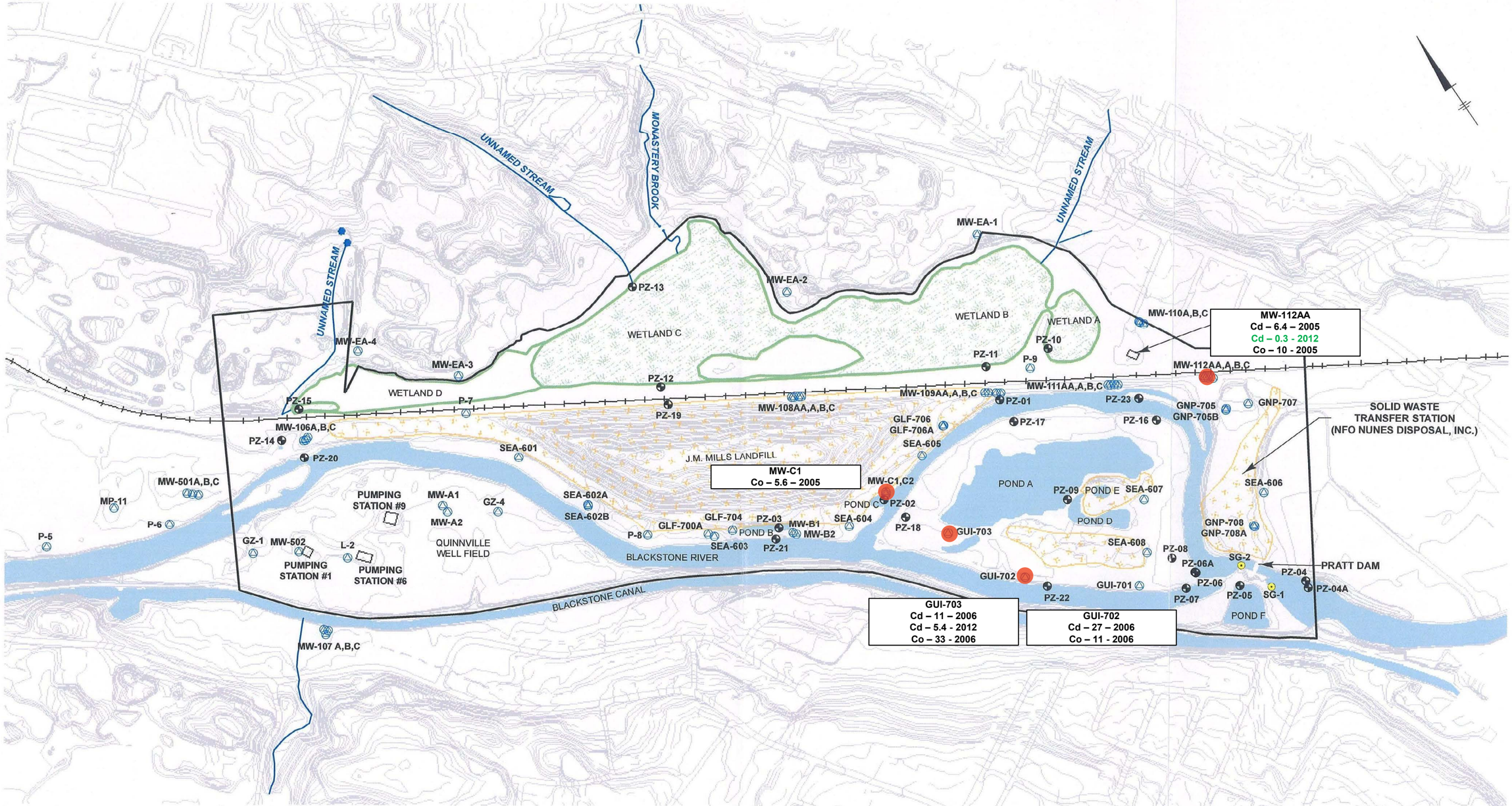
- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- OU2 BOUNDARY **(RI Site Study Area)**
- BURIED WASTE
- WETLAND (INTERMITTENTLY WET)
- SURFACE WATER

0 500 1,000 Feet
GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

FIGURE GW-5. EXCEEDANCES OF HUMAN HEALTH GROUNDWATER PSs ARSENIC (PS = 10 ug/L)

6/15/07 SYR-85 EAB KEW MTK
Peterson/Puritan (37902 012)
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LEGEND:

- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- OU2 BOUNDARY **(RI Site Study Area)**
- BURIED WASTE
- WETLAND (INTERMITTENTLY WET)
- SURFACE WATER

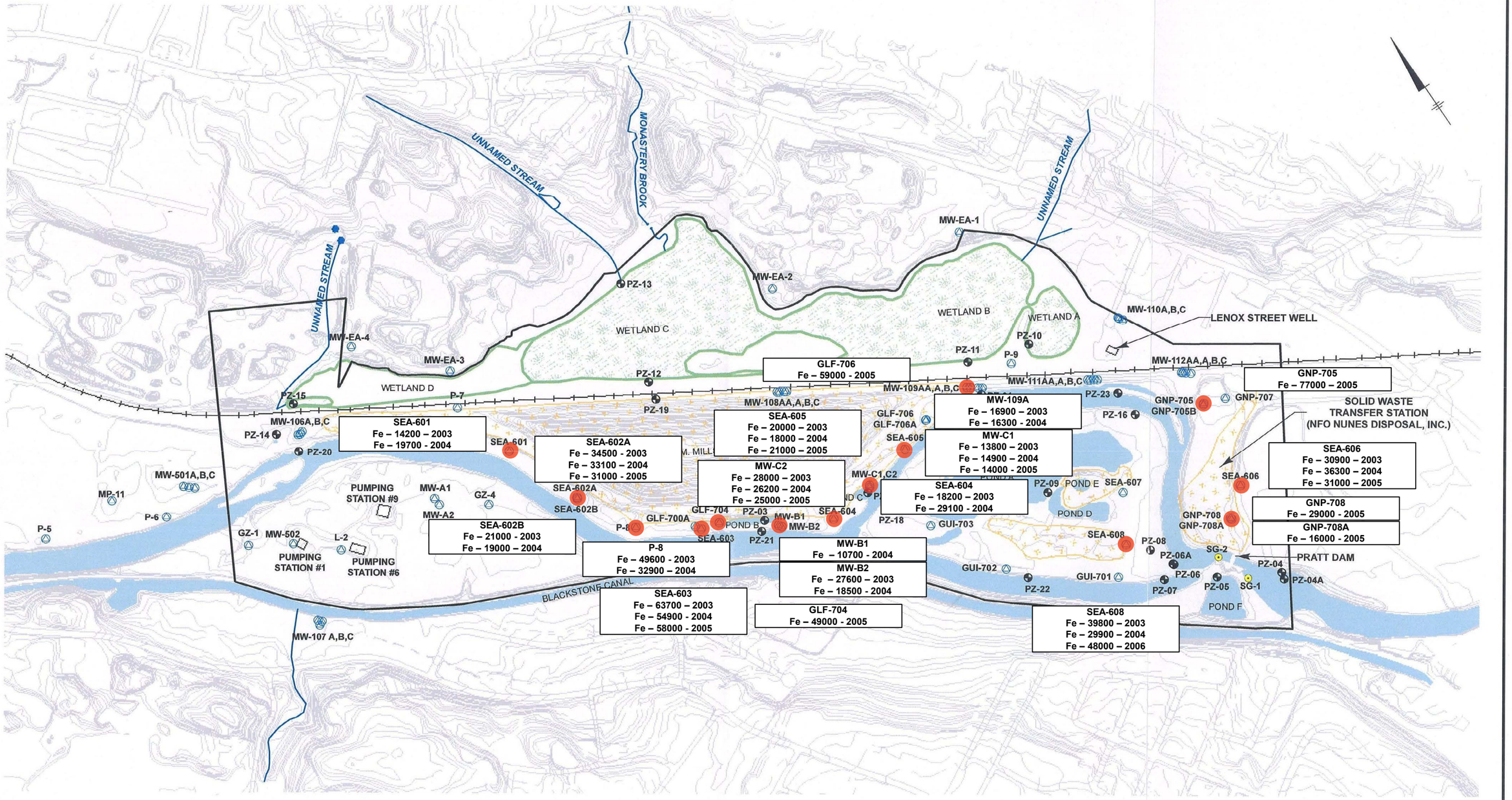
0 500 1,000 Feet

GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

FIGURE GW-6.
EXCEEDANCES OF HUMAN HEALTH GROUNDWATER PSs
ALUMINUM (PS = 15540 ug/L)
CADMIUM (PS = 5 ug/L)
COBALT (PS = 4.7 ug/L)
LEAD (PS = 15 ug/L)

6/15/07 SYR-85 EAB KEW MTK
Peterson/Puritan (37902 012)
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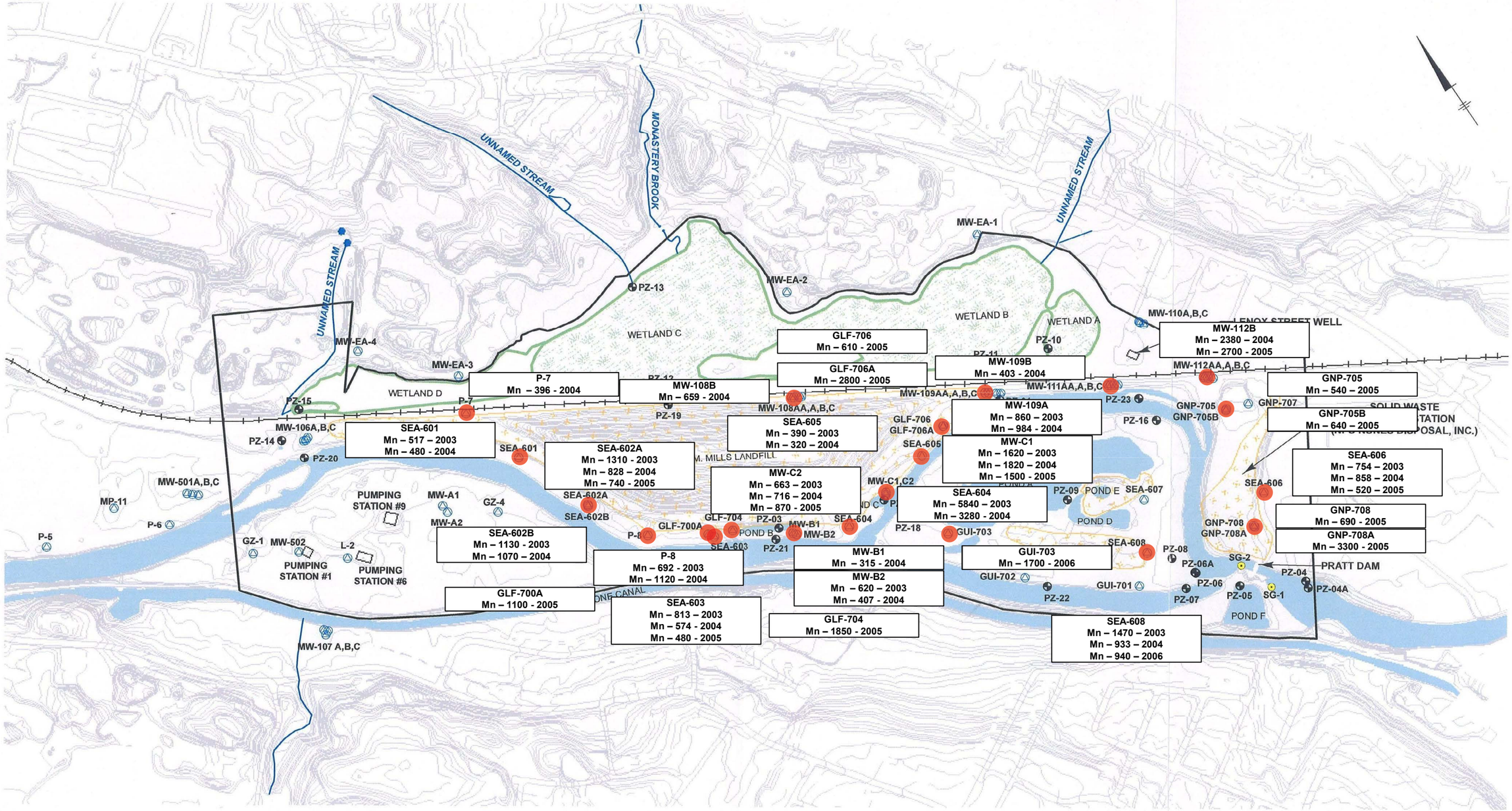
- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- OU2 BOUNDARY **(RI Site Study Area)**
- BURIED WASTE
- WETLAND (INTERMITTENTLY WET)
- SURFACE WATER

0 500 1,000 Feet
GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

FIGURE GW-7. EXCEEDANCES OF HUMAN HEALTH GROUNDWATER PSs IRON (PS = 10878 ug/L)

6/15/07 SYR-85 EAB KEW MTK
Peterson/Puritan (37902.012)
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LEGEND:

- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- OU2 BOUNDARY **(RI Site Study Area)**
- BURIED WASTE
- WETLAND (INTERMITTENTLY WET)
- SURFACE WATER

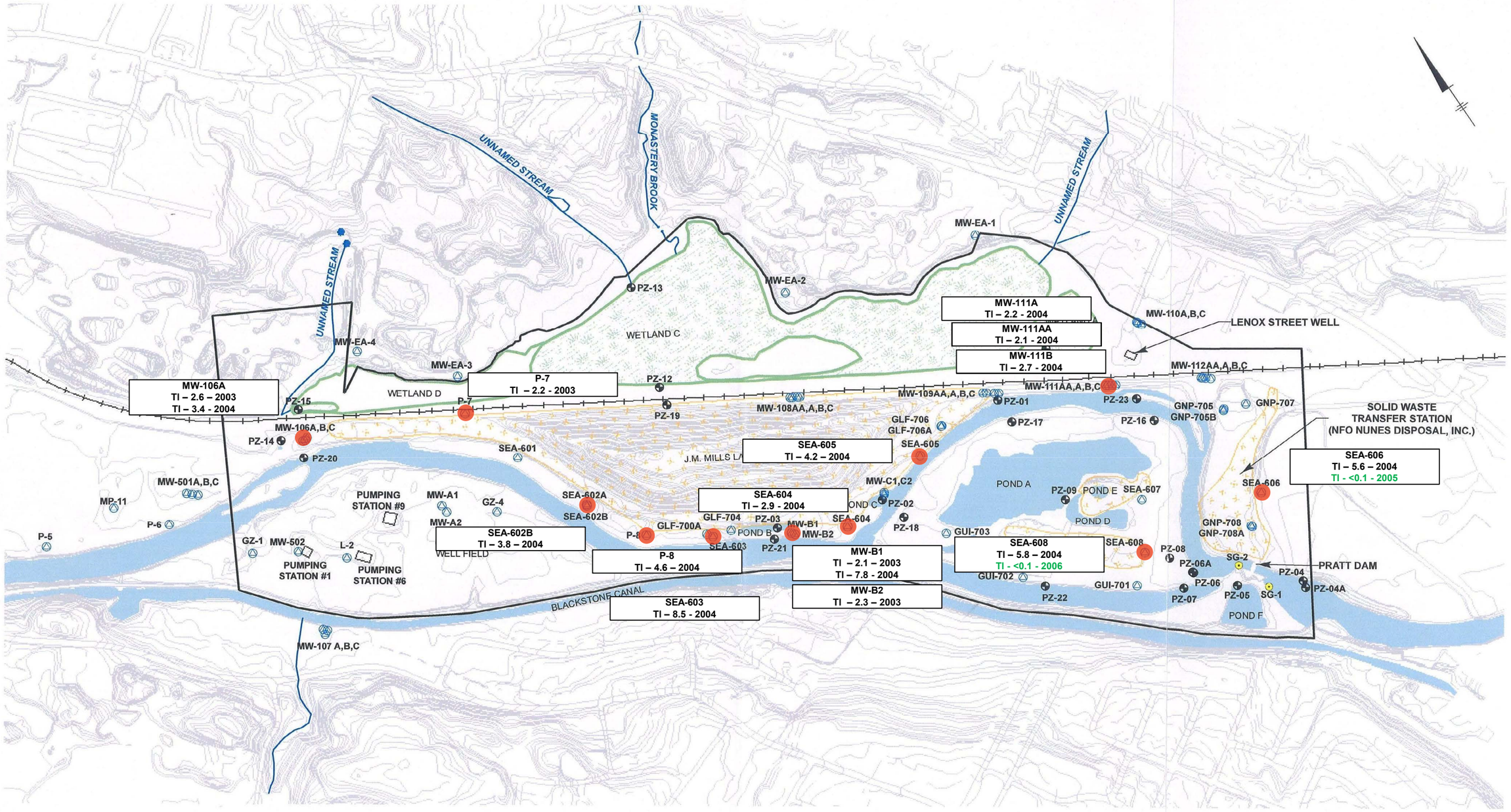
0 500 1,000 Feet

GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

FIGURE GW-8. EXCEEDANCES OF HUMAN HEALTH GROUNDWATER PSs MANGANESE (PS = 300 ug/L)

6/15/07 SYR-85 EAB KEW MTK
Peterson/Puritan (37902.012)
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LEGEND:

- MONITORING WELL
- PIEZOMETER/STAFF GAUGE
- STAFF GAUGE
- OU2 BOUNDARY **(RI Site Study Area)**
- BURIED WASTE
- WETLAND (INTERMITTENTLY WET)
- SURFACE WATER

0 500 1,000 Feet
GRAPHIC SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

FIGURE GW-9. EXCEEDANCES OF HUMAN HEALTH GROUNDWATER PSs THALLIUM (PS = 0.5 ug/L)

6/15/07 SYR-85 EAB KEW MTK
Peterson/Puritan (37902.012)
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APPENDIX I

ARARs/TBCs

Table I-1a
Chemical-Specific ARARs and TBCs for Groundwater
Alternative GW-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLs), 40 CFR Subparts B and G	Relevant and Appropriate	Establishes MCLs for common organic and inorganic contaminants applicable to public drinking water supplies. Used as relevant and appropriate standards for aquifers and surface water bodies that are potential drinking water sources.	This alternative would not prevent exposure to contaminants that exceed MCLs and would not meet this standard.
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Goals (MCLGs), 40 CFR Subpart F	Relevant and Appropriate	Establishes maximum contaminant level goals (MCLGs) for public water supplies. MCLGs are health goals for drinking water sources. These unenforceable health goals are available for a number of organic and inorganic compounds.	This alternative would not prevent exposure to contaminants that exceed MCLGs and would not meet this standard.
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	This alternative would not prevent exposure to potential carcinogenic risks, calculated using these standards, caused by exposure to groundwater contaminants.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	This alternative would not prevent exposure to potential carcinogenic risks to children, calculated using these standards, caused by exposure to groundwater contaminants.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are considered to be the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime	This alternative would not prevent exposure to potential non-carcinogenic risks, calculated using these standards, caused by exposure to groundwater contaminants.

Table I-1a
Chemical-Specific ARARs and TBCs for Groundwater
Alternative GW-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	This alternative would not prevent exposure to potential carcinogenic risks, calculated using these standards, caused by exposure to groundwater contaminants.
Federal Requirements	EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	This alternative would not prevent exposure to potential non-carcinogenic risks, calculated using these advisories, caused by exposure to groundwater contaminants.
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases, CRIR12-180-001; DEM-DSR-01-93, section 8.03	Applicable	These regulations set remediation standards for groundwater at NPL sites within the state based on groundwater classification.	This alternative would not prevent exposure to any groundwater contaminants that exceed state groundwater standards that are more stringent than federal regulatory or risk-based standards.

Notes:
With no action, there are no location- or action-specific ARARs.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-2a
Chemical-Specific ARARs and TBCs for Groundwater
Alternative GW-2: Long Term Monitoring and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in groundwater.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	Used to calculate potential carcinogenic risks to children caused by exposure to contaminants.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are considered to be the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime.	Used to compute the individual incremental cancer risk resulting from exposure to non-carcinogenic contaminants in groundwater.
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in groundwater.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-2b
Location-Specific ARARs and TBCs for Groundwater
Alternative GW-2: Long Term Monitoring and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains disturbed by well installation, maintenance, and monitoring..
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas due to well installation, maintenance, and monitoring. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this alternative.
Federal Requirements	Clean Water Act, Section 404; Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Activities involving discharge of dredged material and/or excavation and/or installation or maintenance of monitoring wells that include dredging or filling in wetlands will be implemented to meet these requirements, including mitigation of altered wetlands/aquatic resources, as required.

Table I-2b
Location-Specific ARARs and TBCs for Groundwater
Alternative GW-2: Long Term Monitoring and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Regulatory Requirements	Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; RIDEM Rules And Regulations Governing the Administration and Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00-6.00, 10.00, 11.00 and 13.00.	Applicable	Defines and establishes provisions for the protection of swamps, marshes and other fresh water wetlands resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland.	Action taken under this alternative will be done in compliance with this requirement.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection

Table I-2c
Action-Specific ARARs and TBCs for Groundwater
Alternative GW-2: Long Term Monitoring and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLs), 40 CFR Subparts B and G	Relevant and Appropriate	Establishes MCLs for common organic and inorganic contaminants applicable to public drinking water supplies. Used as relevant and appropriate standards for aquifers and surface water bodies that are potential drinking water sources.	MCLs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Goals (MCLGs), 40 CFR Subpart F	Relevant and Appropriate	Establishes maximum contaminant level goals (MCLGs) for public water supplies. MCLGs are health goals for drinking water sources. These unenforceable health goals are available for a number of organic and inorganic compounds.	Non-zero MCLGs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.

Table I-2c
Action-Specific ARARs and TBCs for Groundwater
Alternative GW-2: Long Term Monitoring and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	The Health Advisories will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.
Federal Requirements	EPA Groundwater Protection Strategy	TBC	The Groundwater Protection Strategy provides a common reference for preserving clean groundwater and protecting the public health against the effects of past contamination. Guidelines for consistency in groundwater protection programs focus on the highest beneficial use of a groundwater aquifer and defines three classes of groundwater.	In accordance with federal guidance, groundwater within the compliance boundary for the waste management area that comprises the entire area of the OU will be subject to groundwater use restrictions for as long as contamination remains in place.
State Requirements	RI Rules and Regulations for Groundwater Quality, RIDEM (6-2010), Appendix 1	Applicable	Establishes construction standards for permanent monitoring wells and abandonment procedures.	Monitoring wells will be installed and abandoned in accordance with these standards.

