Proposed Plan for Amending the Records of Decision for the Wyckoff/Eagle Harbor Superfund Site (Operable Units 1, 2, and 4)

U.S. Environmental Protection Agency, Region 10

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Key Terms and Acronyms

§	Section
µg/kg	micrograms per kilogram
µg/kg dw	micrograms per kilogram dry weight
µg/L	micrograms per liter
95UCL	95th Percentile Upper Confidence Limit on the Mean
ARAR	applicable or relevant and appropriate requirement
c	cancer
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
DMMP	Dredged Material Management Program
DNAPL	dense nonaqueous phase liquid
EAB	enhanced aerobic biodegradation
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
FFS	Focused Feasibility Study
HPAH	high-molecular weight polycyclic aromatic hydrocarbon
HpCDD	heptachlorodibenzo-p-dioxin
HxCDF	hexachlorodibenzofuran
ISS	in-situ solidification/stabilization
LAET	lowest apparent effects threshold
LNAPL	light nonaqueous phase liquid
LPAH	low molecular weight polycyclic aromatic hydrocarbon
mg/kg	milligram per kilogram
mg/kg-day	milligrams per kilogram per day
MNR	monitored natural recovery
MTCA	Washington Model Toxics Control Act
N/A	not applicable
NAPL	nonaqueous phase liquid
nc	noncancer
NCP	National Contingency Plan
NOAA Fisheries	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
NS	none specified
O&M	operations and maintenance
OCDD	octachlorodibenzodioxin
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCP	pentachlorophenol
PeCDF	pentachlorodibenzofuran

ppb	parts per billion
ppm	parts per million
PRG	preliminary remediation goal
Proposed Plan	Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site
RAO	remedial action objective
RI	remedial investigation
ROD	Record of Decision
SCO	Washington State Sediment Cleanup Objective
Site	Wyckoff/Eagle Harbor Superfund Site
SMS	Washington State Sediment Management Standard
TarGOST	Tar-specific Green Optical Scanning Tool
TCDD	Tetrachlorodibenzo-p-dioxin
TEF	toxicity equivalency factor
TEQ	toxicity equivalency quotient
UCL	upper confidence limit
UCL95	95th Percentile Upper Confidence Limit on the Mean
WAC	Washington Administrative Code

SECTION 1

Introduction

1.1 Public Comment Period

In accordance with the Comprehensive Environmental Recovery, Compensation and Liability Act (CERCLA), the U.S. Environmental Protection Agency (EPA) is seeking comments from the public on this *Proposed Plan for Amending the Records of Decision for the Wyckoff/Eagle Harbor Superfund Site (Operable Units 1, 2, and 4)* (Proposed Plan), including the Preferred Alternatives, other alternatives considered, and the supporting information. Public comments are important and can help shape the cleanup plan. The EPA wants to hear from you and will consider public comments before making a final cleanup decision for the Wyckoff/Eagle Harbor Superfund Site (Site). EPA will accept comments through May 31, 2016.

EPA, in consultation with the State of Washington, may modify the Preferred Alternatives or select another response action presented in this Proposed Plan based on new information or public comment. EPA will consider comments received and select the remedial actions in a Record of Decision (ROD) Amendment. EPA's response to public comments will be provided in the Responsiveness Summary, which will be part of the ROD Amendment. EPA anticipates issuing the ROD Amendment, which will be made available to the public, in late 2016.

1.1.1 Where to Review the Proposed Plan and Administrative Record

The Administrative Record, which contains the Proposed Plan and other documents that support the basis for the Preferred Alternatives, is available for public review at the following locations:

- **Bainbridge Public Library**
  1270 Madison Avenue
  Bainbridge Island, WA 98110
  206-842-4162 (call for hours)

- **EPA Superfund Records Center**
  1200 Sixth Avenue
  Seattle, WA 98101
  800-424-4372, extension 4494 (call for appointment)

- **Online:** www.epa.gov/superfund/wyckoff-eagle-harbor

1.1.2 Opportunities to Review and Comment on this Proposed Plan

Written comments may be submitted at any time during the public comment period by U.S. mail or email to the following recipients:

- **U.S. Mail:** Helen Bottcher, EPA Region 10 (ECL-122), 1200 Sixth Avenue, Suite 900, Seattle WA 98101

- **Email:** wyckoffcomments@epa.gov

EPA will hold a public meeting to present the information provided in this Proposed Plan, take comments from the public, and provide the public the opportunity to ask EPA questions. We will accept oral and written comments at the public meeting.

Additional meeting information will be published in the *Bainbridge Island Review* and the *Bainbridge Islander*, as well as on EPA's website (www.epa.gov/superfund/wyckoff-eagle-harbor). EPA will notify our Site email list about the meeting.

Public Meeting

Wednesday, April 27, 2016
5:00 to 6:30 p.m.—Open House and Poster Session
6:30 to 9:30 p.m.—Presentation and Formal Public Comment Period
The City of Bainbridge Island
City Hall Council Chambers
280 Madison Avenue
Bainbridge Island, WA 98110

1.2 Background

This Proposed Plan identifies the EPA's Preferred Alternatives to address contamination remaining in two areas of the Site—the upland portion of the former wood-treating facility and the nearshore portion of the beaches adjacent to the former wood-treating facility. These actions amend the remedies previously selected in 1994 and 2000.

This Proposed Plan also presents the other alternatives evaluated, explains the rationale for the Preferred Alternatives, and summarizes information from the *Draft Final Focused Feasibility Study Wyckoff/Eagle Harbor Superfund Site Operable Unit 1* (EPA, 2016a), *Draft Final Non-Aqueous Phase Liquid Focused Feasibility Study for the Soil and Groundwater Operable Units (OU2/OU4) Wyckoff/Eagle Harbor Superfund Site* (EPA, 2016b), and other key documents contained in the Administrative Record. The Preferred Alternatives address the risks posed by the remaining soil, groundwater, and sediment contamination at the Site. The Administrative Record can be found at the information repositories listed in Section 1.1.1.

EPA is issuing this Proposed Plan as part of its public participation responsibilities under Section 300.430(f)(2) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The Preferred Alternatives or other alternatives considered as part of this Proposed Plan are necessary to protect human health and the environment from actual or threatened releases of hazardous substances.

1.3 Summary of Proposed Alternatives

EPA proposes to use in-situ solidification/stabilization (ISS) to treat the most heavily contaminated soils in the center of the former Wyckoff wood-treating facility. Reagents, including cement, would be mixed into the soil to prevent the contamination from migrating any further. Outside the central area, two other technologies would be employed to treat less heavily contaminated soils. Contamination would be extracted through groundwater wells, and air would be injected into the groundwater to promote the breakdown of contaminants by naturally occurring bacteria. A new concrete wall would be built around the perimeter of the upland portion and a final cap would be installed over the soil treatment portion.

In the adjacent beaches, EPA proposes to treat the remaining areas of contamination with partial excavation and capping. Contaminated sediments would be excavated to a depth of 30 inches. The excavated areas would be backfilled with a 4- to 6-inch thick layer of reactive material, then with clean gravelly sand. The reactive layer would prevent contaminants from moving up through the cap. The clean gravelly sand layer would be thick enough to protect burrowing organisms from exposure to contamination left below the cap and provide beach habitat appropriate for fish and other marine organisms in Eagle Harbor.

These proposed remedial actions are estimated to cost between $71 and $81 million dollars using a 7-percent discount rate. Cleanup construction would be funded through a mix of 90-percent federal funds from the EPA Superfund Program and 10-percent state funds from the Washington Department of Ecology's (Ecology's) Toxics Cleanup Program. Once the remedial construction is complete and remedial action objectives (RAOs) have been met, Ecology would assume the responsibility for long-term Site operations and maintenance (O&M).

SECTION 2

Scope and Role

This section identifies the four cleanup units within the Site and describes how this Proposed Plan would alter the remedial decisions currently in place.

2.1 Site Location and Operable Units

The Wyckoff/Eagle Harbor Superfund Site is located on the east side of Bainbridge Island in Central Puget Sound, Washington (Figure 2-1). For administrative purposes, EPA divided the Site into four operable units (OUs):

- **OU-1: East Harbor OU** includes contaminated offshore sediments in Eagle Harbor and the nearshore sediments adjacent to the former Wyckoff facility. The nearshore area includes West Beach, the North Shoal, and East Beach. A ROD for this OU was issued by EPA in 1994 (EPA, 1994). The ROD selected capping as the primary remedy for contaminated sediments, with monitored natural recovery (MNR) for the nearshore area adjacent to the former Wyckoff facility. EPA modified the cleanup decision in 2007, issuing an Explanation of Significant Differences (ESD) to address previously undiscovered contamination in West Beach with an engineered cap (EPA, 2007).
- **OU-2/OU-4: Soil and Groundwater OUs** includes contaminated soils and groundwater associated with the former Wyckoff facility, as well as the remaining buried structures. These OUs were originally identified separately. OU-2 included unsaturated soils and buildings and other structures associated with the former wood-treating facility. OU-4 included groundwater and saturated subsurface soils. These two areas, which are generally referred to as the *upland*, are being addressed collectively. A ROD for these areas was issued by EPA in 2000 (EPA, 2000).
- **OU-3: West Harbor OU** includes upland areas as well as offshore and nearshore contaminated sediment associated with former shipyard operations in the western portion of Eagle Harbor. A ROD for this area was issued by EPA in 1992 (EPA, 1992). Cleanup work was completed in 1997.

The primary contaminants of concern (COCs) are creosote, pentachlorophenol (PCP), and polycyclic aromatic hydrocarbons (PAHs). Creosote and PCP are chemicals used in wood preservatives. Creosote is a complex mixture of PAHs and phenols. These contaminants are present in the soil and groundwater OUs at the former wood-treating facility and in the sediments in the adjacent beaches.