Table I-2c
Action-Specific ARARs and TBCs for Groundwater
Alternative GW-2: Long Term Monitoring and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases , CRIR12-180-001; DEM-DSR-01-93, sections 8.01, 8.03	Applicable	These regulations set remediation standards for groundwater at NPL sites within the state based on groundwater classification.	State standards that are more stringent than federal standards will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place.
State Requirements	RI Solid Waste Regulations – Groundwater Monitoring Wells, DEM OSMSW0401, 2.1.08(a)(8)	Applicable	Contains requirements for construction of monitoring wells to monitor a solid waste landfill.	The substantive requirements of this section of the regulations will be met for construction of new monitoring wells for areas where solid waste is managed in place.
State Requirements	RI Solid Waste Regulations – Long Term Monitoring, DEM OWMSW0401, 2.1.08(c)	Applicable	Contains requirements for monitoring wells.	The substantive requirements of this section of the regulations will be met by maintaining monitoring wells for groundwater conditions at the Site where solid waste is managed in place. It will be supported with a Long Term Monitoring Plan (LTMP) for groundwater. The LTMP will be directed by a work plan that will contain the specific monitoring requirements.

Table I-2c
Action-Specific ARARs and TBCs for Groundwater
Alternative GW-2: Long Term Monitoring and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Solid Waste Management, DEM OWMSW0401, 2.3.11	Applicable	Contains requirements for monitoring wells.	The substantive requirements of this section of the regulations will be met by maintaining monitoring wells for groundwater conditions at the Site where solid waste is managed in place.
State Requirements	Rules and Regulations for Hazardous Waste Management, Standards for Identification and Listing of Hazardous Waste, CRIR12-030-003 Rule 5.8	Applicable	Defines the listed and characteristic hazardous wastes.	These regulations would apply when determining whether or not a waste generated from either installing, sampling, or maintaining monitoring wells is hazardous, either by being listed or by exhibiting a hazardous characteristic.
State Requirements	Rules and Regulations for Hazardous Waste Management, Standards for Generators of Hazardous Waste, CRIR 12-030-003 Rule 5.0	Applicable	Establishes handling and pre-transport requirements for hazardous waste.	These regulations would apply to any waste generated from either installing, sampling, or maintaining monitoring wells, if hazardous.

Table I-2c
Action-Specific ARARs and TBCs for Groundwater
Alternative GW-2: Long Term Monitoring and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rules and Regulations for Hazardous Waste Management, Operational Requirements for Treatment, Storage, and Disposal Facilities, Groundwater Monitoring, CRIR 12-030-003 Rule 9.03	Applicable	Contains requirements for monitoring wells.	The substantive requirements of this section of the regulations will be met by maintaining monitoring wells for groundwater conditions at the site where hazardous waste in managed in place. It will be supported with a Long Term Monitoring Plan (LTMP) for groundwater. The LTMP will be directed by a work plan that will contain the specific monitoring requirements.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-3a
Chemical-Specific ARARs and TBCs for J.M. Mills Landfill
Alternative JM-SO-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	This alternative would not prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	This alternative would not prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk to children, developed using this guidance.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are considered to be the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime.	This alternative would not prevent exposure soil/debris contaminants which contribute to a calculated non-carcinogenic risk, developed using this guidance.
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	This alternative would not prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance.
Federal Requirements	EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	This alternative would not prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance.

Table I-3a
Chemical-Specific ARARs and TBCs for J.M. Mills Landfill
Alternative JM-SO-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Recommendations of the Technical Review Workgroup for Lead for an approach to Assessing Risks Associated with Adult Exposure to Lead In Soil, EPA-540-R-03-001 (January 2003)	TBC	EPA Guidance for evaluating risks posed by lead in soil.	This alternative would not prevent exposure to lead in soil/debris which contributes to a calculated risk, developed using this guidance.
Federal Requirements	USEPA Interim Ecological Soil Screening Levels (SSLs) (USEPA, 2003)	TBC	SSLs were established to provide screening toxicity thresholds.	SSLs were used for selecting Chemicals of Potential Concern (COPCs) and for characterizing ecological effects. This alternative would not prevent exposure to soil contaminants which contribute to a calculated ecological risk, developed using this guidance.
Federal Requirements	ORNL Toxicological Benchmarks for Wildlife (Sample et al., 1996)	TBC	These benchmarks were established to provide screening toxicity thresholds.	These benchmarks were used for selecting COPCs and for characterizing ecological effects. This alternative would not prevent exposure to soil contaminants which contribute to a calculated ecological risk, developed using this guidance.

Table I-3a
Chemical-Specific ARARs and TBCs for J.M. Mills Landfill
Alternative JM-SO-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	ORNL Toxicological Benchmarks for Screening Contaminants of Concern for Effects of Soil and Litter Invertebrates and Heterotrophic Process (Efroymson et al., 1997)	TBC	These benchmarks were established to provide screening toxicity thresholds.	These benchmarks were used for selecting COPCs and for characterizing ecological effects. This alternative would not prevent exposure to soil contaminants which contribute to a calculated ecological risk, developed using this guidance.
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.02	Applicable	These regulations set remediation standards for soil at NPL sites when they are more stringent than federal standards.	This alternative would not prevent exposure to any soil contaminants that exceed state soil standards that are more stringent than federal risk-based standards.

Notes:
For the No Action alternative, there are no location- or action-specific ARARs.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-4a

Chemical-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	Used to calculate potential carcinogenic risks to children caused by exposure to contaminants in soil/debris.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are considered to be the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime.	Used to calculate potential non-carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.

Table I-4a

Chemical-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Recommendations of the Technical Review Workgroup for Lead for an approach to Assessing Risks Associated with Adult Exposure to Lead In Soil, EPA-540-R-03-001 (January 2003)	TBC	EPA Guidance for evaluating risks posed by lead in soil.	Used to calculate potential risks caused by exposure to lead in soil/debris.
Federal Requirements	USEPA Interim Ecological Soil Screening Levels (SSLs) (USEPA, 2003)	TBC	SSLs were established to provide screening toxicity thresholds.	Consolidation of all contaminated material under the cap will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.
Federal Requirements	ORNL Toxicological Benchmarks for Wildlife (Sample et al., 1996)	TBC	These benchmarks were established to provide screening toxicity thresholds.	Consolidation of all contaminated material under the cap will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.

Table I-4a

Chemical-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	ORNL Toxicological Benchmarks for Screening Contaminants of Concern for Effects of Soil and Litter Invertebrates and Heterotrophic Process (Efroymson et al., 1997)	TBC	These benchmarks were established to provide screening toxicity thresholds.	Consolidation of all contaminated material under the cap will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.02	Applicable	These regulations set remediation standards for soil at NPL sites when they are more stringent than federal standards.	The action to be taken under this alternative will meet the remediation standards for soil, as required.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-4b

Location-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains disturbed by soil excavation and cap construction.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas due to soil excavation and cap construction. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this alternative.
Federal Requirements	Clean Water Act, Section 404; Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	The cap will be constructed in a manner that will minimize the area of wetlands altered, to the extent possible.

Table I-4b

Location-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Resource Conservation and Recovery Act (RCRA), 42 U.S.C, §§ 6901 *et seq.*, General Facility Standards, Location Standards; 40 C.F.R. § 264.18	Relevant and Appropriate	Seismic and floodplain standards that apply to all hazardous waste facilities.	The RCRA C cap remedy will be implemented to meet substantive seismic and floodplain standards.
Federal Requirements	Fish and Wildlife Coordination Act, 16 U.S.C. §661 *et seq.*	Applicable	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or other federal waters for any purpose to take action to protect fish and wildlife resources that may be affected by the action.	Measures to mitigate or compensate adverse project related impacts to fish and wildlife resources will be taken, if determined necessary.
Federal Requirements	National Historical Preservation Act, 16 U.S.C. 469 *et seq.*; 36 C.F.R. Part 65	Applicable	When a federal agency finds, or is notified, that its activities in connection with a federal construction project may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archeological data, the substantive standards under the Act will be met.	If, during the remedial design or remedial action, it is determined that this alternative may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archaeological data, the substantive standards under the Act will be met.

Table I-4b

Location-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Hazardous Waste Management - Section 8.05: Location Standards for Hazardous Waste Facilities	Applicable for Treatment and Storage Facilities; Relevant and Appropriate for Landfills	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b), with some exceptions, are incorporated by reference. Treatment and storage facilities located within the 100-year floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-year flood, unless it can be demonstrated that no adverse effects on human health or environment will result from washout.	Treatment, and/or storage of hazardous materials may take place at the Site, which is partially located within the 100-year floodplain as long as the contamination would not be subject to washout in a 100-year flooding event.
State Requirements	Rhode Island Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; DEM Rules And Regulations Governing the Administration And Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00 and 5.00	Applicable	Defines and establishes provisions for the protection of swamps, marshes, 100-year floodplain and other fresh water wetland resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland.	Action taken under this alternative will be done in compliance with this requirement.

Table I-4b

Location-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Historic Preservation Act, RIGL 42-45 *et seq.*	Applicable	Requires action to take into account effects on properties included on or eligible for the National register of Historic Places and minimizes harm to National Historic Landmarks.	Features with potential historical/cultural significance will be evaluated during the remedial design phase and activities will be coordinated with the State Agency as required.

Key:

ARAR	=	Applicable or Relevant and Appropriate Requirement
CFR	=	Code of Federal Regulations
EPA	=	U.S. Environmental Protection Agency
PRGs	=	Preliminary Remediation Goals
RIDEM	=	Rhode Island Department of Environmental Protection
RIGL	+	Rhode Island General Laws
TBC	=	To Be Considered

Table I-4c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Water Act Federal Water Quality Criteria, Section 304(a) ; 40 CFR 131.11	Applicable	National Recommended Water Quality Criteria (NRWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation/backfill and capping must be conducted so that there are no exceedances of NRWQC. Water quality standards used to develop monitoring standards both during the active remedial period and for long-term monitoring of the protectiveness of the waste management area that will be established under this alternative.
Federal Requirements	Clean Water Act – National Pollutant Discharge Elimination System (NPDES), 40 C.F.R. Parts 122 and 125	Applicable	Includes stormwater standards for activities disturbing more than one acre.	Best management practices will be used to meet stormwater standards during the remedial action.
Federal Requirements	Toxic Substances Control Act (TSCA) 15 U.S.C. 2601 *et seq.*; PCB Remediation Waste, 40 C.F.R. 761.61(c)	Applicable	This section of the TSCA regulations provides risk-based cleanup and disposal options for PCB remediation waste based on the risks posed by the concentrations at which the PCBs are found. Written approval for the proposed risk-based cleanup must be obtained from the Director, Office of Site Remediation and Restoration, USEPA Region 1.	All soil exceeding identified PCB cleanup levels will be removed, dewatered (if required) and disposed of under the RCRA C cap system that meets TSCA protectiveness standards. The excavation, transportation/ dewatering, and management of PCB contaminated media will be performed in a manner to comply with TSCA. The ROD includes a finding by the Director, Office of Site Remediation and Restoration, USEPA Region 1,

Table I-4c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
				that the remedy's soil PCB cleanup levels, along with the excavation, dewatering, management and disposal of the of the PCB-contaminated media under a RCRA C cap will not pose an unreasonable risk to human health or the environment.
Federal Requirements	RCRA, Air Emission Standards for Process Vents, 40 CFR 264, Subpart AA	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	If operations (e.g., leachate or landfill gas collection) manage hazardous wastes with organic concentrations of at least 10 ppm by weight, system vents will comply with these requirements.
Federal Requirements	RCRA , Air Emission Standards for Equipment Leaks, 40 CFR 264, Subpart BB	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10% by weight.	If equipment contains or comes into contact with hazardous wastes (e.g., during leachate or landfill gas collection) containing organic concentrations of at least 10% by weight, then these regulations will be followed.
Federal Requirements	RCRA, Air Emission Standards for Tanks, Surface Impoundments, and Containers, 40 CFR 264, Subpart CC	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emissions standards for tanks, surface impoundments, and containers used to manage hazardous waste. Emission controls required if tanks, surface impoundments, and containers used to manage hazardous waste have more than 500 ppmw of volatile organics.	If tanks, surface impoundments, and containers used to manage hazardous waste (e.g., during leachate or landfill gas collection) have more than 500 ppmw of volatile organics, then these requirements will be met.

Table I-4c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Air Act (CAA), 42 U.S.C. §§ 7401 *et seq.*, Standards of Performance for Municipal Solid Waste Landfills, 40 C.F.R. Part 60, Subpart WWW	Relevant and Appropriate	Air emission standards for landfills greater than 2.5 Mg in design capacity and emitting 50 Mg/year or more of non-methane organic compounds	The landfill cap will be designed and constructed to allow for the collection and treatment, if required under these standards, of landfill gases.
Federal Requirements	Clean Air Act (CAA), Hazardous Air Pollutants, 42.U.S.C. § 112(b)(1), National Emission Standards for Hazardous Air Pollutants (NESHAPS), 40 C.F.R. Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust and other release sources.	If the excavation of contaminated soil, installation and maintenance of the RCRA C cap, and the control of landfill gasses generate regulated air pollutants, then measures will be implemented to meet these standards.
Federal Requirements	Framework for Investigating Asbestos-Contaminated Superfund Sites, OSWER Directive #9200.0-68 (Sept. 2008)	TBC	Guidance on investigating and characterizing the potential human exposure from asbestos contamination in outdoor soil at Superfund sites.	Any areas that were subject to previous asbestos removal actions will be investigated under these guidance standards if they are not to be located under the RCRA C cap. Areas of asbestos contamination outside of the capped area will be excavated and consolidated under the cap.

Table I-4c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAPS), Standards tor Inactive waste disposal sites for asbestos mills and manufacturing and fabricating Operations, 40 C.F.R. § 61.151	Relevant and Appropriate	NESHAPS standards for preventing air releases from inactive asbestos disposal sites, including cover standards, dust suppression, and land use controls.	Any areas of asbestos contaminated soil will be consolidated under the RCRA C cap, which meets the substantive requirements of these standards. ICs will be established to maintain the cap and to address any potential asbestos exposure in case the cap is disturbed.
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLs), 40 CFR Subparts B and G	Relevant and Appropriate	Establishes MCLs for common organic and inorganic contaminants applicable to public drinking water supplies. Used as relevant and appropriate standards for aquifers and surface water bodies that are potential drinking water sources.	MCLs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA C cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.

Table I-4c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLGs), 40 CFR Subpart F	Relevant and Appropriate	Establishes maximum contaminant level goals (MCLGs) for public water supplies. MCLGs are health goals for drinking water sources. These unenforceable health goals are available for a number of organic and inorganic compounds.	Non-zero MCLGs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA C cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.
Federal Requirements	EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	The Health Advisories will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA C cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.

Table I-4c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	EPA Technical Guidance: Revised Alternative Cap Design Guidance Proposed for Unlined, Hazardous Waste Landfills in the EPA Region 1 (February 5, 2001)	TBC	Guidance for landfill covers in EPA Region 1. Presents recommended technical specifications for multilayer landfill cover design.	Cap construction will be protective in accordance with the guidance.
Federal Requirements	EPA Technical Guidance: Final Covers on Hazardous Waste Landfills and Surface Impoundments (July 1989)	TBC	Guidance for landfill covers recommending technical specifications for multilayer landfill cover designs.	Cap construction will be protective in accordance with the guidance.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Hazardous Waste Determination, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.8	Applicable	Requires a determination be made as to whether waste meets the definition of hazardous waste, including "Rhode Island Waste" as defined in Rule 3.	These regulations would apply when determining whether or not a waste generated during the remedial action is hazardous.

Table I-4c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Generator Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.00	Applicable	Sets generator standards for handling and disposal of hazardous waste. Incorporates provisions of 40 C.F.R. Part 262.	Any hazardous waste identified will be handled and disposed according to these standards.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Facility Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 7.01(B)(1) and (B)(3), 7.10	Relevant and Appropriate	Relevant and appropriate facility standards regarding: restrictions for landfills (Rule 7.01(B)(1) and (B)(3); inspections (Rule 7.10)	The RCRA C cap will be designed, constructed and maintained in a manner that will protect groundwater beyond the compliance boundary for the landfill and control discharges of surface or subsurface contamination in violation of any federal or state standard.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Operational Requirements for Treatment, Storage, and Disposal Facilities, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 9.00	Relevant and Appropriate	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities.	Management and treatment of on-site treatment residues and waste derived from the construction and maintenance of the RCRA C cap; from leachate or landfill gas collection; or from any investigation-derived waste will comply with these regulations.

Table I-4c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Hazardous Waste Management, , Land Disposal Facilities, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rules 10.01 and 10.02	Relevant and Appropriate	Outlines design, operational, and closure requirements for new hazardous waste landfills.	Design, construction, maintenance, closure, and post-closure of the RCRA C cap will meet the relevant and appropriate standards.
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.04	Applicable	These regulations set remediation standards for groundwater at NPL sites when they are more stringent than federal standards.	These regulations will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA C cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet these standards.
State Requirements	Water Pollution Control, Water Quality Regulations, RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with Site activities.	Excavation and capping must be conducted so that there are no exceedances of water quality standards.

Table I-4c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Water Pollution Control - Pollution Discharge Elimination Systems, RIGL 42-16 *et seq.*; CRIR 12-190-003 Rule 31	Applicable	Includes storm water requirements for construction projects that disturb over one acre.	Best management practices will be used to meet storm water standards during the remedial action.
State Requirements	RI Air Pollution Control Regulation No. 1: Visible Emissions, RIGL 23-23 *et seq.*; CRIR 12-31-01	Applicable	Establishes opacity limitations for contaminant emissions.	Remediation activities could potentially result in visible emissions. If these standards are exceeded, emissions would need to be managed through engineering controls.
State Requirements	RI Air Pollution Control Regulation No. 5: Fugitive Dust, RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable measures be taken to prevent particulate matter from becoming airborne.	Remediation activities could potentially result in fugitive dust. Appropriate measures would need to be taken to prevent particulate matter from becoming airborne.
State Requirements	RI Air Pollution Control Regulation No. 7: Emissions of Air Detrimental to Persons or Property, RIGL 23-23*e t seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants that may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Remediation activities may result in emissions. Appropriate measure would need to be taken to comply with these regulations.

Table I-4c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Air Pollution Control Regulation No. 16: Operation of Air Pollution Control Equipment, RIGL 23-23*e t seq.*; CRIR 12-31-16	Applicable	Any air pollution control system shall be operated according to its design specifications whenever the source on which it is installed is in operation or is emitting air contaminants.	If active treatment of landfill gas emissions is required, the system will be operated in accordance with these standards.
State Requirements	RI Air Pollution Control Regulation No. 22: Air Toxics Guidelines and Air Modeling Guidelines, RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation activities may result in emissions of toxics to the atmosphere if these contaminants are present in soil. Appropriate measure would need to be taken to comply with these regulations.
State Requirements	Drilling of Drinking Water Wells; Rules and Regulations Governing the Enforcement of Chapter 46-13.2 Relating to the Drilling of Drinking Water Wells, RIGL 46-13..2 *et seq.*	Applicable	Prohibits installing drinking water wells in contaminated aquifers. Establishes standards for decommissioning monitoring wells (Rule 9.03).	Under these standards drinking water wells are prohibited within the waste management area that will be established under this alternative and monitoring wells used will be properly decommissioned when no longer needed.

Table I-4c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-2: RCRA Subtitle C Cap of Whole Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rules and Regulations for Groundwater Quality RIGL Ch. 46-12, Section 46-12-2; Ch. 46-13.1, Ch. 23-18.9, Sec. 23-18-9.1; DEM Rules and Regulations for Groundwater Quality (Mar 2005), Appendix 1	Applicable	Identifies the standards and specifications that must be followed for installation or abandonment of monitoring wells.	Under this alternative, wells installed for monitoring the waste management area will be installed and abandoned according to these standards.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
RIGL = Rhode Island General Law
TBC = To Be Considered

Table I-5a

Chemical-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	Used to calculate potential carcinogenic risks to children caused by exposure to contaminants in soil/debris.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are considered to be the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime.	Used to calculate potential non-carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.

Table I-5a

Chemical-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Recommendations of the Technical Review Workgroup for Lead for an approach to Assessing Risks Associated with Adult Exposure to Lead In Soil, EPA-540-R-03-001 (January 2003)	TBC	EPA Guidance for evaluating risks posed by lead in soil.	Used to calculate potential risks caused by exposure to lead in soil/debris.
Federal Requirements	USEPA Interim Ecological Soil Screening Levels (SSLs) (USEPA, 2003)	TBC	SSLs were established to provide screening toxicity thresholds.	Consolidation of all contaminated material under the cap will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.
Federal Requirements	ORNL Toxicological Benchmarks for Wildlife (Sample et al., 1996)	TBC	These benchmarks were established to provide screening toxicity thresholds.	Consolidation of all contaminated material under the cap will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.

Table I-5a

Chemical-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	ORNL Toxicological Benchmarks for Screening Contaminants of Concern for Effects of Soil and Litter Invertebrates and Heterotrophic Process (Efroymson et al., 1997)	TBC	These benchmarks were established to provide screening toxicity thresholds.	Consolidation of all contaminated material under the cap will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.02	Applicable	These regulations set remediation standards for soil at NPL sites when they are more stringent than federal standards.	The perimeter soil cap may not prevent the release of contaminated material in the event of a flood so this alternative will not address potential releases of contaminated material that exceeds these standards.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-5b

Location-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	The proposed combination RCRA C and perimeter soil cap will not meet required standards for withstanding a 500-year storm event that would alter areas of floodplain and federal jurisdictional wetland. Outside of the capped areas, disturbance to the floodplain will be minimized and mitigated.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas due to soil excavation and cap construction. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this alternative.
Federal Requirements	Clean Water Act, Section 404; Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	The cap will be constructed in a manner that will minimize the area of wetlands altered, to the extent possible.

Table I-5b

Location-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Resource Conservation and Recovery Act (RCRA), 42 U.S.C, §§ 6901 *et seq.*, General Facility Standards, Location Standards; 40 C.F.R. § 264.18	Relevant and Appropriate	Seismic and floodplain standards that apply to all hazardous waste facilities.	The proposed combination RCRA C and perimeter soil cap will not meet required standards for withstanding a 100-year storm event. The combination cap can be designed to meet required seismic standards.
Federal Requirements	Fish and Wildlife Coordination Act, 16 U.S.C. §661 *et seq.*	Applicable	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or other federal waters for any purpose to take action to protect fish and wildlife resources that may be affected by the action.	Measures to mitigate or compensate adverse project related impacts to fish and wildlife resources will be taken, if determined necessary.
Federal Requirements	National Historical Preservation Act, 16 U.S.C. 469 *et seq.*; 36 C.F.R. Part 65	Applicable	When a federal agency finds, or is notified, that its activities in connection with a federal construction project may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archeological data, the substantive standards under the Act will be met.	If, during the remedial design or remedial action, it is determined that this alternative may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archaeological data, the substantive standards under the Act will be met.

Table I-5b

Location-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Hazardous Waste Management - Section 8.05: Location Standards for Hazardous Waste Facilities	Applicable for Treatment and Storage Facilities; Relevant and Appropriate for Landfills	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b), with some exceptions, are incorporated by reference. Treatment and storage facilities located within the 100-year floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-year flood, unless it can be demonstrated that no adverse effects on human health or environment will result from washout.	Treatment, and/or storage of hazardous materials may take place at the Site, which is partially located within the 100-year floodplain as long as the contamination would not be subject to washout in a 100-year flooding event. These standards are also relevant and appropriate to the design, construction, operation, and maintenance of the J.M. Mills Landfill. The proposed combination RCRA C and perimeter soil cap will not meet required standards for withstanding a 100-year storm event.
State Requirements	Rhode Island Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; DEM Rules And Regulations Governing the Administration And Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00 and 5.00	Applicable	Defines and establishes provisions for the protection of swamps, marshes, 100-year floodplain and other fresh water wetland resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland.	The proposed combination RCRA C and perimeter soil cap will not meet required standards for withstanding a 100-year storm event that would alter areas of floodplain and state jurisdictional wetland.

Table I-5b

Location-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Historic Preservation Act, RIGL 42-45 *et seq.*	Applicable	Requires action to take into account effects on properties included on or eligible for the National register of Historic Places and minimizes harm to National Historic Landmarks.	Features with potential historical/cultural significance will be evaluated during the remedial design phase. Should this remedy impact properties/structures determined to be protected by this standard, activities will be coordinated with the State Agency.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
RIGL + Rhode Island General Laws
TBC = To Be Considered

Table I-5c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Water Act Federal Water Quality Criteria, Section 304(a) ; 40 CFR 131.11	Applicable	National Recommended Water Quality Criteria (NRWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation/backfill and capping must be conducted so that there are no exceedances of NRWQC. Water quality standards used to develop monitoring standards both during the active remedial period and for long-term monitoring of the protectiveness of the waste management area that will be established under this alternative.
Federal Requirements	Clean Water Act – National Pollutant Discharge Elimination System (NPDES), 40 C.F.R. Parts 122 and 125	Applicable	Includes stormwater standards for activities disturbing more than one acre.	Best management practices will be used to meet stormwater standards during the remedial action.
Federal Requirements	Toxic Substances Control Act (TSCA) 15 U.S.C. 2601 *et seq.*; PCB Remediation Waste, 40 C.F.R. 761.61(c)	Applicable	This section of the TSCA regulations provides risk-based cleanup and disposal options for PCB remediation waste based on the risks posed by the concentrations at which the PCBs are found. Written approval for the proposed risk-based cleanup must be obtained from the Director, Office of Site Remediation and Restoration, USEPA Region 1.	The proposed combination RCRA C and perimeter soil cap will not meet required TSCA protectiveness standards since the risk of flood damage to the perimeter cap may cause a release of PCBs that would pose an unreasonable risk to human health or the environment.

Table I-5c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	RCRA, Air Emission Standards for Process Vents, 40 CFR 264, Subpart AA	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	If operations (e.g., leachate or landfill gas collection) manage hazardous wastes with organic concentrations of at least 10 ppm by weight, system vents will comply with these requirements.
Federal Requirements	RCRA , Air Emission Standards for Equipment Leaks, 40 CFR 264, Subpart BB	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10% by weight.	If equipment contains or comes into contact with hazardous wastes (e.g., during leachate or landfill gas collection) containing organic concentrations of at least 10% by weight, then these regulations will be followed.
Federal Requirements	RCRA, Air Emission Standards for Tanks, Surface Impoundments, and Containers, 40 CFR 264, Subpart CC	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emissions standards for tanks, surface impoundments, and containers used to manage hazardous waste. Emission controls required if tanks, surface impoundments, and containers used to manage hazardous waste have more than 500 ppmw of volatile organics.	If tanks, surface impoundments, and containers used to manage hazardous waste (e.g., during leachate or landfill gas collection) have more than 500 ppmw of volatile organics, then these requirements will be met.
Federal Requirements	Clean Air Act (CAA), 42 U.S.C. §§ 7401 *et seq.*, Standards of Performance for Municipal Solid Waste Landfills, 40 C.F.R. Part 60, Subpart WWW	Relevant and Appropriate	Air emission standards for landfills greater than 2.5 Mg in design capacity and emitting 50 Mg/year or more of non-methane organic compounds.	The proposed design will not be effective in achieving the landfill gas collection necessary to comply with these standards.

Table I-5c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Air Act (CAA), Hazardous Air Pollutants, 42.U.S.C. § 112(b)(1), National Emission Standards for Hazardous Air Pollutants (NESHAPS), 40 C.F.R. Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust and other release sources.	If the excavation of contaminated soil, and the installation and maintenance of the combination cap generate regulated air pollutants, then measures will be implemented to meet these standards. However, the proposed cap design will not be effective in achieving the landfill gas collection (post-construction) necessary to comply with these standards.
Federal Requirements	Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAPS), Standards tor Inactive waste disposal sites for asbestos mills and manufacturing and fabricating Operations, 40 C.F.R. § 61.151	Relevant and Appropriate	NESHAPS standards for preventing air releases from inactive asbestos disposal sites, including cover standards, dust suppression, and land use controls.	Any areas of asbestos contaminated soil will be consolidated under the combination cap. The asbestos would need to be capped in the area meeting RCRA C standards to meet these requirements, due to the risk of release from flooding in the perimeter cap area.

Table I-5c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Framework for Investigating Asbestos-Contaminated Superfund Sites, OSWER Directive #9200.0-68 (Sept. 2008)	TBC	Guidance on investigating and characterizing the potential human exposure from asbestos contamination in outdoor soil at Superfund sites.	Any areas that were subject to previous asbestos removal actions will be investigated under these guidance standards if they are not to be located under the cap. Areas of asbestos contamination outside of the capped area will be excavated and consolidated under the cap.
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLs), 40 CFR Subparts B and G	Relevant and Appropriate	Establishes MCLs for common organic and inorganic contaminants applicable to public drinking water supplies. Used as relevant and appropriate standards for aquifers and surface water bodies that are potential drinking water sources.	MCLs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLGs), 40 CFR Subpart F	Relevant and Appropriate	Establishes maximum contaminant level goals (MCLGs) for public water supplies. MCLGs are health goals for drinking water sources. These unenforceable health goals are available for a number of organic and inorganic compounds.	Non-zero MCLGs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not

Table I-5c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
				migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.
Federal Requirements	EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	The Health Advisories will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.
Federal Requirements	EPA Technical Guidance: Revised Alternative Cap Design Guidance Proposed for Unlined, Hazardous Waste Landfills in the EPA Region 1 (February 5, 2001)	TBC	Guidance for landfill covers in EPA Region 1. Presents recommended technical specifications for multilayer landfill cover design.	The proposed combination RCRA C and perimeter soil cap will be protective in the top portion of the RCRA C cap only, while the remaining portion of the soil cap does not comply with the guidance because it does not meet RCRA C performance criteria.

Table I-5c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	EPA Technical Guidance: Final Covers on Hazardous Waste Landfills and Surface Impoundments (July 1989)	TBC	Guidance for landfill covers recommending technical specifications for multilayer landfill cover designs.	The proposed combination RCRA C and perimeter soil cap will be protective in the top portion of the RCRA C cap only, while the remaining portion of the soil cap does not comply with the guidance because it does not meet RCRA C performance criteria.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Hazardous Waste Determination, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.8	Applicable	Requires a determination be made as to whether waste meets the definition of hazardous waste, including "Rhode Island Waste" as defined in Rule 3.	These regulations would apply when determining whether or not a waste generated during the remedial action is hazardous.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Generator Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.00	Applicable	Sets generator standards for handling and disposal of hazardous waste. Incorporates provisions of 40 C.F.R. Part 262.	Any hazardous waste identified will be handled and disposed according to these standards.

Table I-5c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Facility Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 7.01(B)(1) and (B)(3), 7.10	Relevant and Appropriate	Relevant and appropriate facility standards regarding: restrictions for landfills (Rule 7.01(B)(1) and (B)(3); inspections (Rule 7.10)	The combination cap will not control discharges of surface or subsurface contamination since the soil perimeter cap will not meet federal or state floodplain protection standards.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Operational Requirements for Treatment, Storage, and Disposal Facilities, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 9.00	Relevant and Appropriate	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities.	Management and treatment of on-site treatment residues and waste derived from the construction and maintenance of the cap; from leachate or landfill gas collection; or from any investigation-derived waste will comply with these regulations.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Land Disposal Facilities, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rules 10.01 and 10.02	Relevant and Appropriate	Standards for hazardous waste land disposal facilities.	The soil perimeter cap component of this alternative does not fully meet these standards.

Table I-5c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.04	Applicable	These regulations set remediation standards for groundwater at NPL sites when they are more stringent than federal standards.	These regulations will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet these standards.
State Requirements	Water Pollution Control, Water Quality Regulations, RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with Site activities.	Excavation and capping must be conducted so that there are no exceedances of water quality standards.
State Requirements	Water Pollution Control - Pollution Discharge Elimination Systems, RIGL 42-16 *et seq.*; CRIR 12-190-003 Rule 31	Applicable	Includes storm water requirements for construction projects that disturb over one acre.	Best management practices will be used to meet stormwater standards during the remedial action.
State Requirements	RI Air Pollution Control Regulation No. 1: Visible Emissions, RIGL 23-23 *et seq.*; CRIR 12-31-01	Applicable	Establishes opacity limitations for contaminate emissions.	Remediation activities could potentially result in visible emissions. If these standards are exceeded, emissions would need to be managed through engineering controls.

Table I-5c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Air Pollution Control Regulation No. 5: Fugitive Dust, RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable measures be taken to prevent particulate matter from becoming airborne.	Remediation activities could potentially result in fugitive dust. Appropriate measures would need to be taken to prevent particulate matter from becoming airborne.
State Requirements	RI Air Pollution Control Regulation No. 7: Emissions of Air Detrimental to Persons or Property, RIGL 23-23*e t seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants that may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Remediation activities may result in emissions. Appropriate measure would need to be taken to comply with these regulations. However, the proposed cap design will not be effective in achieving the landfill gas collection (post-construction) necessary to comply with these standards.
State Requirements	RI Air Pollution Control Regulation No. 16: Operation of Air Pollution Control Equipment, RIGL 23-23*e t seq.*; CRIR 12-31-16	Applicable	Any air pollution control system shall be operated according to its design specifications whenever the source on which it is installed is in operation or is emitting air contaminants.	If active treatment of landfill gas emissions is required, the system will be operated in accordance with these standards.
State Requirements	RI Air Pollution Control Regulation No. 22: Air Toxics Guidelines and Air Modeling Guidelines, RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation activities may result in emissions of toxics to the atmosphere if these contaminants are present in soil. Appropriate measure would need to be taken to comply with these regulations.

Table I-5c

Action-Specific ARARs and TBCs for J.M. Mills Landfill

Alternative JM-SO-3: Combination RCRA Subtitle C Cap (top)/Perimeter Soil Cap (side slopes) of Landfill, Removal of Soil Exceeding PRGs from Riverbank and Floodplain, Bank Restoration, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Drilling of Drinking Water Wells; Rules and Regulations Governing the Enforcement of Chapter 46-13.2 Relating to the Drilling of Drinking Water Wells, RIGL 46-13..2 *et seq.*	Applicable	Prohibits installing drinking water wells in contaminated aquifers. Establishes standards for decommissioning monitoring wells (Rule 9.03).	Under these standards drinking water wells are prohibited within the waste management area that will be established under this alternative and monitoring wells used will be properly decommissioned when no longer needed.
State Requirements	Rules and Regulations for Groundwater Quality RIGL Ch. 46-12, Section 46-12-2; Ch. 46-13.1, Ch. 23-18.9, Sec. 23-18-9.1; DEM Rules and Regulations for Groundwater Quality (Mar 2005), Appendix 1	Applicable	Identifies the standards and specifications that must be followed for installation or abandonment of monitoring wells.	Under this alternative, wells installed for monitoring the waste management area will be installed and abandoned according to these standards.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
RIGL = Rhode Island General Law
TBC = To Be Considered

Table I-6a
Chemical-Specific ARARs and TBCs for Nunes Parcel
Alternative NP-SO-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	This alternative would not prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	This alternative would not prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk to children, developed using this guidance.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are considered to be the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime.	This alternative would not prevent exposure to soil/debris contaminants which contribute to a calculated non-carcinogenic risk, developed using this guidance.
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	This alternative would not prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance.
Federal Requirements	EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	This alternative would not prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance.

Table I-6a
Chemical-Specific ARARs and TBCs for Nunes Parcel
Alternative NP-SO-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Recommendations of the Technical Review Workgroup for Lead for an approach to Assessing Risks Associated with Adult Exposure to Lead In Soil, EPA-540-R-03-001 (January 2003)	TBC	EPA Guidance for evaluating risks posed by lead in soil.	This alternative would not prevent exposure to lead in soil/debris which contributes to a calculated risk, developed using this guidance.
Federal Requirements	NOAA Effects Range-Low (ERL) values for marine and estuarine sediments (Long et al., 1995; Long and Morgan, 1990)	TBC	The ERL value is equivalent to the lower 10th percentile of the available toxicity data, which is estimated to be the approximate concentration at which adverse effects are likely to occur in sensitive life stages and/or species of sediment-dwelling organisms.	ERLs were used for selecting Chemicals of Potential Concern (COPCs) in Pond I and for characterizing ecological effects. This alternative would not prevent exposure to sediment contaminants which contribute to a calculated ecological risk, developed using this guidance.
Federal Requirements	U.S. DOE, Office of Environmental Management, Secondary Chronic Values (SCVs) (Jones et al., 1997)	TBC	The SCVs are toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota.	SCVs were used for selecting COPCs in Pond I and for characterizing ecological effects. This alternative would not prevent exposure to sediment contaminants which contribute to a calculated ecological risk, developed using this guidance.

Table I-6a
Chemical-Specific ARARs and TBCs for Nunes Parcel
Alternative NP-SO-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	U.S. EPA Sediment Quality Criterion (SQC) and Sediment Quality Benchmarks (SQBs) (USEPA, 1996)	TBC	SQCs and SQBs were established to provide screening toxicity thresholds.	SQCs and SQBs were used for selecting COPCs in Pond I and for characterizing ecological effects. This alternative would not prevent exposure to sediment contaminants which contribute to a calculated ecological risk, developed using this guidance.
Federal Requirements	NOAA Screening Quick Reference Tables, Threshold Effects Level (TEL) (Buchman, 1999)	TBC	TELs represent the concentration below which adverse effects are expected to occur only rarely.	TELs were used for selecting COPCs in Pond I and for characterizing ecological effects. This alternative would not prevent exposure to sediment contaminants which contribute to a calculated ecological risk, developed using this guidance.

Table I-6a
Chemical-Specific ARARs and TBCs for Nunes Parcel
Alternative NP-SO-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.02	Applicable	These regulations set remediation standards for soil at NPL sites when they are more stringent than federal standards.	This alternative would not prevent exposure to any soil contaminants that exceed state soil standards that are more stringent than federal risk-based standards.

Notes:
For the No Action alternative, there are no location- or action-specific ARARs.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-7a

Chemical-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance. ICs will prevent activities that will disturb the capped material.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk to children developed using this guidance. ICs will prevent activities that will disturb the capped material.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to soil/debris contaminants which contribute to a calculated non-carcinogenic risk, developed using this guidance. ICs will prevent activities that will disturb the capped material.

Table I-7a

Chemical-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance. ICs will prevent activities that will disturb the capped material.
Federal Requirements	EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an accept risk from a carcinogen.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance. ICs will prevent activities that will disturb the capped material.
Federal Requirements	Recommendations of the Technical Review Workgroup for Lead for an approach to Assessing Risks Associated with Adult Exposure to Lead In Soil, EPA-540-R-03-001 (January 2003)	TBC	EPA guidance for evaluating risks posed by lead in soil.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to lead contaminated soil/debris which contribute to a calculated risk, developed using this guidance. ICs will prevent activities that will disturb the capped material.

Table I-7a

Chemical-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	NOAA Effects Range-Low (ERL) values for marine and estuarine sediments (Long et al., 1995; Long and Morgan, 1990)	TBC	The ERL value is equivalent to the lower 10th percentile of the available toxicity data, which is estimated to be the approximate concentration at which adverse effects are likely to occur in sensitive life stages and/or species of sediment-dwelling organisms.	This alternative would prevent exposure to sediment contaminants in Pond I which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs.
Federal Requirements	U.S. DOE, Office of Environmental Management, Secondary Chronic Values (SCVs) (Jones et al., 1997)	TBC	The SCVs are toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota.	This alternative would prevent exposure to sediment contaminants in Pond I which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs.
Federal Requirements	U.S. EPA Sediment Quality Criterion (SQC) and Sediment Quality Benchmarks (SQBs) (USEPA, 1996)	TBC	SQCs and SQBs were established to provide screening toxicity thresholds.	This alternative would prevent exposure to sediment contaminants in Pond I which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs.
Federal Requirements	NOAA Screening Quick Reference Tables, Threshold Effects Level (TEL) (Buchman, 1999)	TBC	TELs represent the concentration below which adverse effects are expected to occur only rarely.	This alternative would prevent exposure to sediment contaminants in Pond I which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs

Table I-7a

Chemical-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State Solid Waste ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.02	Applicable	These regulations set remediation standards for soil at NPL sites when they are more stringent than federal standards.	The action to be taken under this alternative will meet the remediation standards for soil, as required.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-7b

Location-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains disturbed by soil excavation and cap construction.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas due to soil excavation and cap construction. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this alternative.
Federal Requirements	Clean Water Act, Section 404; Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	The cap will be constructed in a manner that will minimize the area of wetlands altered, to the extent possible.

Table I-7b

Location-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Fish and Wildlife Coordination Act, 16 U.S.C. §661 *et seq.*	Applicable	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or other federal waters for any purpose to take action to protect fish and wildlife resources that may be affected by the action.	Measures to mitigate or compensate adverse project related impacts to fish and wildlife resources will be taken, if determined necessary.
Federal Requirements	National Historical Preservation Act, 16 U.S.C. 469 *et seq.*; 36 C.F.R. Part 65	Applicable	When a federal agency finds, or is notified, that its activities in connection with a federal construction project may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archeological data, the substantive standards under the Act will be met.	If, during the remedial design or remedial action, it is determined that this alternative may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archaeological data, the substantive standards under the Act will be met.
Federal Requirements	Resource Conservation and Recovery Act (RCRA), 42 U.S.C, §§ 6901 *et seq.*, General Facility Standards, Location Standards; 40 C.F.R. § 264.18	Relevant and Appropriate	Seismic and floodplain standards that apply to all hazardous waste facilities.	The RCRA D cap remedy will be implemented to meet substantive seismic and floodplain standards.

Table I-7b

Location-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.14(b)	Applicable	Standards for protecting wetlands and water quality. A variance has been issued for subsection 2.3.14(c), regarding floodplain restrictions, since the landfill is already located in a floodplain.	Installation of a RCRA D compliant cap that can withstand a 500-year storm event may alter areas of state jurisdictional wetlands, and perimeter land within 50 feet of wetlands. Mitigation measures, as required, will be taken to compensate for the resource areas altered by the cap.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.22	Applicable	Solid waste disposal facilities located in unstable areas must demonstrate that engineering measures have been incorporated into the facility's unit's design to ensure that the integrity of the structural components of the facility will not be disrupted.	The landfill cap can be designed, constructed and maintained to prevent any release of contamination due to unstable conditions, including flooding events, since the capped landfill will be located in a floodplain.
State Requirements	Rhode Island Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; DEM Rules And Regulations Governing the Administration And Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00 and 5.00	Applicable	Defines and establishes provisions for the protection of swamps, marshes, 100-year floodplain and other fresh water wetland resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland.	Mitigation measures, as required, will be taken to compensate for the resource areas altered by the cap.

Table I-7b

Location-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Historic Preservation Act, RIGL 42-45 *et seq.*	Applicable	Requires action to take into account effects on properties included on or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks.	Features with potential historical/cultural significance will be evaluated during the remedial design phase and activities will be coordinated with the State Agency as required.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
RIGL = Rhode Island General Laws
TBC = To Be Considered

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Water Act Federal Water Quality Criteria, Section 304(a) ; 40 CFR 131.11	Applicable	National Recommended Water Quality Criteria (NRWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation/backfill and capping must be conducted so that there are no exceedances of NRWQC. Water quality standards will be used to develop monitoring standards both during the active remedial period and for long-term monitoring of the protectiveness of the waste management area that will be established under this alternative.
Federal Requirements	Clean Water Act – National Pollutant Discharge Elimination System (NPDES), 40 C.F.R. Parts 122 and 125	Applicable	Includes stormwater standards for activities disturbing more than one acre.	Best management practices will be used to meet stormwater standards during the remedial action.
Federal Requirements	Toxic Substances Control Act (TSCA) 15 U.S.C. 2601 *et seq.*; PCB Remediation Waste, 40 C.F.R. 761.61(c)	Applicable	This section of the TSCA regulations provides risk-based cleanup and disposal options for PCB remediation waste based on the risks posed by the concentrations at which the PCBs are found. Written approval for the proposed risk-based cleanup must be obtained from the Director, Office of Site Remediation and Restoration, USEPA Region 1.	All soil exceeding identified PCB cleanup levels will be removed, dewatered (if required) and disposed of under the RCRA D cap system that meets TSCA protectiveness standards. The excavation, transportation/ dewatering, and management of PCB contaminated media will be performed in a manner to comply with TSCA. The ROD includes a finding by the Director, Office of

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
				Site Remediation and Restoration, USEPA Region 1, that the remedy's soil PCB cleanup levels, along with the excavation, dewatering, management and disposal of the of the PCB-contaminated media under a RCRA D cap will not pose an unreasonable risk to human health or the environment.
Federal Requirements	RCRA, Air Emission Standards for Process Vents, 40 CFR 264, Subpart AA	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	If operations (e.g., leachate or landfill gas collection) manage hazardous wastes with organic concentrations of at least 10 ppm by weight, system vents will comply with these requirements.
Federal Requirements	RCRA , Air Emission Standards for Equipment Leaks, 40 CFR 264, Subpart BB	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10% by weight.	If equipment contains or comes into contact with hazardous wastes (e.g., during leachate or landfill gas collection) containing organic concentrations of at least 10% by weight, then these regulations will be followed.
Federal Requirements	RCRA, Air Emission Standards for Tanks, Surface Impoundments, and Containers, 40 CFR 264, Subpart CC	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emissions standards for tanks, surface impoundments, and containers used to manage hazardous waste. Emission controls required if tanks, surface impoundments, and containers used to manage hazardous waste have more than 500 ppmw of volatile organics.	If tanks, surface impoundments, and containers used to manage hazardous waste (e.g., during leachate or landfill gas collection) have more than 500 ppmw of volatile organics, then these requirements will be met.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Air Act (CAA), 42 U.S.C. §§ 7401 *et seq.*, Standards of Performance for Municipal Solid Waste Landfills, 40 C.F.R. Part 60, Subpart WWW	Relevant and Appropriate	Air emission standards for landfills greater than 2.5 Mg in design capacity and emitting 50 Mg/year or more of non-methane organic compounds.	The landfill cap will be designed and constructed to allow for the collection and treatment, if required under these standards, of landfill gases.
Federal Requirements	Clean Air Act (CAA), Hazardous Air Pollutants, 42.U.S.C. § 112(b)(1), National Emission Standards for Hazardous Air Pollutants (NESHAPS), 40 C.F.R. Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust and other release sources.	If the excavation of contaminated soil, installation and maintenance of the RCRA D cap, and the control of landfill gasses generate regulated air pollutants, then measures will be implemented to meet these standards.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAPS), Standards tor Inactive waste disposal sites for asbestos mills and manufacturing and fabricating Operations, 40 C.F.R. § 61.151	Relevant and Appropriate	NESHAPS standards for preventing air releases from inactive asbestos disposal sites, including cover standards, dust suppression, and land use controls.	Any areas of asbestos contaminated soil will be consolidated under the RCRA D cap, which meets the substantive requirements of these standards. ICs will be established to maintain the cap and to address any potential asbestos exposure in case the cap is disturbed.
Federal Requirements	Framework for Investigating Asbestos-Contaminated Superfund Sites, OSWER Directive #9200.0-68 (Sept. 2008)	TBC	Guidance on investigating and characterizing the potential human exposure from asbestos contamination in outdoor soil at Superfund sites.	Any areas that were subject to previous asbestos removal actions will be investigated under these guidance standards if they are not to be located under the RCRA D cap. Areas of asbestos contamination outside of the capped area will be excavated and consolidated under the cap.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLs), 40 CFR Subparts B and G	Relevant and Appropriate	Establishes MCLs for common organic and inorganic contaminants applicable to public drinking water supplies. Used as relevant and appropriate standards for aquifers and surface water bodies that are potential drinking water sources.	MCLs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA D cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLGs), 40 CFR Subpart F	Relevant and Appropriate	Establishes maximum contaminant level goals (MCLGs) for public water supplies. MCLGs are health goals for drinking water sources. These unenforceable health goals are available for a number of organic and inorganic compounds.	Non-zero MCLGs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA D cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	The Health Advisories will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA D cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.
Federal Requirements	EPA Technical Guidance: Revised Alternative Cap Design Guidance Proposed for Unlined, Hazardous Waste Landfills in the EPA Region 1 (February 5, 2001)	TBC	Guidance for landfill covers in EPA Region 1. Presents recommended technical specifications for multilayer landfill cover design.	The proposed RCRA D cap does not comply with the guidance because it does not meet RCRA C performance criteria.
Federal Requirements	EPA Technical Guidance: Final Covers on Hazardous Waste Landfills and Surface Impoundments (July 1989)	TBC	Guidance for landfill covers recommending technical specifications for multilayer landfill cover designs.	The proposed RCRA D cap does not comply with the guidance because it does not meet RCRA C performance criteria.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Hazardous Waste Determination, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.8	Applicable	Requires a determination be made as to whether waste meets the definition of hazardous waste, including "Rhode Island Waste" as defined in Rule 3.	These regulations would apply when determining whether or not a waste generated during the remedial action is hazardous.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Generator Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.00	Applicable	Sets generator standards for handling and disposal of hazardous waste. Incorporates provisions of 40 C.F.R. Part 262.	Any hazardous waste identified will be handled and disposed according to these standards.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Facility Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 7.01(B)(1) and (B)(3), 7.10	Relevant and Appropriate	Relevant and appropriate facility standards regarding: restrictions for landfills (Rule 7.01(B)(1) and (B)(3); inspections (Rule 7.10)	The RCRA D cap will be designed, constructed and maintained in a manner that will protect groundwater beyond the compliance boundary for the landfill and control discharges of surface or subsurface contamination in violation of any federal or state standard.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Operational Requirements for Treatment, Storage, and Disposal Facilities, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 9.00	Relevant and Appropriate	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities.	Management and treatment of on-site treatment residues and waste derived from the construction and maintenance of the RCRA D cap; from leachate or landfill gas collection; or from any investigation-derived waste will comply with these regulations.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Land Disposal Facilities, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rules 10.01 and 10.02	Relevant and Appropriate	Outlines design, operational, and closure requirements for new hazardous waste landfills.	The RCRA D cap does not fully meet these standards.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.7.10	Applicable	Requires dust control.	Dust must be controlled at the site during cap construction and during maintenance activities.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.7.12 (a)	Applicable	Requires solid waste management facilities be designed and maintained to protect the health and safety of personnel at the facility and persons in close proximity.	Under this subsection health and safety of construction workers and persons in the proximity of the site would be maintained during construction and maintenance activities.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.7.14(b)	Applicable	Regulation states that an approved closure plan must be implemented.	The site will be closed by installing the RCRA D cap in accordance with the substantive requirements of this section.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.8.01 (a) and 1.8.01 (b)	Applicable	Requires facilities to monitor groundwater and to meet closure requirements.	The substantive requirements of this section of the rules will be met by monitoring groundwater and meeting closure requirements.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.04	Applicable	Requires that sedimentation and erosion control be addressed.	Erosion and sediment control measures will be developed for this site in accordance with the substantive requirements of this section.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.08 (a) (8)	Applicable	Contains requirements for construction of monitoring wells to monitor a solid waste landfill.	The substantive requirements of this section of the regulations will be met for construction of new monitoring wells.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.08 (c)	Applicable	Contains requirements for environmental monitoring.	The substantive requirements of this section of the regulations will be met by having and maintaining monitoring wells and surface water monitoring, if required, for the purpose of monitoring environmental conditions around the capped landfill.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.11	Applicable	Requirement to establish a conservation easement that prohibits development on the landfill without regulatory approval and gives access to the site to regulatory authorities.	The easement will be part of the institutional controls established to prevent activities that will conflict with the remedial action.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.12	Applicable	Requirement to address landfill gas recovery.	The substantive requirements in this section will be met if landfill gas recovery is required for the capped landfill.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.2.00	Applicable	Solid waste landfill construction standards. Variances apply to substantive sections that aren't applicable to capping an existing landfill.	Substantive requirements will be met except for provisions excluded by variances, by installing and maintaining a RCRA D cap on the landfill.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.04(c), (f)	Applicable	Contains requirements for final cover.	The substantive requirements of this section of the regulations will be met by installing a RCRA D compliant cap which achieves permeability standards that are protective of human health and the environment.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.05(a)	Applicable	Regulations set standards so that no solid waste disposal area shall be operated so as to cause or to be likely to cause pollution of the ground waters or surface waters of the State at or beyond the boundary of the waste management area compliance boundary.	The RCRA D cap will meet the design, construction and maintenance standards to prevent the release of contaminants to surface waters and groundwater beyond the compliance boundary for the waste management area.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.06	Applicable	Standards for waste handling.	Wastes consolidated from elsewhere on site will be handled and added to the landfill in compliance with these standards.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.06(d)(6)	Applicable	Specific standards for disposing of asbestos.	If any asbestos-contaminated material is disposed of under the cap it will be handled in compliance with these standards.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.08	Applicable	Standards for landfill gas control.	The substantive requirements of this section of the rules will be met as required to address any potential landfill gas at the landfill once it is capped.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.10	Applicable	Contains requirements for surface water drainage.	The substantive requirements of this section of the rules will be met through design of appropriate surface drainage considerations for the cover.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.11	Applicable	Contains requirements for monitoring wells.	The substantive requirements of this section of the regulations will be met by having and maintaining monitoring wells for the purpose of monitoring groundwater conditions around the capped landfill.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.04	Applicable	These regulations set remediation standards for groundwater at NPL sites when they are more stringent than federal standards.	These regulations will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA D cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet these standards.
State Requirements	Water Pollution Control, Water Quality Regulations, RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Excavation and capping must be conducted so that there are no exceedances of water quality standards.
State Requirements	Water Pollution Control - Pollution Discharge Elimination Systems, RIGL 42-16 *et seq.*; CRIR 12-190-003 Rule 31	Applicable	Includes storm water requirements for construction projects that disturb over one acre.	Best management practices will be used to meet stormwater standards during the remedial action.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Air Pollution Control Regulation No. 1: Visible Emissions, RIGL 23-23 *et seq.*; CRIR 12-31-01	Applicable	Establishes opacity limitations for contaminate emissions.	Remediation activities could potentially result in visible emissions. If these standards are exceeded, emissions would need to be managed through engineering controls.
State Requirements	RI Air Pollution Control Regulation No. 5: Fugitive Dust, RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable measures be taken to prevent particulate matter from becoming airborne.	Remediation activities could potentially result in fugitive dust. Appropriate measures would need to be taken to prevent particulate matter from becoming airborne.
State Requirements	RI Air Pollution Control Regulation No. 7: Emissions of Air Detrimental to Persons or Property, RIGL 23-23*e t seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants that may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Remediation activities may result in emissions. Appropriate measure would need to be taken to comply with these regulations.
State Requirements	RI Air Pollution Control Regulation No. 16: Operation of Air Pollution Control Equipment, RIGL 23-23*e t seq.*; CRIR 12-31-16	Applicable	Any air pollution control system shall be operated according to its design specifications whenever the source on which it is installed is in operation or is emitting air contaminants.	If active treatment of landfill gas emissions is required, the system will be operated in accordance with these standards.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-2: RCRA Subtitle D Cap (meeting State ARARs) of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Air Pollution Control Regulation No. 22: Air Toxics Guidelines and Air Modeling Guidelines, RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation activities may result in emissions of toxics to the atmosphere if these contaminants are present in soil. Appropriate measure would need to be taken to comply with these regulations.
State Requirements	Drilling of Drinking Water Wells; Rules and Regulations Governing the Enforcement of Chapter 46-13.2 Relating to the Drilling of Drinking Water Wells, RIGL 46-13..2 *et seq.*	Applicable	Prohibits installing drinking water wells in contaminated aquifers. Establishes standards for decommissioning monitoring wells (Rule 9.03).	Under these standards drinking water wells are prohibited within the waste management area that will be established under this alternative and monitoring wells used will be properly decommissioned when no longer needed.
State Requirements	Rules and Regulations for Groundwater Quality RIGL Ch. 46-12, Section 46-12-2; Ch. 46-13.1, Ch. 23-18.9, Sec. 23-18-9.1; DEM Rules and Regulations for Groundwater Quality (Mar 2005), Appendix 1	Applicable	Identifies the standards and specifications that must be followed for installation or abandonment of monitoring wells.	Under this alternative, wells installed for monitoring the waste management area will be installed and abandoned according to these standards.

Key:

ARAR	=	Applicable or Relevant and Appropriate Requirement
CFR	=	Code of Federal Regulations
CRIR	=	Code of Rhode Island Rules
EPA	=	U.S. Environmental Protection Agency
RIDEM	=	Rhode Island Department of Environmental Protection
RIGL	=	Rhode Island General Laws
TBC	=	To Be Considered

Table I-8a

Chemical-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance. ICs will prevent activities that will disturb the capped material.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk to children developed using this guidance. ICs will prevent activities that will disturb the capped material.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to soil/debris contaminants which contribute to a calculated non-carcinogenic risk, developed using this guidance. ICs will prevent activities that will disturb the capped material.

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Chemical-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance. ICs will prevent activities that will disturb the capped material.
Federal Requirements	EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an accept risk from a carcinogen.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to soil/debris contaminants which contribute to a calculated carcinogenic risk, developed using this guidance. ICs will prevent activities that will disturb the capped material.
Federal Requirements	Recommendations of the Technical Review Workgroup for Lead for an approach to Assessing Risks Associated with Adult Exposure to Lead In Soil, EPA-540-R-03-001 (January 2003)	TBC	EPA guidance for evaluating risks posed by lead in soil.	Capping of the landfill, with consolidation of all contaminated material under the cap, will prevent exposure to lead contaminated soil/debris which contribute to a calculated risk, developed using this guidance. ICs will prevent activities that will disturb the capped material.

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Chemical-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	NOAA Effects Range-Low (ERL) values for marine and estuarine sediments (Long et al., 1995; Long and Morgan, 1990)	TBC	The ERL value is equivalent to the lower 10th percentile of the available toxicity data, which is estimated to be the approximate concentration at which adverse effects are likely to occur in sensitive life stages and/or species of sediment-dwelling organisms.	This alternative would prevent exposure to sediment contaminants in Pond I which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs.
Federal Requirements	U.S. DOE, Office of Environmental Management, Secondary Chronic Values (SCVs) (Jones et al., 1997)	TBC	The SCVs are toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota.	This alternative would prevent exposure to sediment contaminants in Pond I which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs.
Federal Requirements	U.S. EPA Sediment Quality Criterion (SQC) and Sediment Quality Benchmarks (SQBs) (USEPA, 1996)	TBC	SQCs and SQBs were established to provide screening toxicity thresholds.	This alternative would prevent exposure to sediment contaminants in Pond I which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs.
Federal Requirements	NOAA Screening Quick Reference Tables, Threshold Effects Level (TEL) (Buchman, 1999)	TBC	TELs represent the concentration below which adverse effects are expected to occur only rarely.	This alternative would prevent exposure to sediment contaminants in Pond I which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs

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Chemical-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.02	Applicable	These regulations set remediation standards for soil at NPL sites when they are more stringent than federal standards.	The action to be taken under this alternative will meet the remediation standards for soil, as required.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

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Location-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains disturbed by soil excavation and cap construction.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas due to soil excavation and cap construction. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this alternative.
Federal Requirements	Clean Water Act, Section 404; Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	The cap will be constructed in a manner that will minimize the area of wetlands altered, to the extent possible.

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Location-Specific ARARs and TBCs for Nunes Parcel
Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Resource Conservation and Recovery Act (RCRA), 42 U.S.C, §§ 6901 *et seq.*, General Facility Standards, Location Standards; 40 C.F.R. § 264.18	Relevant and Appropriate	Seismic and floodplain standards that apply to all hazardous waste facilities.	The RCRA C cap remedy will be implemented to meet substantive seismic and floodplain standards.
Federal Requirements	Fish and Wildlife Coordination Act, 16 U.S.C. §661 *et seq.*	Applicable	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or other federal waters for any purpose to take action to protect fish and wildlife resources that may be affected by the action.	Measures to mitigate or compensate adverse project related impacts to fish and wildlife resources will be taken, if determined necessary.
Federal Requirements	National Historical Preservation Act, 16 U.S.C. 469 *et seq.*; 36 C.F.R. Part 65	Applicable	When a federal agency finds, or is notified, that its activities in connection with a federal construction project may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archeological data, the substantive standards under the Act will be met.	If, during the remedial design or remedial action, it is determined that this alternative may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archaeological data, the substantive standards under the Act will be met.

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Location-Specific ARARs and TBCs for Nunes Parcel
Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.14(b)	Applicable	Standards for protecting wetlands and water quality. A variance has been issued for subsection 2.3.14(c), regarding floodplain restrictions, since the landfill is already located in a floodplain.	Installation of a RCRA C compliant cap that can withstand a 500-year storm event may alter areas of state jurisdictional wetlands, and perimeter land within 50 feet of wetlands. Mitigation measures, as required, will be taken to compensate for the resource areas altered by the cap.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.22	Applicable	Solid waste disposal facilities located in unstable areas must demonstrate that engineering measures have been incorporated into the facility's unit's design to ensure that the integrity of the structural components of the facility will not be disrupted.	The landfill cap can be designed, constructed and maintained to prevent any release of contamination due to unstable conditions, including flooding events, since the capped landfill will be located in a floodplain.
State Requirements	Rhode Island Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; DEM Rules And Regulations Governing the Administration And Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00 and 5.00	Applicable	Defines and establishes provisions for the protection of swamps, marshes, 100-year floodplain and other fresh water wetland resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland.	Mitigation measures, as required, will be taken to compensate for the resource areas altered by the cap.

Table I-8b
Location-Specific ARARs and TBCs for Nunes Parcel
Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Historic Preservation Act, RIGL 42-45 *et seq.*	Applicable	Requires action to take into account effects on properties included on or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks.	Features with potential historical/cultural significance will be evaluated during the remedial design phase and activities will be coordinated with the State Agency as required.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
RIGL = Rhode Island General Laws
TBC = To Be Considered

Table I-8c
Action-Specific ARARs and TBCs for Nunes Parcel
Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Water Act Federal Water Quality Criteria, Section 304(a) ; 40 CFR 131.11	Applicable	National Recommended Water Quality Criteria (NRWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation/backfill and capping must be conducted so that there are no exceedances of NRWQC. Water quality standards will be used to develop monitoring standards both during the active remedial period and for long-term monitoring of the protectiveness of the waste management area that will be established under this alternative.
Federal Requirements	Clean Water Act – National Pollutant Discharge Elimination System (NPDES), 40 C.F.R. Parts 122 and 125	Applicable	Includes stormwater standards for activities disturbing more than one acre.	Best management practices will be used to meet stormwater standards during the remedial action.
Federal Requirements	Toxic Substances Control Act (TSCA) 15 U.S.C. 2601 *et seq.*; PCB Remediation Waste, 40 C.F.R. 761.61(c)	Applicable	This section of the TSCA regulations provides risk-based cleanup and disposal options for PCB remediation waste based on the risks posed by the concentrations at which the PCBs are found. Written approval for the proposed risk-based cleanup must be obtained from the Director, Office of Site Remediation and Restoration, USEPA Region 1.	All soil exceeding identified PCB cleanup levels will be removed, dewatered (if required) and disposed of under the RCRA C cap system that meets TSCA protectiveness standards. The excavation, transportation/ dewatering, and management of PCB contaminated media will be performed in a manner to comply with TSCA. The ROD includes a finding by the Director, Office of Site Remediation and Restoration, USEPA Region 1, that the remedy's soil PCB

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
				cleanup levels, along with the excavation, dewatering, management and disposal of the of the PCB-contaminated media under a RCRA C cap will not pose an unreasonable risk to human health or the environment.
Federal Requirements	RCRA, Air Emission Standards for Process Vents, 40 CFR 264, Subpart AA	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	If operations (e.g., leachate or landfill gas collection) manage hazardous wastes with organic concentrations of at least 10 ppm by weight, system vents will comply with these requirements.
Federal Requirements	RCRA , Air Emission Standards for Equipment Leaks, 40 CFR 264, Subpart BB	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10% by weight.	If equipment contains or comes into contact with hazardous wastes (e.g., during leachate or landfill gas collection) containing organic concentrations of at least 10% by weight, then these regulations will be followed.
Federal Requirements	RCRA, Air Emission Standards for Tanks, Surface Impoundments, and Containers, 40 CFR 264, Subpart CC	Applicable	This section of RCRA has not been delegated to the State of Rhode Island. Air emissions standards for tanks, surface impoundments, and containers used to manage hazardous waste. Emission controls required if tanks, surface impoundments, and containers used to manage hazardous waste have more than 500 ppmw of volatile organics.	If tanks, surface impoundments, and containers used to manage hazardous waste (e.g., during leachate or landfill gas collection) have more than 500 ppmw of volatile organics, then these requirements will be met.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Air Act (CAA), 42 U.S.C. §§ 7401 *et seq.*, Standards of Performance for Municipal Solid Waste Landfills, 40 C.F.R. Part 60, Subpart WWW	Relevant and Appropriate	Air emission standards for landfills greater than 2.5 Mg in design capacity and emitting 50 Mg/year or more of non-methane organic compounds.	The landfill cap will be designed and constructed to allow for the collection and treatment, if required under these standards, of landfill gases.
Federal Requirements	Clean Air Act (CAA), Hazardous Air Pollutants, 42.U.S.C. § 112(b)(1), National Emission Standards for Hazardous Air Pollutants (NESHAPS), 40 C.F.R. Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust and other release sources.	If the excavation of contaminated soil, installation and maintenance of the RCRA C cap, and the control of landfill gasses generate regulated air pollutants, then measures will be implemented to meet these standards.
Federal Requirements	CAA, National Emission Standards for Hazardous Air Pollutants (NESHAPS), Standards tor Inactive waste disposal sites for asbestos mills and manufacturing and fabricating Operations, 40 C.F.R. § 61.151	Relevant and Appropriate	NESHAPS standards for preventing air releases from inactive asbestos disposal sites, including cover standards, dust suppression, and land use controls.	Any areas of asbestos contaminated soil will be consolidated under the RCRA C cap, which meets the substantive requirements of these standards. ICs will be established to maintain the cap and to address any potential asbestos exposure in case the cap is disturbed.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Framework for Investigating Asbestos-Contaminated Superfund Sites, OSWER Directive #9200.0-68 (Sept. 2008)	TBC	Guidance on investigating and characterizing the potential human exposure from asbestos contamination in outdoor soil at Superfund sites.	Any areas that were subject to previous asbestos removal actions will be investigated under these guidance standards if they are not to be located under the RCRA C cap. Areas of asbestos contamination outside of the capped area will be excavated and consolidated under the cap.
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLs), 40 CFR Subparts B and G	Relevant and Appropriate	Establishes MCLs for common organic and inorganic contaminants applicable to public drinking water supplies. Used as relevant and appropriate standards for aquifers and surface water bodies that are potential drinking water sources.	MCLs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA C cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLGs), 40 CFR Subpart F	Relevant and Appropriate	Establishes maximum contaminant level goals (MCLGs) for public water supplies. MCLGs are health goals for drinking water sources. These unenforceable health goals are available for a number of organic and inorganic compounds.	Non-zero MCLGs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA C cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.
Federal Requirements	EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	The Health Advisories will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA C cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	EPA Technical Guidance: Revised Alternative Cap Design Guidance Proposed for Unlined, Hazardous Waste Landfills in the EPA Region 1 (February 5, 2001)	TBC	Guidance for landfill covers in EPA Region 1. Presents recommended technical specifications for multilayer landfill cover design.	Cap construction will be protective in accordance with the guidance.
Federal Requirements	EPA Technical Guidance: Final Covers on Hazardous Waste Landfills and Surface Impoundments (July 1989)	TBC	Guidance for landfill covers recommending technical specifications for multilayer landfill cover designs.	Cap construction will be protective in accordance with the guidance.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Hazardous Waste Determination, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.8	Applicable	Requires a determination be made as to whether waste meets the definition of hazardous waste, including "Rhode Island Waste" as defined in Rule 3.	These regulations would apply when determining whether or not a waste generated during the remedial action is hazardous.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Generator Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.00	Applicable	Sets generator standards for handling and disposal of hazardous waste. Incorporates provisions of 40 C.F.R. Part 262.	Any hazardous waste identified will be handled and disposed according to these standards.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Facility Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 7.01(B)(1) and (B)(3), 7.10	Relevant and Appropriate	Relevant and appropriate facility standards regarding: restrictions for landfills (Rule 7.01(B)(1) and (B)(3); inspections (Rule 7.10)	The RCRA C cap will be designed, constructed and maintained in a manner that will protect groundwater beyond the compliance boundary for the landfill and control discharges of surface or subsurface contamination in violation of any federal or state standard.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Operational Requirements for Treatment, Storage, and Disposal Facilities, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 9.00	Relevant and Appropriate	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities.	Management and treatment of on-site treatment residues and waste derived from the construction and maintenance of the RCRA C cap; from leachate or landfill gas collection; or from any investigation-derived waste will comply with these regulations.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Land Disposal Facilities, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rules 10.01 and 10.02	Relevant and Appropriate	Outlines design, operational, and closure requirements for new hazardous waste landfills.	Design, construction, maintenance, closure, and post-closure of the RCRA C cap will meet the relevant and appropriate standards.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.7.10	Applicable	Requires dust control.	Dust must be controlled at the site during cap construction and during maintenance activities.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.7.12 (a)	Applicable	Requires solid waste management facilities be designed and maintained to protect the health and safety of personnel at the facility and persons in close proximity.	Under this subsection health and safety of construction workers and persons in the proximity of the site would be maintained during construction and maintenance activities.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.7.14(b)	Applicable	Regulation states that an approved closure plan must be implemented.	The site will be closed by installing the RCRA C cap in accordance with the substantive requirements of this section of the rules.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.8.01 (a) and 1.8.01 (b)	Applicable	Requires facilities to monitor groundwater and to meet closure requirements.	The substantive requirements of this section of the rules will be met by monitoring groundwater and meeting closure requirements.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.04	Applicable	Requires that sedimentation and erosion control be addressed.	Erosion and sediment control measures will be developed for this site in accordance with the substantive requirements of this section.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.08 (a) (8)	Applicable	Contains requirements for construction of monitoring wells to monitor a solid waste landfill.	The substantive requirements of this section of the regulations will be met for construction of new monitoring wells.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.11	Applicable	Requirement to establish a conservation easement that prohibits development on the landfill without regulatory approval and gives access to the site to regulatory authorities.	The easement will be part of the institutional controls established to prevent activities that will conflict with the remedial action.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.08 (c)	Applicable	Contains requirements for environmental monitoring.	The substantive requirements of this section of the regulations will be met by having and maintaining monitoring wells and surface water monitoring, if required, for the purpose of monitoring environmental conditions around the capped landfill.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.12	Applicable	Requirement to address landfill gas recovery.	The substantive requirements in this section will be met if landfill gas recovery is required for the capped landfill.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.2.00	Applicable	Solid waste landfill construction standards. Variances apply to substantive sections that aren't applicable to capping an existing landfill.	Substantive requirements will be met except for provisions excluded by variances, by installing and maintaining a RCRA C cap on the landfill.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.04(c), (f)	Applicable	Contains requirements for final cover.	The substantive requirements of this section of the regulations will be met by installing a RCRA C compliant cap which achieves permeability standards that are protective of human health and the environment.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.05(a)	Applicable	Regulations set standards so that no solid waste disposal area shall be operated so as to cause or to be likely to cause pollution of the ground waters or surface waters of the State at or beyond the boundary of the waste management area compliance boundary.	The RCRA C cap will meet the design, construction and maintenance standards to prevent the release of contaminants to surface waters and groundwater beyond the compliance boundary for the waste management area.

Table I-8c

Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.06	Applicable	Standards for waste handling.	Wastes consolidated from elsewhere on site will be handled and added to the landfill in compliance with these standards.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.06(d)(6)	Applicable	Specific standards for disposing of asbestos.	If any asbestos-contaminated material is disposed of under the cap it will be handled in compliance with these standards.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.08	Applicable	Standards for landfill gas control.	The substantive requirements of this section of the rules will be met, as required to address any potential landfill gas at the landfill once it is capped.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.10	Applicable	Contains requirements for surface water drainage.	The substantive requirements of this section of the rules will be met through design of appropriate surface drainage considerations for the cover.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.11	Applicable	Contains requirements for monitoring wells..	The substantive requirements of this section of the regulations will be met by having and maintaining monitoring wells for the purpose of monitoring groundwater conditions around the capped landfill.

Table I-8c

Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.04	Applicable	These regulations set remediation standards for groundwater at NPL sites when they are more stringent than federal standards.	These regulations will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the RCRA C cap. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet these standards.
State Requirements	Water Pollution Control, Water Quality Regulations, RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Excavation and capping must be conducted so that there are no exceedances of water quality standards.
State Requirements	Water Pollution Control - Pollution Discharge Elimination Systems, RIGL 42-16 *et seq.*; CRIR 12-190-003 Rule 31	Applicable	Includes storm water requirements for construction projects that disturb over one acre.	Best management practices will be used to meet stormwater standards during the remedial action.
State Requirements	RI Air Pollution Control Regulation No. 1: Visible Emissions, RIGL 23-23 *et seq.*; CRIR 12-31-01	Applicable	Establishes opacity limitations for contaminate emissions.	Remediation activities could potentially result in visible emissions. If these standards are exceeded, emissions would need to be managed through engineering controls.

Table I-8c

Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Air Pollution Control Regulation No. 5: Fugitive Dust, RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable measures be taken to prevent particulate matter from becoming airborne.	Remediation activities could potentially result in fugitive dust. Appropriate measures would need to be taken to prevent particulate matter from becoming airborne.
State Requirements	RI Air Pollution Control Regulation No. 7: Emissions of Air Detrimental to Persons or Property, RIGL 23-23*e t seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants that may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Remediation activities may result in emissions. Appropriate measure would need to be taken to comply with these regulations.
State Requirements	RI Air Pollution Control Regulation No. 16: Operation of Air Pollution Control Equipment, RIGL 23-23*e t seq.*; CRIR 12-31-16	Applicable	Any air pollution control system shall be operated according to its design specifications whenever the source on which it is installed is in operation or is emitting air contaminants.	If active treatment of landfill gas emissions is required, the system will be operated in accordance with these standards.
State Requirements	RI Air Pollution Control Regulation No. 22: Air Toxics Guidelines and Air Modeling Guidelines, RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation activities may result in emissions of toxics to the atmosphere if these contaminants are present in soil. Appropriate measure would need to be taken to comply with these regulations.

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Action-Specific ARARs and TBCs for Nunes Parcel

Alternative NP-SO-3: RCRA Subtitle C Cap of Landfill, Consolidation, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Drilling of Drinking Water Wells; Rules and Regulations Governing the Enforcement of Chapter 46-13.2 Relating to the Drilling of Drinking Water Wells, RIGL 46-13..2 *et seq.*	Applicable	Prohibits installing drinking water wells in contaminated aquifers. Establishes standards for decommissioning monitoring wells (Rule 9.03).	Under these standards drinking water wells are prohibited within the waste management area that will be established under this alternative and monitoring wells used will be properly decommissioned when no longer needed.
State Requirements	Rules and Regulations for Groundwater Quality RIGL Ch. 46-12, Section 46-12-2; Ch. 46-13.1, Ch. 23-18.9, Sec. 23-18-9.1; DEM Rules and Regulations for Groundwater Quality (Mar 2005), Appendix 1	Applicable	Identifies the standards and specifications that must be followed for installation or abandonment of monitoring wells.	Under this alternative, wells installed for monitoring the waste management area will be installed and abandoned according to these standards.

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ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
RIGL = Rhode Island General Laws
TBC = To Be Considered

Table I-9a
Chemical-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	This alternative would not prevent exposure to soil contaminants which contribute to a calculated carcinogenic risk, developed using this guidance.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	This alternative would not prevent exposure to soil contaminants which contribute to a calculated carcinogenic risk to children, developed using this guidance.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are considered to be the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a life time.	This alternative would not prevent exposure to soil contaminants which contribute to a calculated non-carcinogenic risk, developed using this guidance.
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	This alternative would not prevent exposure to soil contaminants which contribute to a calculated carcinogenic risk, developed using this guidance.

Table I-9a
Chemical-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Recommendations of the Technical Review Workgroup for Lead for an approach to Assessing Risks Associated with Adult Exposure to Lead In Soil, EPA-540-R-03-001 (January 2003)	TBC	EPA Guidance for evaluating risks posed by lead in soil.	This alternative would not prevent exposure to lead in soil which contributes to a calculated risk, developed using this guidance.
Federal Requirements	USEPA Interim Ecological Soil Screening Levels (SSLs) (USEPA, 2003)	TBC	SSLs were established to provide screening toxicity thresholds.	SSLs were used for selecting Chemicals of Potential Concern (COPCs) and for characterizing ecological effects. This alternative would not prevent exposure to soil contaminants which contribute to a calculated ecological risk, developed using this guidance.
Federal Requirements	ORNL Toxicological Benchmarks for Wildlife (Sample et al., 1996)	TBC	These benchmarks were established to provide screening toxicity thresholds.	These benchmarks were used for selecting COPCs and for characterizing ecological effects. This alternative would not prevent exposure to soil contaminants which contribute to a calculated ecological risk, developed using this guidance.

Table I-9a
Chemical-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	ORNL Toxicological Benchmarks for Screening Contaminants of Concern for Effects of Soil and Litter Invertebrates and Heterotrophic Process (Efroymson et al., 1997)	TBC	These benchmarks were established to provide screening toxicity thresholds.	These benchmarks were used for selecting COPCs and for characterizing ecological effects. This alternative would not prevent exposure to soil contaminants which contribute to a calculated ecological risk, developed using this guidance.
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.02	Applicable	These regulations set direct contact and leachability remediation standards for soil at NPL sites when they are more stringent than federal standards.	This alternative would not prevent exposure to any soil contaminants that exceed State soil standards that are more stringent than federal risk-based standards.

Notes:
With no action, there are no location- or action-specific ARARs.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-10a

Chemical-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	Used to calculate potential carcinogenic risks to children caused by exposure to contaminants in soil/debris.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are considered to be the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime.	Used to calculate potential non-carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.

Table I-10a

Chemical-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Recommendations of the Technical Review Workgroup for Lead for an approach to Assessing Risks Associated with Adult Exposure to Lead In Soil, EPA-540-R-03-001 (January 2003)	TBC	EPA Guidance for evaluating risks posed by lead in soil.	Used to calculate potential risks caused by exposure to lead in soil/debris.
Federal Requirements	USEPA Interim Ecological Soil Screening Levels (SSLs) (USEPA, 2003)	TBC	SSLs were established to provide screening toxicity thresholds.	Removal and/or covering of all contaminated material will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.
Federal Requirements	ORNL Toxicological Benchmarks for Wildlife (Sample et al., 1996)	TBC	These benchmarks were established to provide screening toxicity thresholds.	Removal and/or covering of all contaminated material will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.

Table I-10a

Chemical-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	ORNL Toxicological Benchmarks for Screening Contaminants of Concern for Effects of Soil and Litter Invertebrates and Heterotrophic Process (Efroymson et al., 1997)	TBC	These benchmarks were established to provide screening toxicity thresholds.	Removal and/or covering of all contaminated material will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.02	Applicable	These regulations set direct contact and leachability remediation standards for soil at NPL sites when they are more stringent than federal standards.	The action to be taken under this alternative will meet the remediation standards for soil, as required.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-10b

Location-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains disturbed by soil/waste excavation and cover construction activities.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas due to soil/waste excavation and cover construction activities. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this alternative.
Federal Requirements	Clean Water Act, Section 404; Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	The excavation and transportation of the top two feet of contaminated soil/debris and covering of remaining subsurface contamination will be conducted to minimize the area of wetlands altered, to the extent possible. Areas of altered wetlands will be mitigated, as required.

Table I-10b

Location-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Fish and Wildlife Coordination Act, 16 U.S.C. §661 *et seq.*	Applicable	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or other federal waters for any purpose to take action to protect fish and wildlife resources that may be affected by the action.	Measures to mitigate or compensate adverse project related impacts to fish and wildlife resources will be taken, if determined necessary.
Federal Requirements	National Historical Preservation Act, U.S.C. 469 *et seq.*; 36 C.F.R. Part 65	Applicable	When a federal agency finds, or is notified, that its activities in connection with a federal construction project may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archeological data, the substantive standards under the Act will be met.	If, during the remedial design or remedial action, it is determined that this alternative may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archaeological data, substantive standards under the Act will be met.
State Requirements	Rhode Island Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; DEM Rules And Regulations Governing the Administration And Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00 and 5.00	Applicable	Defines and establishes provisions for the protection of swamps, marshes, 100-year floodplain and other fresh water wetland resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland.	Action taken under this alternative will be done in compliance with this requirement.

Table I-10b

Location-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Resource Conservation and Recovery Act (RCRA), 42 U.S.C, §§ 6901 *et seq.*, General Facility Standards, Location Standards; 40 C.F.R. § 264.18	Relevant and Appropriate	Seismic and floodplain standards that apply to all hazardous waste facilities.	The cover can be designed, constructed and maintained to meet seismic requirements, however the cover does not comply with RCRA standards.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.22	Relevant and Appropriate	Solid waste disposal facilities located in unstable areas must demonstrate that engineering measures have been incorporated into the facility's unit's design to ensure that the integrity of the structural components of the facility will not be disrupted.	This alternative establishes a waste management area within a 100 year flood zone. The substantive requirements of this section of the regulations will be met as long as the cover on the waste left in place can withstand a 100-year flood event without release of contaminants.

Table I-10b

Location-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Historic Preservation Act, RIGL 42-45 *et seq.*	Applicable	Requires action to take into account effects on properties included on or eligible for the National register of Historic Places and minimizes harm to National Historic Landmarks.	Features with potential historical/cultural significance will be evaluated during the remedial design phase and activities will be coordinated with the State Agency as required.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
RIGL + Rhode Island General Laws
TBC = To Be Considered

Table I-10c

Action-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Water Act Federal Water Quality Criteria, Section 304(a) ; 40 CFR 131.11	Applicable	National Recommended Water Quality Criteria (NRWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Action taken under this alternative will be conducted so that there are no exceedances of NRWQC. Water quality standards will be used to develop monitoring standards during the active remedial period and for long-term monitoring under this alternative.
Federal Requirements	Clean Water Act – National Pollutant Discharge Elimination System (NPDES), 40 C.F.R. Parts 122 and 125	Applicable	Establishes the specifications for discharging pollutants from any point source into the waters of the U.S. Also, includes stormwater standards for activities disturbing more than one acre.	Any water discharged to surface water bodies during remedial activities will comply with this regulation. Best management practices will be used to meet stormwater standards during the remedial action.
Federal Requirements	Toxic Substances Control Act (TSCA) 15 U.S.C. 2601 *et seq.*; PCB Remediation Waste, 40 C.F.R. 761.61(c)	Applicable	This section of the TSCA regulations provides risk-based cleanup and disposal options for PCB remediation waste based on the risks posed by the concentrations at which the PCBs are found. Written approval for the proposed risk-based cleanup must be obtained from the Director, Office of Site Remediation and Restoration, USEPA Region 1.	All soil exceeding identified PCB cleanup levels will be removed, dewatered (if required) and disposed of under the on-site landfill caps that meets TSCA protectiveness standards. The ROD will include a finding by the Director, Office of Site Remediation and Restoration, USEPA Region 1, that the remedy's soil PCB cleanup levels, along with the excavation, dewatering, management and disposal of the of the PCB-contaminated media under an on-site landfill cap will not pose an

Table I-10c

Action-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
				unreasonable risk to human health or the environment. Any PCB-contaminated material left in place and covered must not pose an unreasonable risk.
Federal Requirements	Clean Air Act (CAA), Hazardous Air Pollutants, 42.U.S.C. § 112(b)(1), National Emission Standards for Hazardous Air Pollutants (NESHAPS), 40 C.F.R. Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust and other release sources.	If the excavation of contaminated soil and the installation and maintenance of the cover generates regulated air pollutants, then measures will be implemented to meet these standards.
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Levels (MCLs), 40 CFR Subparts B and G	Relevant and Appropriate	Establishes MCLs for common organic and inorganic contaminants applicable to public drinking water supplies. Used as relevant and appropriate standards for aquifers and surface water bodies that are potential drinking water sources.	MCLs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the cover. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.

Table I-10c

Action-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Safe Drinking Water Act Maximum Contaminant Level Goals (MCLGs), 40 CFR Subpart F	Relevant and Appropriate	Establishes maximum contaminant level goals (MCLGs) for public water supplies. MCLGs are health goals for drinking water sources. These unenforceable health goals are available for a number of organic and inorganic compounds.	Non-zero MCLGs will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the cover. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.
Federal Requirements	EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	The Health Advisories will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the cover. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet drinking water standards.

Table I-10c

Action-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	EPA Technical Guidance: Revised Alternative Cap Design Guidance Proposed for Unlined, Hazardous Waste Landfills in the EPA Region 1 (February 5, 2001)	TBC	Guidance for landfill covers in EPA Region 1. Presents recommended technical specifications for multilayer landfill cover design.	The proposed cover does not comply with the guidance because it does not meet RCRA C performance criteria.
Federal Requirements	EPA Technical Guidance: Final Covers on Hazardous Waste Landfills and Surface Impoundments (July 1989)	TBC	Guidance for landfill covers recommending technical specifications for multilayer landfill cover designs.	The proposed cover does not comply with the guidance because it does not meet RCRA C performance criteria.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Hazardous Waste Determination, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.8	Applicable	Requires a determination be made as to whether waste meets the definition of hazardous waste, including "Rhode Island Waste" as defined in Rule 3,	These regulations would apply when determining whether or not a waste generated during the remedial action is hazardous.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Generator Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.00	Applicable	Sets generator standards for handling and disposal of hazardous waste. Incorporates provisions of 40 C.F.R. Part 262.	Any hazardous waste identified will be handled and disposed according to these standards.

Table I-10c

Action-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Facility Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 7.01(B)(1) and (B)(3), 7.10	Relevant and Appropriate	Relevant and appropriate facility standards regarding: restrictions for landfills (Rule 7.01(B)(1) and (B)(3); inspections (Rule 7.10)	The proposed cover is not expected to protect groundwater beyond the compliance boundary for the landfill nor control discharges of surface or subsurface contamination in violation of any federal or state standard.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Operational Requirements for Treatment, Storage, and Disposal Facilities, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 9.00	Relevant and Appropriate	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities.	Management and treatment of on-site treatment residues and waste derived from the construction and maintenance of the proposed cover; from leachate or landfill gas collection; or from any investigation-derived waste will comply with these regulations.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Land Disposal Facilities, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rules 10.01 and 10.02	Relevant and Appropriate	Outlines design, operational, and closure requirements for new hazardous waste landfills.	The proposed cover does not fully meet these standards.

Table I-10c

Action-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.7.10	Relevant and Appropriate	Requires dust control.	Dust must be controlled at the site during cover construction and during maintenance activities.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.7.12 (a)	Relevant and Appropriate	Requires solid waste management facilities be designed and maintained to protect the health and safety of personnel at the facility and persons in close proximity.	Under this subsection health and safety of construction workers and persons in the proximity of the site would be maintained during construction and maintenance activities.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.7.14(b)	Applicable	Regulation states that an approved closure plan must be implemented.	The proposed cover will meet the substantive requirements of this section.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.8.01 (a) and 1.8.01 (b)	Relevant and Appropriate	Requires facilities to monitor groundwater and to meet closure requirements.	The substantive requirements of this section of the regulations will be met by monitoring groundwater and meeting closure requirements.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.04	Relevant and Appropriate	Requires a “Sedimentation and Erosion Control Plan” be developed.	An erosion and sediment control plan will be developed for this site in accordance with the substantive requirements of this section.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.08 (a) (8)	Relevant and Appropriate	Contains requirements for construction of monitoring wells to monitor a solid waste landfill.	The substantive requirements of this section of the regulations will be met for construction of new monitoring wells.

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Action-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.08 (c)	Relevant and Appropriate	Contains requirements for monitoring wells.	The substantive requirements of this section of the regulations will be met by maintaining monitoring wells for the purpose of monitoring groundwater conditions at the site.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.04(c), (f)	Relevant and Appropriate	Contains requirements for final cover.	The substantive requirements of this section of the regulations will be met by installing a minimum of two feet of cover, which achieves permeability standards that are protective of human health and the environment.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.05(a)	Relevant and Appropriate	Regulations set standards so that no solid waste disposal area shall be operated so as to cause or to be likely to cause pollution of the ground waters or surface waters of the State at or beyond the boundary of the waste management area compliance boundary.	The cover system must be designed, constructed and maintained so as to prevent the release of contaminants either to surface waters (including during flooding events) and groundwater beyond the compliance boundary for the waste management area.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.10	Relevant and Appropriate	Contains requirements for surface water drainage.	The substantive requirements of this section of the regulations will be met through design of appropriate surface drainage considerations for the cover.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.3.11	Relevant and Appropriate	Contains requirements for monitoring wells.	The substantive requirements of this section of the regulations will be met by having and maintaining monitoring wells for the purpose of monitoring groundwater conditions.

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Action-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.04	Applicable	These regulations set remediation standards for groundwater at NPL sites when they are more stringent than federal standards.	These regulations will be used to develop performance standards for monitoring the compliance boundary for the waste management area established where contamination is left in place under the cover. Monitoring will ensure that groundwater contamination within the compliance boundary does not migrate beyond the boundary and cause adjacent groundwater not to meet these standards.
State Requirements	Water Pollution Control, Water Quality Regulations, RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with Site activities.	Excavation and covering must be conducted so that there are no exceedances of water quality standards.
State Requirements	Water Pollution Control - Pollution Discharge Elimination Systems, RIGL 42-16 *et seq.*; CRIR 12-190-003 Rule 31	Applicable	Includes storm water requirements for construction projects that disturb over one acre.	Best management practices will be used to meet stormwater standards during the remedial action.
State Requirements	RI Air Pollution Control Regulation No. 1: Visible Emissions, RIGL 23-23 *et seq.*; CRIR 12-31-01	Applicable	Establishes opacity limitations for contaminate emissions.	Remediation activities could potentially result in visible emissions. If these standards are exceeded, emissions would need to be managed through engineering controls.

Table I-10c

Action-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Air Pollution Control Regulation No. 5: Fugitive Dust, RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable measures be taken to prevent particulate matter from becoming airborne.	Remediation activities could potentially result in fugitive dust. Appropriate measures would need to be taken to prevent particulate matter from becoming airborne.
State Requirements	RI Air Pollution Control Regulation No. 7: Emissions of Air Detrimental to Persons or Property, RIGL 23-23*e t seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants that may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Remediation activities may result in emissions. Appropriate measure would need to be taken to comply with these regulations.
State Requirements	RI Air Pollution Control Regulation No. 22: Air Toxics Guidelines and Air Modeling Guidelines, RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation activities may result in emissions of toxics to the atmosphere if these contaminants are present in soil. Appropriate measure would need to be taken to comply with these regulations.
State Requirements	Drilling of Drinking Water Wells; Rules and Regulations Governing the Enforcement of Chapter 46-13.2 Relating to the Drilling of Drinking Water Wells, RIGL 46-13..2 *et seq.*	Applicable	Prohibits installing drinking water wells in contaminated aquifers. Establishes standards for decommissioning monitoring wells (Rule 9.03).	Under these standards drinking water wells are prohibited within the waste management area that will be established under this alternative and monitoring wells used will be properly decommissioned when no longer needed.

Table I-10c

Action-Specific ARARs and TBCs for Unnamed Island

Alternative UI-SO-2: Remove/Consolidate Surface Waste/Soil (0-2 ft) Exceeding PRGs, Geotextile with Riprap where PRG Exceedances Remain, and Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rules and Regulations for Groundwater Quality RIGL Ch. 46-12, Section 46-12-2; Ch. 46-13.1, Ch. 23-18.9, Sec. 23-18-9.1; DEM Rules and Regulations for Groundwater Quality (Mar 2005), Appendix 1	Applicable	Identifies the standards and specifications that must be followed for installation or abandonment of monitoring wells.	Under this alternative, wells installed for monitoring the waste management area will be installed and abandoned according to these standards.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
RIGL = Rhode Island General Law
TBC = To Be Considered

Table I-11a
Chemical-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F	TBC	This provides guidance on assessing risk to children from carcinogens.	Used to calculate potential carcinogenic risks to children caused by exposure to contaminants in soil/debris.
Federal Requirements	EPA Risk Reference Doses (RfDs)	TBC	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. RfDs are considered to be the levels unlikely to cause significant adverse health effects associated with a threshold mechanism of action in human exposure for a lifetime.	Used to calculate potential non-carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.
Federal Requirements	EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to calculate potential carcinogenic risks caused by exposure to contaminants in soil/debris.

Table I-11a
Chemical-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Recommendations of the Technical Review Workgroup for Lead for an approach to Assessing Risks Associated with Adult Exposure to Lead In Soil, EPA-540-R-03-001 (January 2003)	TBC	EPA Guidance for evaluating risks posed by lead in soil.	Used to calculate potential risks caused by exposure to lead in soil/debris.
Federal Requirements	USEPA Interim Ecological Soil Screening Levels (SSLs) (USEPA, 2003)	TBC	SSLs were established to provide screening toxicity thresholds.	Removal of all contaminated material will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.
Federal Requirements	ORNL Toxicological Benchmarks for Wildlife (Sample et al., 1996)	TBC	These benchmarks were established to provide screening toxicity thresholds.	Removal of all contaminated material will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.

Table I-11a
Chemical-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	ORNL Toxicological Benchmarks for Screening Contaminants of Concern for Effects of Soil and Litter Invertebrates and Heterotrophic Process (Efroymson et al., 1997)	TBC	These benchmarks were established to provide screening toxicity thresholds.	Removal of all contaminated material will prevent ecological exposure to contaminated soils which contribute to a calculated risk, developed using this guidance.
State Requirements	RI Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (i.e., Remediation Regulations), CRIR12-180-001; DEM-DSR-01-93, section 8.02	Applicable	These regulations set direct contact and leachability remediation standards for soil at NPL sites when they are more stringent than federal standards.	The action to be taken under this alternative will meet the remediation standards for soil, as required.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-11b
Location-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains disturbed by soil/waste excavation activities.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas due to soil/waste excavation activities. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this alternative.
Federal Requirements	Clean Water Act, Section 404; Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Excavation and disposal work in the floodplain and in any areas of federal jurisdiction wetland will be conducted to minimize the area of wetlands altered, to the extent possible. Areas of altered wetlands will be mitigated, as required.

Table I-11b
Location-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Fish and Wildlife Coordination Act, 16 U.S.C. §661 *et seq.*	Applicable	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or other federal waters for any purpose to take action to protect fish and wildlife resources that may be affected by the action.	Measures to mitigate or compensate adverse project related impacts to fish and wildlife resources will be taken, if determined necessary.
Federal Requirements	National Historical Preservation Act, U.S.C. 469 *et seq.*; 36 C.F.R. Part 65	Applicable	When a federal agency finds, or is notified, that its activities in connection with a federal construction project may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archeological data, the substantive standards under the Act will be met.	If, during the remedial design or remedial action, it is determined that this alternative may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archaeological data, the substantive standards under the Act will be met.
State Requirements	Rhode Island Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; DEM Rules And Regulations Governing the Administration And Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00 and 5.00	Applicable	Defines and establishes provisions for the protection of swamps, marshes, 100-year floodplain and other fresh water wetland resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland.	Action taken under this alternative will be done in compliance with this requirement.

Table I-11b
Location-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Historic Preservation Act, RIGL 42-45 *et seq.*	Applicable	Requires action to take into account effects on properties included on or eligible for the National register of Historic Places and minimizes harm to National Historic Landmarks.	Features with potential historical/cultural significance will be evaluated during the remedial design phase and activities will be coordinated with the State Agency as required.

Key:

ARAR	=	Applicable or Relevant and Appropriate Requirement
CFR	=	Code of Federal Regulations
EPA	=	U.S. Environmental Protection Agency
PRGs	=	Preliminary Remediation Goals
RIDEM	=	Rhode Island Department of Environmental Protection
RIGL	+	Rhode Island General Laws
TBC	=	To Be Considered

Table I-11c
Action-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Water Act Federal Water Quality Criteria, Section 304(a) ; 40 CFR 131.11	Applicable	National Recommended Water Quality Criteria (NRWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Action taken under this alternative will be conducted so that there are no exceedances of NRWQC. Water quality standards used to develop monitoring standards during the active remedial period will be established under this alternative.
Federal Requirements	Clean Water Act – National Pollutant Discharge Elimination System (NPDES), 40 C.F.R. Parts 122 and 125	Applicable	Establishes the specifications for discharging pollutants from any point source into the waters of the U.S. Also, includes stormwater standards for activities disturbing more than one acre.	Any water discharged to surface water bodies during remedial activities will comply with this regulation. Best management practices will be used to meet stormwater standards during the remedial action.
Federal Requirements	Toxic Substances Control Act (TSCA) 15 U.S.C. 2601 *et seq.*; PCB Remediation Waste, 40 C.F.R. 761.61(c)	Applicable	This section of the TSCA regulations provides risk-based cleanup and disposal options for PCB remediation waste based on the risks posed by the concentrations at which the PCBs are found. Written approval for the proposed risk-based cleanup must be obtained from the Director, Office of Site Remediation and Restoration, USEPA Region 1.	All soil exceeding identified PCB cleanup levels will be removed, dewatered (if required) and disposed of under the on-site landfill caps that meets TSCA protectiveness standards. The ROD will include a finding by the Director, Office of Site Remediation and Restoration, USEPA Region 1, that the remedy's soil PCB cleanup levels, along with the excavation, dewatering, management and disposal of the of the PCB-contaminated media under an on-site landfill cap will not pose an unreasonable risk to human health or the environment.

Table I-11c
Action-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Air Act (CAA), Hazardous Air Pollutants, 42.U.S.C. § 112(b)(1), National Emission Standards for Hazardous Air Pollutants (NESHAPS), 40 C.F.R. Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust and other release sources.	If the excavation of contaminated soil generates regulated air pollutants, then measures will be implemented to meet these standards.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Hazardous Waste Determination, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.8	Applicable	Requires a determination be made as to whether waste meets the definition of hazardous waste, including "Rhode Island Waste" as defined in Rule 3.	These regulations would apply when determining whether or not a waste generated during the remedial action is hazardous.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Generator Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.00	Applicable	Sets generator standards for handling and disposal of hazardous waste. Incorporates provisions of 40 C.F.R. Part 262.	Any hazardous waste identified will be handled and disposed according to these standards.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401	Relevant and Appropriate	Regulations for the management of solid waste.	All solid waste will be removed from the Unnamed Island and disposed of at one of the on-site landfills that will be capped as part of this remedial action.

Table I-11c
Action-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.7.10	Relevant and Appropriate	Requires dust control.	Dust must be controlled at the site during excavation activities.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.7.12 (a)	Relevant and Appropriate	Requires solid waste management facilities be designed and maintained to protect the health and safety of personnel at the facility and persons in close proximity.	Under this subsection health and safety of construction workers and persons in the proximity of the site would be maintained during excavation activities.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 1.8.01 (a) and 1.8.01 (b)	Relevant and Appropriate	Requires facilities to meet closure requirements.	The substantive requirements of this section of the regulations will be met by meeting closure requirements.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401, 2.1.04	Relevant and Appropriate	Requires a "Sedimentation and Erosion Control Plan" be developed.	An erosion and sediment control plan will be developed for this site in accordance with the substantive requirements of this section.
State Requirements	Water Pollution Control, Water Quality Regulations, RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with Site activities.	Excavation and disposal at the on-site landfills must be conducted so that there are no exceedances of water quality standards.
State Requirements	Water Pollution Control - Pollution Discharge Elimination Systems, RIGL 42-16 *et seq.*; CRIR 12-190-003 Rule 31	Applicable	Includes storm water requirements for construction projects that disturb over one acre.	Best management practices will be used to meet stormwater standards during the remedial action.

Table I-11c
Action-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Air Pollution Control Regulation No. 1: Visible Emissions, RIGL 23-23 *et seq.*; CRIR 12-31-01	Applicable	Establishes opacity limitations for contaminate emissions.	Remediation activities could potentially result in visible emissions. If these standards are exceeded, emissions would need to be managed through engineering controls.
State Requirements	RI Air Pollution Control Regulation No. 5: Fugitive Dust, RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable measures be taken to prevent particulate matter from becoming airborne.	Remediation activities could potentially result in fugitive dust. Appropriate measures would need to be taken to prevent particulate matter from becoming airborne.
State Requirements	RI Air Pollution Control Regulation No. 7: Emissions of Air Detrimental to Persons or Property, RIGL 23-23*e t seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants that may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Remediation activities may result in emissions. Appropriate measure would need to be taken to comply with these regulations.
State Requirements	RI Air Pollution Control Regulation No. 22: Air Toxics Guidelines and Air Modeling Guidelines, RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation activities may result in emissions of toxics to the atmosphere if these contaminants are present in soil. Appropriate measure would need to be taken to comply with these regulations.

Table I-11c
Action-Specific ARARs and TBCs for Unnamed Island
Alternative UI-SO-3: Remove/Consolidate All Waste/Soil Exceeding PRGs

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Drilling of Drinking Water Wells; Rules and Regulations Governing the Enforcement of Chapter 46-13.2 Relating to the Drilling of Drinking Water Wells, RIGL 46-13.2 *et seq.*	Applicable	Prohibits installing drinking water wells in contaminated aquifers. Establishes standards for decommissioning monitoring wells (Rule 9.03).	Under these standards drinking water wells are prohibited within the waste management area that will be established under this alternative and monitoring wells used will be properly decommissioned when no longer needed.
State Requirements	Rules and Regulations for Groundwater Quality RIGL Ch. 46-12, Section 46-12-2; Ch. 46-13.1, Ch. 23-18.9, Sec. 23-18-9.1; DEM Rules and Regulations for Groundwater Quality (Mar 2005), Appendix 1	Applicable	Identifies the standards and specifications that must be followed for installation or abandonment of monitoring wells.	Under this alternative, wells installed for monitoring the waste management area will be installed and abandoned according to these standards.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
RIGL = Rhode Island General Law
TBC = To Be Considered

Table I-12a
Chemical-Specific ARARs and TBCs for Sediment
Alternative SE-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	NOAA Effects Range-Low (ERL) values for marine and estuarine sediments (Long et al., 1995; Long and Morgan, 1990)	TBC	The ERL value is equivalent to the lower 10th percentile of the available toxicity data, which is estimated to be the approximate concentration at which adverse effects are likely to occur in sensitive life stages and/or species of sediment-dwelling organisms.	ERLs were used for selecting Chemicals of Potential Concern (COPCs) and for characterizing ecological effects. This alternative would not prevent exposure to sediment contaminants which contribute to a calculated ecological risk, developed using this guidance.
Federal Requirements	U.S. DOE, Office of Environmental Management, Secondary Chronic Values (SCVs) (Jones et al., 1997)	TBC	The SCVs are toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota.	SCVs were used for selecting COPCs and for characterizing ecological effects. This alternative would not prevent exposure to sediment contaminants which contribute to a calculated ecological risk, developed using this guidance.
Federal Requirements	U.S. EPA Sediment Quality Criterion (SQC) and Sediment Quality Benchmarks (SQBs) (USEPA, 1996)	TBC	SQCs and SQBs were established to provide screening toxicity thresholds.	SQCs and SQBs were used for selecting COPCs and for characterizing ecological effects. This alternative would not prevent exposure to sediment contaminants which contribute to a calculated ecological risk, developed using this guidance.

Table I-12a
Chemical-Specific ARARs and TBCs for Sediment
Alternative SE-1: No Action

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	NOAA Screening Quick Reference Tables, Threshold Effects Level (TEL) (Buchman, 1999)	TBC	TELs represent the concentration below which adverse effects are expected to occur only rarely.	TELs were used for selecting COPCs and for characterizing ecological effects. This alternative would not prevent exposure to sediment contaminants which contribute to a calculated ecological risk, developed using this guidance.

Notes:
For the No Action alternative, there are no State chemical-specific ARARs and no location- or action-specific ARARs.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-13a
Chemical-Specific ARARs and TBCs for Sediment
Alternative SE-2: Remove/Consolidate Sediment Exceeding PRGs
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	NOAA Effects Range-Low (ERL) values for marine and estuarine sediments (Long et al., 1995; Long and Morgan, 1990)	TBC	The ERL value is equivalent to the lower 10th percentile of the available toxicity data, which is estimated to be the approximate concentration at which adverse effects are likely to occur in sensitive life stages and/or species of sediment-dwelling organisms.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs.
Federal Requirements	U.S. DOE, Office of Environmental Management, Secondary Chronic Values (SCVs) (Jones et al., 1997)	TBC	The SCVs are toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs.
Federal Requirements	U.S. EPA Sediment Quality Criterion (SQC) and Sediment Quality Benchmarks (SQBs) (USEPA, 1996)	TBC	SQCs and SQBs were established to provide screening toxicity thresholds.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs.
Federal Requirements	NOAA Screening Quick Reference Tables, Threshold Effects Level (TEL) (Buchman, 1999)	TBC	TELs represent the concentration below which adverse effects are expected to occur only rarely.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk, by removing all contaminated sediments that exceed PRGs

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-13b
Location-Specific ARARs and TBCs for Sediment
Alternative SE-2: Remove/Consolidate Sediment Exceeding PRGs
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains disturbed by sediment excavation activities.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas due to sediment excavation activities. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this alternative.
Federal Requirements	Fish and Wildlife Coordination Act, 16 U.S.C. §661 *et seq.*	Applicable	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or other federal waters for any purpose to take action to protect fish and wildlife resources that may be affected by the action.	Measures to mitigate or compensate adverse project related impacts to fish and wildlife resources will be taken, if determined necessary.
Federal Requirements	National Historical Preservation Act, U.S.C. 469 *et seq.*; 36 C.F.R. Part 65	Applicable	When a federal agency finds, or is notified, that its activities in connection with a federal construction project may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archeological data, the substantive standards under the Act will be met.	If, during the remedial design or remedial action, it is determined that this alternative may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archaeological data, substantive standards under the Act will be met.

Table I-13b
Location-Specific ARARs and TBCs for Sediment
Alternative SE-2: Remove/Consolidate Sediment Exceeding PRGs
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; DEM Rules And Regulations Governing the Administration And Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00 and 5.00	Applicable	Defines and establishes provisions for the protection of swamps, marshes, 100-year floodplain and other fresh water wetland resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland. Also establishes standards for land within 50 feet of the edge of state-regulated wetlands.	Action taken under this alternative will be done in compliance with this requirement.
State Requirements	Rhode Island Historic Preservation Act, RIGL 42-45 *et seq.*	Applicable	Requires action to take into account effects on properties included on or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks.	Features with potential historical/cultural significance will be evaluated during the remedial design phase and activities will be coordinated with the State Agency, as required.

Key:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
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RIGL = Rhode Island General Laws
TBC = To Be Considered

Table I-13c
Action-Specific ARARs and TBCs for Sediment
Alternative SE-2: Remove/Consolidate Sediment Exceeding PRGs
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, EPA-540-R-05-012 OSWER 9355.0-85 (December 2005)	TBC	Guidance for making remedy decisions for contaminated sediment sites. Some of the relevant sections of the guidance address Remedial Investigations (Ch. 2), FS Considerations (Ch. 3), and Dredging and Excavation (Ch. 6).	Action taken under this alternative will meet guidance standards for addressing contaminated sediments in the wetlands/ waterway.
Federal Requirements	Clean Water Act Federal Water Quality Criteria, Section 304(a) ; 40 CFR 131.11	Applicable	NRWQC are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Action taken under this alternative will be conducted so that there are no exceedances of NRWQC. Water quality standards will be used to develop monitoring standards during the active remedial period under this alternative.
Federal Requirements	Clean Water Act – National Pollutant Discharge Elimination System (NPDES), 40 C.F.R. Parts 122 and 125	Applicable	Establishes the specifications for discharging pollutants from any point source into the waters of the U.S. Also, includes stormwater standards for activities disturbing more than one acre.	Any water discharged to surface water bodies during remedial activities such as sediment dewatering will comply with this regulation. Best management practices will be used to meet stormwater standards during the remedial action.
Federal Requirements	Clean Air Act (CAA), Hazardous Air Pollutants, 42.U.S.C. § 112(b)(1), National Emission Standards for Hazardous Air Pollutants (NESHAPS), 40 C.F.R. Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust and other release sources.	If the excavation and on-site disposal of contaminated sediment generates regulated air pollutants, then measures will be implemented to meet these standards.

Table I-13c
Action-Specific ARARs and TBCs for Sediment
Alternative SE-2: Remove/Consolidate Sediment Exceeding PRGs
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rules and Regulations for Dredging and Management of Dredge Materials, DEM-OWR-DR-0203	Applicable	Addresses dredging activities and disposal of dredge spoils.	Any dredging/excavation of sediment, dewatering, and on-site disposal of dredged sediments will comply with the requirements of these standards.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Hazardous Waste Determination, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.8	Applicable	Requires a determination be made as to whether waste meets the definition of hazardous waste, including "Rhode Island Waste" as defined in Rule 3.	These regulations would apply when determining whether or not a waste generated during the remedial action is hazardous.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Generator Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.00	Applicable	Sets generator standards for handling and disposal of hazardous waste. Incorporates provisions of 40 C.F.R. Part 262.	Any hazardous waste identified will be handled and disposed of according to these standards.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401	Applicable	Regulations for the management of solid waste.	Any solid waste that is excavated/dredged as part of the remedial action will be disposed of at one of the on-site landfills that will be capped as part of this remedial action.
State Requirements	Water Pollution Control, Water Quality Regulations RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with Site activities.	The actions to be taken under this alternative must be conducted so that there are no exceedances of water quality standards.

Table I-13c
Action-Specific ARARs and TBCs for Sediment
Alternative SE-2: Remove/Consolidate Sediment Exceeding PRGs
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Water Pollution Control - Pollution Discharge Elimination Systems, RIGL 42-16 *et seq.*; CRIR 12-190-003 Rule 31	Applicable	Sets requirements for discharges to surface waters and to protect waters from discharges of pollutants. Includes storm water requirements for construction projects that disturb over one acre.	Any water discharged to surface water bodies during remedial activities such as sediment dewatering will comply with this regulation. Best management practices will be used to meet stormwater standards during the remedial action.
State Requirements	RI Air Pollution Control Regulation No. 5: Fugitive Dust, RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable measures be taken to prevent particulate matter from becoming airborne.	Remediation activities could potentially result in fugitive dust. Appropriate measures would need to be taken to prevent particulate matter from becoming airborne.
State Requirements	RI Air Pollution Control Regulation No. 7: Emissions of Air Detrimental to Persons or Property, RIGL 23-23*e t seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants that may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Remediation activities may result in emissions. Appropriate measure would need to be taken to comply with these regulations.
State Requirements	RI Air Pollution Control Regulation No. 22: Air Toxics Guidelines and Air Modeling Guidelines, RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation activities may result in emissions of toxics to the atmosphere if these contaminants are present in soil. Appropriate measures would need to be taken to comply with these regulations.

Key:

ARAR	=	Applicable or Relevant and Appropriate Requirement
CFR	=	Code of Federal Regulations
CRIR	=	Code of Rhode Island Rules
EPA	=	U.S. Environmental Protection Agency
PRGs	=	Preliminary Remediation Goals
RIDEM	=	Rhode Island Department of Environmental Protection
RIGL	=	Rhode Island General Laws
TBC	=	To Be Considered

Table I-14a

Chemical-Specific ARARs and TBCs for Sediment

Alternative SE-3: Remove/consolidate sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	NOAA Effects Range-Low (ERL) values for marine and estuarine sediments (Long et al., 1995; Long and Morgan, 1990)	TBC	The ERL value is equivalent to the lower 10th percentile of the available toxicity data, which is estimated to be the approximate concentration at which adverse effects are likely to occur in sensitive life stages and/or species of sediment-dwelling organisms.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk by removing the top foot of contaminated sediments that exceed PRGs, disposing of the sediment in one of the on-site capped landfills and adding a foot of clean material over remaining deeper contaminated sediments as part of enhanced natural recovery, with monitoring.
Federal Requirements	U.S. DOE, Office of Environmental Management, Secondary Chronic Values (SCVs) (Jones et al., 1997)	TBC	The SCVs are toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk by removing the top foot of contaminated sediments that exceed PRGs, disposing of the sediment in one of the on-site capped landfills and adding a foot of clean material over remaining deeper contaminated sediments as part of enhanced natural recovery, with monitoring.
Federal Requirements	U.S. EPA Sediment Quality Criterion (SQC) and Sediment Quality Benchmarks (SQBs) (USEPA, 1996)	TBC	SQCs and SQBs were established to provide screening toxicity thresholds.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk by removing the top foot of contaminated sediments that

Table I-14a

Chemical-Specific ARARs and TBCs for Sediment

Alternative SE-3: Remove/consolidate sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
				exceed PRGs, disposing of the sediment in one of the on-site capped landfills and adding a foot of clean material over remaining deeper contaminated sediments as part of enhanced natural recovery, with monitoring.
Federal Requirements	NOAA Screening Quick Reference Tables, Threshold Effects Level (TEL) (Buchman, 1999)	TBC	TELs represent the concentration below which adverse effects are expected to occur only rarely.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk, by removing the top foot of contaminated sediments that exceed PRGs, disposing of the sediment in one of the on-site capped landfills and adding a foot of clean material over remaining deeper contaminated sediments as part of enhanced natural recovery, with monitoring.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
TBC = To Be Considered

Table I-14b

Location-Specific ARARs and TBCs for Sediment

Alternative SE-3: Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains disturbed by sediment excavation/cover installation activities.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas due to sediment excavation/cover installation activities. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this sediment alternative.
Federal Requirements	Clean Water Act, Section 404 Guidelines for Discharge of Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Excavation and enhanced natural recovery are subject to these requirements. Activities must be conducted in accordance with these requirements including, but not limited to, mitigation and/or restoration.
Federal Requirements	Fish and Wildlife Coordination Act, 16 U.S.C. §661 *et seq.*	Applicable	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or other federal waters for any purpose to take action to protect fish and wildlife resources that may be affected by the action.	Measures to mitigate or compensate adverse project related impacts to fish and wildlife resources will be taken, if determined necessary.

Table I-14b

Location-Specific ARARs and TBCs for Sediment

Alternative SE-3: Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	National Historical Preservation Act, U.S.C. 469 *et seq.*; 36 C.F.R. Part 65	Applicable	When a federal agency finds, or is notified, that its activities in connection with a federal construction project may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archeological data, the substantive standards under the Act will be met.	If, during the remedial design or remedial action, it is determined that this alternative may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archaeological data, substantive standards under the Act will be met.
State Requirements	Rhode Island Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; DEM Rules And Regulations Governing the Administration And Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00 and 5.00	Applicable	Defines and establishes provisions for the protection of swamps, marshes, 100-year floodplain and other fresh water wetland resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland.	Action taken under this alternative will be done in compliance with this requirement.

Table I-14b

Location-Specific ARARs and TBCs for Sediment

Alternative SE-3: Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Rhode Island Historic Preservation Act, RIGL 42-45 *et seq.*	Applicable	Requires action to take into account effects on properties included on or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks.	Features with potential historical/cultural significance will be evaluated during the remedial design phase and activities will be coordinated with the State Agency as required.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
RIGL = Rhode Island General Laws
TBC = To Be Considered

Table I-14c

Action-Specific ARARs and TBCs for Sediment

Alternative SE-3: Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, EPA-540-R-05-012 OSWER 9355.0-85 (December 2005)	TBC	Guidance for making remedy decisions for contaminated sediment sites. Some of the relevant sections of the guidance address Remedial Investigations (Ch. 2), FS Considerations (Ch. 3), Enhanced Natural Recovery (Ch. 4.5), Dredging.and Excavation (Ch.6), Remedy Selection Considerations (Ch. 7), and Remedial Action and Long-Term Monitoring.	Action taken under this alternative will meet guidance standards for addressing contaminated sediments in the wetlands/ waterway.
Federal Requirements	Clean Water Act Federal Water Quality Criteria, Section 304(a) ; 40 CFR 131.11	Applicable	NRWQC are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Action taken under this alternative will be conducted so that there are no exceedances of NRWQC. Water quality standards will be used to develop monitoring standards during the active remedial period under this alternative.
Federal Requirements	Clean Water Act – National Pollutant Discharge Elimination System (NPDES), 40 C.F.R. Parts 122 and 125	Applicable	Establishes the specifications for discharging pollutants from any point source into the waters of the U.S. Also, includes stormwater standards for activities disturbing more than one acre.	Any water discharged to surface water bodies during remedial activities such as sediment dewatering will comply with this regulation. Best management practices will be used to meet stormwater standards during the remedial action.

Table I-14c

Action-Specific ARARs and TBCs for Sediment

Alternative SE-3: Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Clean Air Act (CAA), Hazardous Air Pollutants, 42.U.S.C. § 112(b)(1), National Emission Standards for Hazardous Air Pollutants (NESHAPS), 40 C.F.R. Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust and other release sources.	If the excavation of the top foot of contaminated sediment, enhanced natural recovery (placement of a one foot cover layer over any remaining subsurface contaminated sediments), and on-site disposal actions generates regulated air pollutants, then measures will be implemented to meet these standards.
State Requirements	Rules and Regulations for Dredging and Management of Dredge Materials, DEM-OWR-DR-0203	Applicable	Addresses dredging activities and disposal of dredge spoils.	Any dredging/excavation of sediment, dewatering, and on-site disposal of dredged sediments, as well as placement of the one foot thick enhanced natural recovery cover layer, will comply with the requirements of these standards.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Hazardous Waste Determination, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.8	Applicable	Requires a determination be made as to whether waste meets the definition of hazardous waste, including "Rhode Island Waste" as defined in Rule 3.	These regulations would apply when determining whether or not a waste generated during the remedial action is hazardous.

Table I-14c

Action-Specific ARARs and TBCs for Sediment

Alternative SE-3: Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Generator Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.00	Applicable	Sets generator standards for handling and disposal of hazardous waste. Incorporates provisions of 40 C.F.R. Part 262.	Any hazardous waste identified will be handled and disposed of according to these standards.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401	Applicable	Regulations for the management of solid waste.	Any solid waste that is excavated/dredged as part of the remedial action will be disposed of at one of the on-site landfills that will be capped as part of this remedial action.
State Requirements	Water Pollution Control, Water Quality Regulations RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with Site activities.	The actions to be taken under this alternative must be conducted so that there are no exceedances of water quality standards.
State Requirements	Water Pollution Control - Pollution Discharge Elimination Systems, RIGL 42-16 *et seq.*; CRIR 12-190-003 Rule 31	Applicable	Sets requirements for discharges to surface waters and to protect waters from discharges of pollutants. Includes storm water requirements for construction projects that disturb over one acre.	Any water discharged to surface water bodies during remedial activities such as sediment dewatering will comply with this regulation. Best management practices will be used to meet stormwater standards during the remedial action.

Table I-14c

Action-Specific ARARs and TBCs for Sediment

Alternative SE-3: Remove/Consolidate Sediment (1 foot) with Subaqueous Cover where PRG Exceedances Remain, Institutional Controls

Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Air Pollution Control Regulation No. 5: Fugitive Dust, RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable measures be taken to prevent particulate matter from becoming airborne.	Remediation activities could potentially result in fugitive dust. Appropriate measures would need to be taken to prevent particulate matter from becoming airborne.
State Requirements	RI Air Pollution Control Regulation No. 7: Emissions of Air Detrimental to Persons or Property, RIGL 23-23*e t seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants that may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Remediation activities may result in emissions. Appropriate measure would need to be taken to comply with these regulations.
State Requirements	RI Air Pollution Control Regulation No. 22: Air Toxics Guidelines and Air Modeling Guidelines, RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation activities may result in emissions of toxics to the atmosphere if these contaminants are present in soil. Appropriate measures would need to be taken to comply with these regulations.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
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EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
RIGL = Rhode Island General Laws
TBC = To Be Considered

Table I-15a
Chemical-Specific ARARs and TBCs for Sediment
Alternative SE-4: Subaqueous Cover (No Sediment Removal) with Institutional Controls
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	NOAA Effects Range-Low (ERL) values for marine and estuarine sediments (Long et al., 1995; Long and Morgan, 1990)	TBC	The ERL value is equivalent to the lower 10th percentile of the available toxicity data, which is estimated to be the approximate concentration at which adverse effects are likely to occur in sensitive life stages and/or species of sediment-dwelling organisms.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk by placing a one foot subaqueous cover over contaminated sediments.
Federal Requirements	U.S. DOE, Office of Environmental Management, Secondary Chronic Values (SCVs) (Jones et al., 1997)	TBC	The SCVs are toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk by placing a one foot subaqueous cover over contaminated sediments.
Federal Requirements	U.S. EPA Sediment Quality Criterion (SQC) and Sediment Quality Benchmarks (SQBs) (USEPA, 1996)	TBC	SQCs and SQBs were established to provide screening toxicity thresholds.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk by placing a one foot subaqueous cover over contaminated sediments.
Federal Requirements	NOAA Screening Quick Reference Tables, Threshold Effects Level (TEL) (Buchman, 1999)	TBC	TELs represent the concentration below which adverse effects are expected to occur only rarely.	This alternative would prevent exposure to sediment contaminants which contribute to a calculated ecological risk by placing a one foot subaqueous cover over contaminated sediments.

Key:

ARAR	=	Applicable or Relevant and Appropriate Requirement
CFR	=	Code of Federal Regulations
EPA	=	U.S. Environmental Protection Agency
PRGs	=	Preliminary Remediation Goals
RIDEM	=	Rhode Island Department of Environmental Protection
TBC	=	To Be Considered

Table I-15b
Location-Specific ARARs and TBCs for Sediment
Alternative SE-4: Subaqueous Cover (No Sediment Removal) with Institutional Controls
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Floodplains Management (Executive Order 11988), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11988), federal agencies are required to avoid long- and short-term adverse impacts associated with the occupancy and modification of federally-designated 100-year and 500-year floodplain wherever there is a practicable alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the floodplains disturbed by subaqueous cover installation activities.
Federal Requirements	Protection of Wetlands (Executive Order 11990), 44 C.F.R. Part 9	Relevant and Appropriate	Per the FEMA regulations (44 C.F.R. Part 9; incorporating requirements under Executive Order 11990), federal agencies are required to avoid adversely impacting federal jurisdictional wetlands unless there is no practicable alternative with lesser effects and the proposed action includes all practicable measures to minimize harm to federal jurisdictional wetlands that may result from such use.	Action to be taken will minimize alterations to protected resource areas due to subaqueous cover installation activities. Mitigation measures, as required, will be taken to compensate for the resource areas altered by this sediment alternative.
Federal Requirements	Clean Water Act, Section 404; Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 33 U.S.C. § 1344; 40 C.F.R. Part 230, 231 and 33 C.F.R. Parts 320-323	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Placing a one-foot thick cover over contaminated sediments, with monitoring, in any areas of wetland will be conducted to minimize the area of wetlands altered, to the extent possible. Areas of altered wetlands will be mitigated, as required.
Federal Requirements	Fish and Wildlife Coordination Act, 16 U.S.C. §661 *et seq*.	Applicable	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or other federal waters for any purpose to take action to protect fish and wildlife resources that may be affected by the action.	Measures to mitigate or compensate adverse project related impacts to fish and wildlife resources will be taken, if determined necessary.

Table I-15b
Location-Specific ARARs and TBCs for Sediment
Alternative SE-4: Subaqueous Cover (No Sediment Removal) with Institutional Controls
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	National Historical Preservation Act, U.S.C. 469 *et seq.*; 36 C.F.R. Part 65	Applicable	When a federal agency finds, or is notified, that its activities in connection with a federal construction project may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archeological data, the substantive standards under the Act will be met.	If, during the remedial design or remedial action, it is determined that this alternative may cause irreparable loss or destruction of significant scientific, pre-historical, historical, or archaeological data, substantive standards under the Act will be met.
State Requirements	Rhode Island Fresh Water Wetlands Act, RIGL 2-1, Sections 2-1-18 through 2-1-20.2; DEM Rules And Regulations Governing the Administration And Enforcement of the Fresh Water Wetlands Act (Dec 2010), Rules 4.00 and 5.00	Applicable	Defines and establishes provisions for the protection of swamps, marshes, 100-year floodplain and other fresh water wetland resource areas in the state. Actions are required to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction of a wetland.	Action taken under this alternative will be done in compliance with this requirement.
State Requirements	Rhode Island Historic Preservation Act, RIGL 42-45 *et seq.*	Applicable	Requires action to take into account effects on properties included on or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks.	Features with potential historical/cultural significance will be evaluated during the remedial design phase and activities will be coordinated with the State Agency as required.

Key:

ARAR	=	Applicable or Relevant and Appropriate Requirement
CFR	=	Code of Federal Regulations
EPA	=	U.S. Environmental Protection Agency
PRGs	=	Preliminary Remediation Goals
RIDEM	=	Rhode Island Department of Environmental Protection
RIGL	=	Rhode Island General Laws
TBC	=	To Be Considered

Table I-15c
Action-Specific ARARs and TBCs for Sediment
Alternative SE-4: Subaqueous Cover (No Sediment Removal) with Institutional Controls
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
Federal Requirements	Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, EPA-540-R-05-012 OSWER 9355.0-85 (December 2005)	TBC	Guidance for making remedy decisions for contaminated sediment sites. Some of the relevant sections of the guidance address Remedial Investigations (Ch. 2), FS Considerations (Ch. 3), In-Situ Capping (Ch. 5), Remedy Selection Considerations (Ch. 7), and Remedial Action and Long-Term Monitoring.	Action taken under this alternative will meet guidance standards for addressing contaminated sediments in the wetlands/ waterway.
Federal Requirements	Clean Water Act Federal Water Quality Criteria, Section 304(a) ; 40 CFR 131.11	Applicable	NRWQC are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Action taken under this alternative will be conducted so that there are no exceedances of NRWQC. Water quality standards will be used to develop monitoring standards during the active remedial period under this alternative.
Federal Requirements	Clean Water Act – National Pollutant Discharge Elimination System (NPDES), 40 C.F.R. Parts 122 and 125	Applicable	Establishes the specifications for discharging pollutants from any point source into the waters of the U.S. Also, includes stormwater standards for activities disturbing more than one acre.	Any water discharged to surface water bodies during remedial activities will comply with this regulation. Best management practices will be used to meet stormwater standards during the remedial action.
State Requirements	Rules and Regulations for Dredging and Management of Dredge Materials, DEM-OWR-DR-0203	Applicable	Addresses dredging activities and disposal of dredge spoils.	Placement of the one foot thick cover will comply with the requirements of these standards.

Table I-15c
Action-Specific ARARs and TBCs for Sediment
Alternative SE-4: Subaqueous Cover (No Sediment Removal) with Institutional Controls
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Hazardous Waste Determination, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.8	Applicable	Requires a determination be made as to whether waste meets the definition of hazardous waste, including "Rhode Island Waste" as defined in Rule 3.	These regulations would apply when determining whether or not a waste generated during the remedial action is hazardous.
State Requirements	RI Rules and Regulations for Hazardous Waste Management, Generator Standards, RIGL 23-9.1 *et seq.*; CRIR 12-030-003 Rule 5.00	Applicable	Sets generator standards for handling and disposal of hazardous waste. Incorporates provisions of 40 C.F.R. Part 262.	Any hazardous waste identified will be handled and disposed according to these standards.
State Requirements	Rhode Island Solid Waste Regulations, DEM OWM-SW0401	Applicable	Regulations for the management of solid waste.	Any solid waste that is excavated/dredged as part of the remedial action will be disposed of at one of the on-site landfills that will be capped as part of this remedial action.
State Requirements	Water Pollution Control, Water Quality Regulations RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with Site activities.	The actions to be taken under this alternative must be conducted so that there are no exceedances of water quality standards.

Table I-15c
Action-Specific ARARs and TBCs for Sediment
Alternative SE-4: Subaqueous Cover (No Sediment Removal) with Institutional Controls
Peterson/Puritan, Inc. Superfund Site, Operable Unit Two

Regulatory Authority	Requirement	Status	Requirement Synopsis	Action to be Taken to Attain Requirement
State Requirements	Water Pollution Control - Pollution Discharge Elimination Systems, RIGL 42-16 *et seq.*; CRIR 12-190-003 Rule 31	Applicable	Sets requirements for discharges to surface waters and to protect waters from discharges of pollutants. Includes storm water requirements for construction projects that disturb over one acre.	Any water discharged to surface water bodies during remedial activities such as sediment dewatering will comply with this regulation. Best management practices will be used to meet stormwater standards during the remedial action.

Key:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
CRIR = Code of Rhode Island Rules
EPA = U.S. Environmental Protection Agency
PRGs = Preliminary Remediation Goals
RIDEM = Rhode Island Department of Environmental Protection
RIGL = Rhode Island General Laws
TBC = To Be Considered

APPENDIX J

J.M. Mills Landfill Cap HELP Modeling

ARCADIS of New York, Inc.
6723 Towpath Road
P O Box 66
Syracuse
New York 13214-0066
Tel 315 446 9120
Fax 315 449 0017

MEMO

To:
Todd Farmen

Copies:

From:
Phil Batten

Date:
March 8, 2013

ARCADIS Project No.:
B0037902.0001.00500

Subject:
Peterson-Puritan Hybrid Cover System Efficiency Evaluation

The hybrid cover system at the Peterson-Puritan site in Cumberland and Lincoln, Rhode Island is a combination of two separate cover system configurations; a Soil Cover and an EPA Region 1 Modified Subtitle C Alternative Cover (Modified Subtitle C Cover). As shown on Figure 1, the configurations of each cover system consist of the following layers from top to bottom:

Soil Cover
- 6 inches of topsoil
- 18 inches of general fill soil

Modified Subtitle C Cover
- 6 inches of topsoil
- 18 inches of general fill soil
- Geosynthetic Drainage Composite (GDC)
- Flexible Membrane Liner (FML)
- Geosynthetic Clay Liner (GCL)
- 12 inches of sand

The hybrid cover system will consist of the Modified Subtitle C Cover installed over the upper 1/3 of the cover area and the Soil Cover installed over the lower 2/3 of the cover area. Figure 2 shows a conceptual cross-section of the hybrid cover system.

Hybrid Cover System Efficiency Evaluation

The hybrid cover system efficiency evaluation was performed using the Hydrologic Evaluation of Landfill Performance (HELP) Model version 3.07. The HELP Model is a quasi-two-dimensional hydrologic model that simulates the movement of infiltrated water through landfill cover components. The HELP Model

incorporates climatological, soil, and design data, combined with parameters for surface storage, snowmelt, runoff, infiltration, evapotranspiration, vegetative growth, soil moisture, and lateral and vertical drainage, to calculate a water balance.

Four types of layers can be modeled using HELP Model: vertical percolation, lateral drainage, barrier soil, and flexible membrane liner (FML). General characteristics of each layer are as described below:

- ***Vertical Percolation Layer*** - a layer of moderate to high-permeability material where flow is vertical and induced by gravity. Waste layers, protection layers, and layers designed to support vegetation are typically designated as vertical percolation layers.

- ***Lateral Drainage Layer*** - a lateral flow layer directly overlying a low-permeability liner layer designed to promote drainage laterally to a collection and removal system. A lateral drainage layer can be a geosynthetic or granular material and may only be underlain by another lateral drainage layer or a low-permeability liner.

- ***Barrier Soil Liner*** - a layer of material designed to restrict vertical drainage due to the low saturated hydraulic conductivity of the soils comprising the layer. Flow in barrier soil liners is vertical.

- ***FML*** - a low-permeability synthetic membrane which reduces percolation to locations where manufacturing or installation defects are present (e.g., punctures, tears, or faulty seaming) (Schroeder, et al., 1994).

For this hybrid cover system evaluation, HELP Model was utilized to calculate the average annual percolation through the two separate cover system configurations.

The configuration (from top to bottom) used for modeling the hydrologic conditions of the Soil Cover system is as follows.

Layer 1: 6-inch-thick vegetative soil layer (vertical percolation layer), using HELP Model default value for soil texture #8, which is an ML soil under the United Soil Classification System (USCS) and a hydraulic conductivity of $1x10^{-4}$ cm/s (user-specific).

Layer 2: 18-inch-thick soil protection layer (vertical percolation layer), using HELP Model default value for soil texture #4, which is a SM soil under the USCS and a hydraulic conductivity of $1x10^{-5}$ cm/s (user-specific).

The configuration (from top to bottom) used for modeling the hydrologic conditions of the Modified Subtitle C Cover system is as follows.

Layer 1: 6-inch-thick vegetative soil layer (vertical percolation layer), using HELP Model default value for soil texture #8, which is an ML soil under the United Soil Classification System (USCS) and a hydraulic conductivity of $1x10^{-4}$ cm/s (user-specific).

Layer 2: 18-inch-thick soil protection layer (vertical percolation layer), using HELP Model default value for soil texture #4, which is a SM soil under the USCS and a hydraulic conductivity of $1x10^{-5}$ cm/s (user-specific).

Layer 3: GDC drainage layer (lateral drainage layer), using HELP Model default values for material texture #34, which is representative of a GDC.

Layer 4: FML (barrier layer), using HELP Model default value for material texture #35, which is representative of a 60-mil FML.

Layer 5: GCL (barrier soil layer), using HELP Model default value for soil texture #17, which is representative of a bentonite mat and a hydraulic conductivity of $1x10^{-7}$ cm/s (user-specific).

Layer 6: 12-inch-thick gas venting layer (vertical percolation layer), using HELP Model default value for soil texture #6, which is a SL soil under the USCS and a hydraulic conductivity of $1x10^{-3}$ cm/s (user-specific).

Parameters pertaining to the physical properties of each layer, including porosity, field capacity and initial water content, were established from the default values within the HELP Model.

The following design parameters were used in the HELP Model analysis:

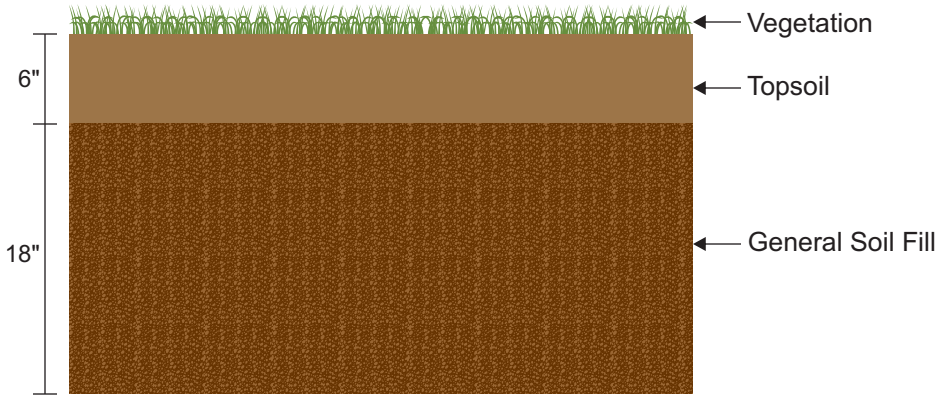
- The runoff curve numbers were calculated by HELP Model based on surface slope, slope length, soil texture of the top layer of the cover system and the vegetative cover.
- The fraction of area allowing runoff was set to 100 percent, as the hybrid cover system was assumed to be completed for the hydrologic analysis.
- The maximum leaf area index was set at 3.5 (approximately the middle of the range for a good stand of grass based on guidance values presented in the User's Guide for HELP Model v.3).
- An evaporative zone depth of 12 inches was used (assumed to be the full 6-inch vegetative soil layer and 6-inches of the soil protection layer - which is within the range of guidance values presented in the User's Guide for HELP Model v.3).
- The initial moisture contents for the various soil layers are calculated by HELP Model under nearly steady-state conditions (i.e., they are not user-specified moisture contents).
- For the purposes of this calculation, the drainage slope length was assumed to be 100 feet for both the 4% and 33% slope evaluations.
- The pinhole density, installations defects and placement quality of the FML is based on suggested values presented in the User's Guide for HELP model v.3.
- The weather data (i.e., precipitation, evapotranspiration, temperature, and solar radiation) used in the hydrologic analysis is based on HELP Model information for Providence, Rhode Island.
- The hydrologic analysis is based on a 30 year simulation period.

A summary of the modeling results for a one-acre area of the hybrid cover system is presented in Attachment A. It is noted that the purpose of the HELP Model simulations were to determine the

percolation rate through the cover system, therefore it was not necessary (or applicable) to use the actual landfill acreage. Output from the HELP Model is presented in Attachment B.

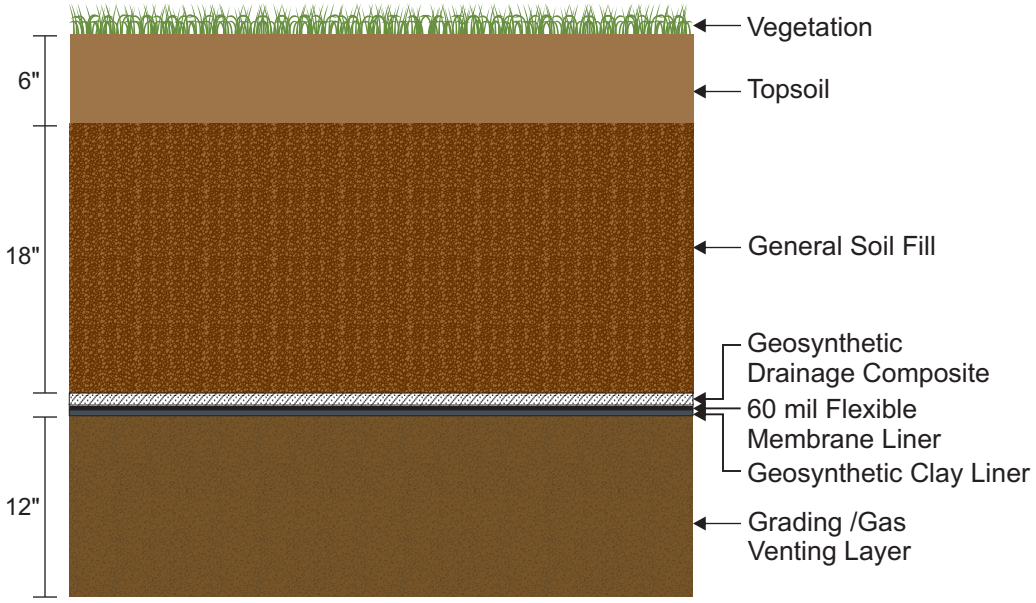
ARCADIS

Figures



SOIL COVER

NOT TO SCALE



EPA REGION 1 SUBTITLE C ALTERNATIVE COVER

NOT TO SCALE

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

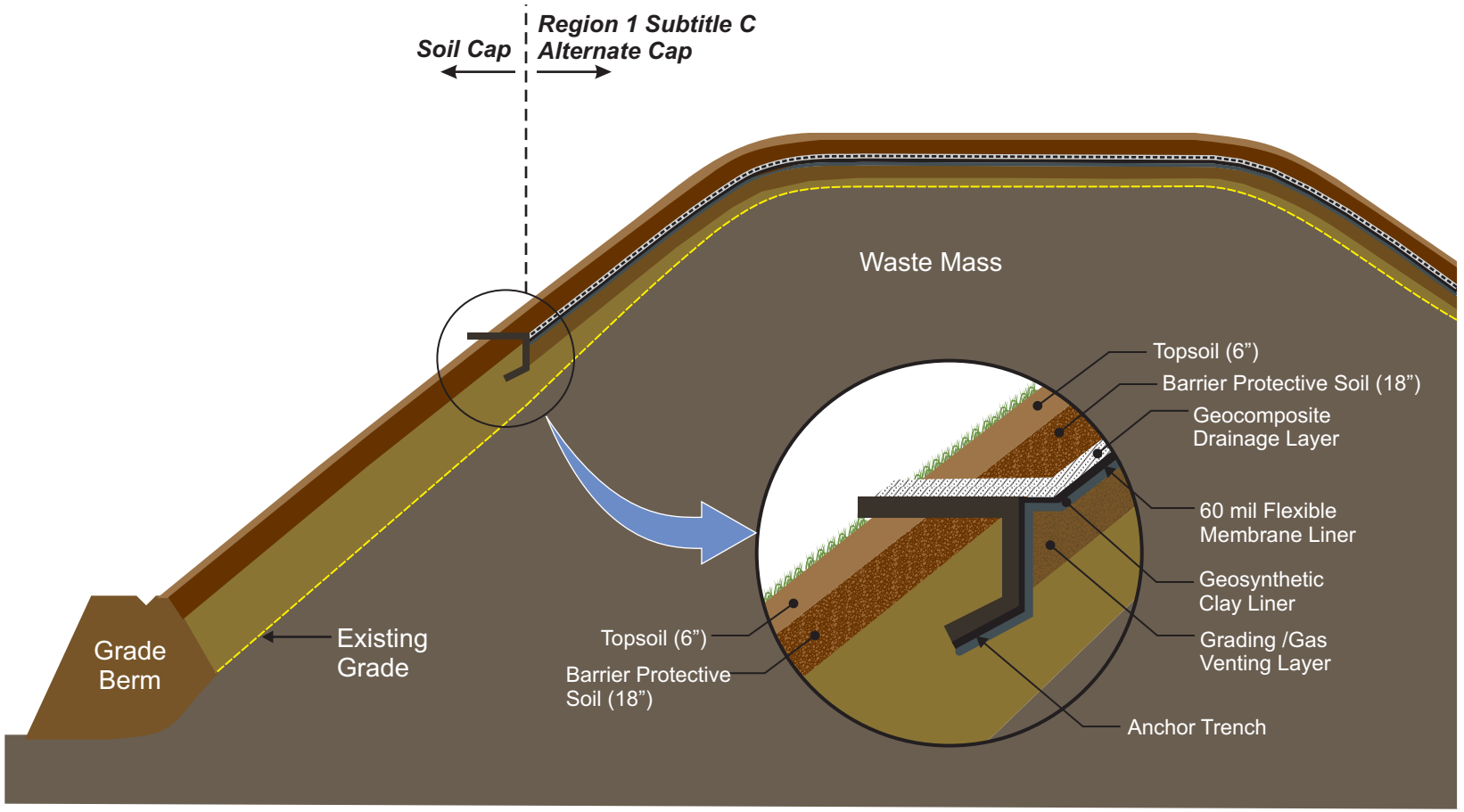
COVER SYSTEM

DRAFT
FOR DISCUSSION PURPOSES ONLY

ARCADIS

FIGURE
1

02/27/2013 SYRACUSE, NY-ENV/CAD-DJHOWES
B0037902/0001/00500/CDR/37902G03.CDR



NOT TO SCALE

ALTERNATIVE JM SO-3

DRAFT

NOTES:

1. Grade berm/regrading of existing slopes to achieve 3V: 1H maximum sideslope.

2. Upper 1/3 of JM Mills Landfill to receive alternate Subtitle C cap and lower 2/3 to receive soil cap.

PETERSON PURITAN SUPERFUND SITE - OU2
CUMBERLAND AND LINCOLN, RHODE ISLAND

CONCEPTUAL CROSS-SECTION COMBINATION REGION 1 SUBTITLE C ALTERNATE SOIL CAP

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FIGURE
2

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Attachment A

Efficiency Evaluation Summary

Summary of Hybrid Cover System Efficiency Evaluation
Peterson-Puritan Superfund Site
Cumberland and Lincoln, Rhode Island

Cover System Analysis		Average Annual Infiltration Rate per Slope Area (gal/acre/year)[3]		Planimetric Area (acres)[4]		Total Infiltration per Slope Area (gal/year)[5]		Overall Infiltration by Cover System[6] (gal/year)	Approximate Cover System Efficiency[7]
		4% Slope	33% Slope	4% Slope	33% Slope	4% Slope	33% Slope		
Soil Cover[1]		355,649	353,267	2.8	17.1	995,817	6,040,874	7,036,690	70%
EPA Region 1 Modified Subtitle C Alternative Cover (Modified Subtitle C)[2,9]		0	0	2.8	17.1	0	0	0	99%
Hybrid Cover System	Top 1/3 Modified Subtitle C	----	----	2.8	3.8	0	0	4,698,457	80%[8]
	Bottom 2/3 Soil Cover	----	----	----	13.3	----	4,698,457		

Notes:

1. Soil Cover is approximately 24 inches thick and consists of (top to bottom) 6 inches of topsoil (hyd. cond. 10^{-4}) and 18 inches of general fill (hyd. cond. 10^{-5}).
2. EPA Region 1 Modified Subtitle C Alternative Cover is approximately 36 inches thick and consists of (top to bottom) 6 inches of topsoil (hyd. cond. 10^{-4}), 18 inches of general fill (hyd. cond. 10^{-5}), geosynthetic drainage composite (GDC), flexible membrane liner (FML), geosynthetic clay liner (GCL) and 12 inches of sand (hyd. cond. 10^{-3}).
3. The Average Annual Infiltration Rate per Slope Area was determined using Hydrologic Evaluation of Landfill Performance (HELP Model) software version 3.07. The infiltration rate through the cover system is presented in the HELP Model Output as a pecolation/leakage rate in ft^3/acre/year.
4. Planimetric Areas were determined using Terramodel and are based on the conceptual design information. The existing grading configuration may vary.
5. The Total Infiltration per Slope Area was calculated by multiplying the Planimetric Area by the Average Annual Infiltration Rate per Slope Area.
6. The Overall Infiltration was calculated by adding together the Total Infiltration Rate per Slope Area for the 4% and 33% slopes.
7. The Approximate Cover System Efficiency was determined by HELP Model, unless otherwise noted.
8. The Approximate Cover System Efficiency for the top 1/3 EPA Region 1 Modified Subtitle C and bottom 2/3 Soil Cover system scenario was calculated by multiplying the percentage of the overall cover system with the Modified Subtitle C (33.3%) by the Approximate Cover System Efficiency for the Modified Subtitle C (99%), multiplying the percentage of the overall cover system with the Soil Cover (66.6%) by the Approximate Cover System Efficiency for the Soil Cover (70%), adding the two values together and multiplying by 100 (e.g., 0.33+0.47 = 0.80*100 = 80%).
9. While the HELP Model results for the Modified Subtitle C cover system have indicated zero infiltration, it is recognized that actual infiltration will, in fact, be greater than zero. The actual amount of infiltration once installed, will depend on the number and type of material/product defects.

ARCADIS

Attachment B

HELP Model Output

ARCADIS

Soil Cover

ARCADIS

4% Slope

```
**********************************************************************
**********************************************************************
**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07 (1 November 1997)         **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY           **
**                    USAE WATERWAYS EXPERIMENT STATION             **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY       **
**                                                                  **
**                                                                  **
**********************************************************************
**********************************************************************


PRECIPITATION DATA FILE:    C:\WHI\UNSAT22\data\P106.VHP\_weather1.dat
TEMPERATURE DATA FILE:      C:\WHI\UNSAT22\data\P106.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:  C:\WHI\UNSAT22\data\P106.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:    C:\WHI\UNSAT22\data\P106.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:  C:\WHI\UNSAT22\data\P106.VHP\I_385375.inp
OUTPUT DATA FILE:           C:\WHI\UNSAT22\data\P106.VHP\O_385375.prt


TIME:  17:30     DATE:   2/26/2013


**********************************************************************

     TITLE:  Soil Cover - 4%

**********************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =     15.24   CM
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.1746 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.100000000000E-02 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 4

THICKNESS	=	45.72	CM
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.1050	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2720	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000000000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 4.% AND A SLOPE LENGTH OF 30. METERS.

SCS RUNOFF CURVE NUMBER	=	74.68	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.4047	HECTARES
EVAPORATIVE ZONE DEPTH	=	30.5	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	6.403	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	13.716	CM
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.484	CM
INITIAL SNOW WATER	=	0.000	CM
INITIAL WATER IN LAYER MATERIALS	=	15.095	CM
TOTAL INITIAL WATER	=	15.095	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM Providence RI

STATION LATITUDE	=	41.82	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	121	
END OF GROWING SEASON (JULIAN DATE)	=	290	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	64.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.06	3.72	4.29	3.95	3.48	2.79
3.01	4.04	3.54	3.75	4.22	4.47

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	29.30	37.40	47.90	57.60	66.80
72.50	71.10	63.50	53.20	43.40	32.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI
AND STATION LATITUDE = 42.00 DEGREES

DETAILED OUTPUT FOR YEARS 1 THROUGH 30 IS NOT INCLUDED. SEE SUMMARY DATA BELOW.

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	44.14	(5.459)	160223.5	100.00
RUNOFF	7.463	(3.8492)	27089.08	16.907
EVAPOTRANSPIRATION	23.551	(2.7728)	85489.69	53.357
PERCOLATION/LEAKAGE THROUGH LAYER 2	13.09678	(3.56632)	47540.286	29.67123
CHANGE IN WATER STORAGE	0.029	(2.0777)	104.45	0.065

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30 and their dates (DDDYYYY)

	(INCHES)	(CU. FT.)	
PRECIPITATION	3.96	14374.48669	2780014
RUNOFF	3.616	13125.54968	420026
PERCOLATION/LEAKAGE THROUGH LAYER 2	1.511495	5486.60592	880010
SNOW WATER	8.00	29024.1440	250004

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4441
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0815

****

ARCADIS

33% Slope

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**********************************************************************
**********************************************************************
**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07 (1 November 1997)         **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY           **
**                    USAE WATERWAYS EXPERIMENT STATION             **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY       **
**                                                                  **
**                                                                  **
**********************************************************************
**********************************************************************


PRECIPITATION DATA FILE:    C:\WHI\UNSAT22\data\P106.VHP\_weather1.dat
TEMPERATURE DATA FILE:      C:\WHI\UNSAT22\data\P106.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:  C:\WHI\UNSAT22\data\P106.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:    C:\WHI\UNSAT22\data\P106.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:  C:\WHI\UNSAT22\data\P106.VHP\I_385375.inp
OUTPUT DATA FILE:           C:\WHI\UNSAT22\data\P106.VHP\O_385375.prt


TIME:  17:37     DATE:   2/26/2013


**********************************************************************

     TITLE:  Soil Cover - 33%

**********************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   8
          THICKNESS                    =     15.24   CM
          POROSITY                     =      0.4630 VOL/VOL
          FIELD CAPACITY               =      0.2320 VOL/VOL
          WILTING POINT                =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1747 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000000000E-02 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 4

THICKNESS	=	45.72	CM
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.1050	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2719	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000000000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 33.% AND A SLOPE LENGTH OF 30. METERS.

SCS RUNOFF CURVE NUMBER	=	76.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.4047	HECTARES
EVAPORATIVE ZONE DEPTH	=	30.5	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	6.404	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	13.716	CM
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.484	CM
INITIAL SNOW WATER	=	0.000	CM
INITIAL WATER IN LAYER MATERIALS	=	15.095	CM
TOTAL INITIAL WATER	=	15.095	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM Providence RI

STATION LATITUDE	=	41.82	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	121	
END OF GROWING SEASON (JULIAN DATE)	=	290	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	64.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%

AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.06	3.72	4.29	3.95	3.48	2.79
3.01	4.04	3.54	3.75	4.22	4.47

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	29.30	37.40	47.90	57.60	66.80
72.50	71.10	63.50	53.20	43.40	32.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI
AND STATION LATITUDE = 42.00 DEGREES

DETAILED OUTPUT FOR YEARS 1 THROUGH 30 IS NOT INCLUDED. SEE SUMMARY DATA BELOW.

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	44.14	(5.459)	160223.5	100.00
RUNOFF	7.530	(3.8573)	27332.04	17.059
EVAPOTRANSPIRATION	23.572	(2.8264)	85565.01	53.404
PERCOLATION/LEAKAGE THROUGH LAYER 2	13.00909	(3.55022)	47221.957	29.47255
CHANGE IN WATER STORAGE	0.029	(2.0804)	104.49	0.065

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30 and their dates (DDDYYYY)

	(INCHES)	(CU. FT.)	
PRECIPITATION	3.96	14374.48669	2780014
RUNOFF	3.616	13125.18533	420026
PERCOLATION/LEAKAGE THROUGH LAYER 2	1.441945	5234.14554	880010
SNOW WATER	8.00	29024.1440	250004

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4454
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0815

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ARCADIS

EPA Region 1 Modified Subtitle C
Alternative Cover

ARCADIS

4% Slope

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**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07 (1 November 1997)         **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY           **
**                    USAE WATERWAYS EXPERIMENT STATION             **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY       **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:    C:\WHI\UNSAT22\data\P106.VHP\_weather1.dat
TEMPERATURE DATA FILE:      C:\WHI\UNSAT22\data\P106.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:  C:\WHI\UNSAT22\data\P106.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:    C:\WHI\UNSAT22\data\P106.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:  C:\WHI\UNSAT22\data\P106.VHP\I_385394.inp
OUTPUT DATA FILE:           C:\WHI\UNSAT22\data\P106.VHP\O_385394.prt


TIME:  15:42     DATE:   2/27/2013


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     TITLE:  EPA Region 1 Modified Subtitle C - 4%

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =     15.24   CM
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.2137 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.100000000000E-02 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 4

THICKNESS	=	45.72	CM
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.1050	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2743	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000000000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 34

THICKNESS	=	0.60	CM
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0153	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	33.0000000000	CM/SEC
SLOPE	=	4.00	PERCENT
DRAINAGE LENGTH	=	30.5	METERS

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.10	CM
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.200000000000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.47	HOLES/HECTARE
FML INSTALLATION DEFECTS	=	4.94	HOLES/HECTARE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.60	CM
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000000000E-07	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 6

THICKNESS	=	30.48	CM
POROSITY	=	0.4530	VOL/VOL
FIELD CAPACITY	=	0.1900	VOL/VOL
WILTING POINT	=	0.0850	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1310	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000000000E-01	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 4.% AND A SLOPE LENGTH OF 30. METERS.

SCS RUNOFF CURVE NUMBER	=	74.68	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.4047	HECTARES
EVAPORATIVE ZONE DEPTH	=	30.5	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	6.943	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	13.716	CM
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.484	CM
INITIAL SNOW WATER	=	0.000	CM
INITIAL WATER IN LAYER MATERIALS	=	20.252	CM
TOTAL INITIAL WATER	=	20.252	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM Providence RI

STATION LATITUDE	=	41.82	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	121	
END OF GROWING SEASON (JULIAN DATE)	=	290	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	64.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.06	3.72	4.29	3.95	3.48	2.79
3.01	4.04	3.54	3.75	4.22	4.47

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	29.30	37.40	47.90	57.60	66.80
72.50	71.10	63.50	53.20	43.40	32.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI
AND STATION LATITUDE = 42.00 DEGREES

DETAILED OUTPUT FOR YEARS 1 THROUGH 30 IS NOT INCLUDED. SEE SUMMARY DATA BELOW.

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	44.14	(5.459)	160223.5	100.00
RUNOFF	7.337	(3.7753)	26633.30	16.623
EVAPOTRANSPIRATION	20.421	(2.5534)	74125.67	46.264
LATERAL DRAINAGE COLLECTED FROM LAYER 3	16.35371	(3.34432)	59362.656	37.04991
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 4	0.001	(0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.01289	(0.01903)	46.786	0.02920
CHANGE IN WATER STORAGE	0.015	(2.0387)	55.08	0.034

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30 and their dates (DDDYYYY)

	(INCHES)	(CU. FT.)	
PRECIPITATION	3.96	14374.48669	2780014
RUNOFF	3.622	13147.78911	420026
DRAINAGE COLLECTED FROM LAYER 3	1.58194	5742.32666	880010
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00006	880010
AVERAGE HEAD ON TOP OF LAYER 4	0.021		
MAXIMUM HEAD ON TOP OF LAYER 4	0.042		
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.4 FEET		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000421	1.52644	10001
SNOW WATER	8.00	29024.1440	250004

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4329
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0815

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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ARCADIS

33% Slope

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07 (1 November 1997)         **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY           **
**                    USAE WATERWAYS EXPERIMENT STATION             **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY       **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:    C:\WHI\UNSAT22\data\P106.VHP\_weather1.dat
TEMPERATURE DATA FILE:      C:\WHI\UNSAT22\data\P106.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:  C:\WHI\UNSAT22\data\P106.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:    C:\WHI\UNSAT22\data\P106.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:  C:\WHI\UNSAT22\data\P106.VHP\I_385394.inp
OUTPUT DATA FILE:           C:\WHI\UNSAT22\data\P106.VHP\O_385394.prt


TIME:  15:36     DATE:   2/27/2013


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     TITLE:  EPA Region 1 Modified Subtitle C - 33%

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   8
          THICKNESS                     =     15.24   CM
          POROSITY                      =      0.4630 VOL/VOL
          FIELD CAPACITY                =      0.2320 VOL/VOL
          WILTING POINT                 =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.2138 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.100000000000E-02 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 4

THICKNESS	=	45.72	CM
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.1050	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2744	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000000000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 34

THICKNESS	=	0.60	CM
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	33.0000000000	CM/SEC
SLOPE	=	33.00	PERCENT
DRAINAGE LENGTH	=	30.5	METERS

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.10	CM
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.200000000000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.47	HOLES/HECTARE
FML INSTALLATION DEFECTS	=	4.94	HOLES/HECTARE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.60	CM
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000000000E-07	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 6

THICKNESS	=	30.48	CM
POROSITY	=	0.4530	VOL/VOL
FIELD CAPACITY	=	0.1900	VOL/VOL
WILTING POINT	=	0.0850	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1309	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000000000E-01	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 33.% AND A SLOPE LENGTH OF 30. METERS.

SCS RUNOFF CURVE NUMBER	=	76.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.4047	HECTARES
EVAPORATIVE ZONE DEPTH	=	30.5	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	6.945	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	13.716	CM
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.484	CM
INITIAL SNOW WATER	=	0.000	CM
INITIAL WATER IN LAYER MATERIALS	=	20.249	CM
TOTAL INITIAL WATER	=	20.249	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM Providence RI

STATION LATITUDE	=	41.82	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	121	
END OF GROWING SEASON (JULIAN DATE)	=	290	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	64.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.06	3.72	4.29	3.95	3.48	2.79
3.01	4.04	3.54	3.75	4.22	4.47

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	29.30	37.40	47.90	57.60	66.80
72.50	71.10	63.50	53.20	43.40	32.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Providence RI
AND STATION LATITUDE = 42.00 DEGREES

DETAILED OUTPUT FOR YEARS 1 THROUGH 30 IS NOT INCLUDED. SEE SUMMARY DATA BELOW.

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	44.14	(5.459)	160223.5	100.00
RUNOFF	7.427	(3.8591)	26960.68	16.827
EVAPOTRANSPIRATION	20.839	(2.3493)	75644.29	47.212
LATERAL DRAINAGE COLLECTED FROM LAYER 3	15.84529	(3.41818)	57517.134	35.89806
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.001	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000	(0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.01287	(0.01900)	46.726	0.02916
CHANGE IN WATER STORAGE	0.015	(2.0604)	54.68	0.034

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30 and their dates (DDDYYYY)

	(INCHES)	(CU. FT.)	
PRECIPITATION	3.96	14374.48669	2780014
RUNOFF	3.622	13147.88726	420026
DRAINAGE COLLECTED FROM LAYER 3	1.50431	5460.53255	880010
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00002	890010
AVERAGE HEAD ON TOP OF LAYER 4	0.012		
MAXIMUM HEAD ON TOP OF LAYER 4	0.005		
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000419	1.52103	10001
SNOW WATER	8.00	29024.1440	250004

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4324
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0815

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.