2.2 Impact of this Proposed Plan

Extensive cleanup actions have been completed since the Site was listed on the National Priorities List in 1987. This Proposed Plan addresses contamination remaining in OU-1, OU-2, and OU-4 only. The remedial actions completed in OU-3 are functioning as designed, and no further actions are proposed.

After considering public comments on this Proposed Plan, EPA will issue a ROD Amendment for the Site. The ROD Amendment will be an interim action, which means that the cleanup decisions will not be the final cleanup decisions for these three OUs.

The ROD Amendment will supersede the ROD for the Soil and Groundwater OUs issued by EPA in 2000. Groundwater in OU-4 is divided into two aquifers: the Upper Aquifer and the Lower Aquifer, which are separated by an aquitard. At this time, EPA is proposing active cleanup of soils and groundwater in the Upper Aquifer only. The Upper Aquifer is the only source of contamination to the Lower Aquifer, so actions to treat contamination in the Upper Aquifer will minimize further degradation of the Lower Aquifer. EPA will reassess contamination in the Lower Aquifer after construction activities in the Upper Aquifer are complete. Any cleanup actions needed in the Lower Aquifer will be addressed in a future CERCLA decision document.

The ROD Amendment will also amend the 1994 East Harbor OU ROD (EPA, 1994) and the 2007 ESD (EPA, 2007). The ROD Amendment will establish a new cleanup decision for the intertidal beaches, including West Beach, North Shoal, and East Beach. No changes to the cleanup decision are proposed for the subtidal areas of Eagle Harbor, where the remedy will remain unchanged from the 1994 ROD. The ROD Amendment will also document the selection of additional cleanup actions in North Shoal and East Beach. No additional cleanup actions are needed on West Beach.

SECTION 3

Site Background

This section briefly summarizes the Site's long history, emphasizing events and Site features that informed EPA's selection of the Preferred Alternatives presented in this Proposed Plan.

3.1 Early Site History

The Suquamish People have lived in Western Washington for thousands of years. Bainbridge Island and Eagle Harbor are in the heart of the Suquamish ancestral territory. Archaeological sites on the Eagle Harbor shoreline document fishing, shellfish collecting, plant collecting, and hunting activities dating back hundreds of years. Anthropologists recorded a few of the many place names used by the Suquamish and obtained the name of ilalidaltxʷ for Eagle Harbor in the Suquamish dialect, meaning "home of the eagles."

In 1855, Suquamish leader Chief Seattle signed the Treaty of Point Elliott with the United States. The Suquamish gave up title to their aboriginal lands, with the exception of a reservation at Port Madison, and reserved their fishing and hunting rights. Eagle Harbor is part of the Tribe's usual and accustomed fishing area. Tribal biologists have been actively involved in the cleanup and restoration of Eagle Harbor since the early 1990s.

3.2 History of Site Operations

Wood-treating operations began at the Site in the early 1900s. At that time, the land that is now inside the steel sheet pile wall enclosing OU-2/OU-4 was a mudflat with a large sand spit. Figure 3-1 shows the 1907 shoreline with the current Site features overlain. Early operations took place on docks and pile supported buildings. Over time, a series of bulkheads were built and the area behind them filled, creating the existing dry land.

From the early 1900s through 1988, a succession of companies treated wood at the Wyckoff property for use as railroad ties, utility poles, pier pilings, and wood stave pipes. The Wyckoff wood-preserving plant was one of the largest in the United States, and its products were sold throughout the United States and the world. When wood-treating operations began in the early 1900s, poles were treated by wrapping them with burlap and asphalt. By 1910, pressure treatment with creosote or bunker oil had begun. In later years, wood was also treated with PCP.

For decades, logs were treated using heat and pressure inside retorts, which are long, cylindrical tanks sealed at both ends. Freshly treated wood was removed from the retorts and dried in the open air. Excess chemical solution that dripped from the wood went directly onto the ground and seeped into the soil and groundwater. This practice began in the mid-1940s and continued until operations ceased in 1988. Other significant contaminant releases resulted from leaking storage tanks and piping, storing treated wood in the water, and using process wastes and sludge as fill between two bulkheads in the 1950s. Nearly 90 years of wood-treating operations resulted in extensive contamination of the Site's soils and groundwater. The contamination extended into Eagle Harbor, affecting nearly 100 acres of intertidal and subtidal sediment.

3.3 Previous Investigations and Cleanup Actions in Soils/Groundwater Operable Units

In 1984, EPA issued a Unilateral Administrative Order requiring the Wyckoff Company to conduct environmental investigation activities, which revealed the presence of significant soil and groundwater contamination. The Site was listed on the National Priorities List in 1987 and a more thorough Site investigation was completed in 1989 (CH2M, 1989).

In 2000, EPA issued a ROD selecting a remedy for the upland soil and groundwater areas which included steam injection and groundwater extraction. The 2000 ROD (EPA, 2000) also included a contingency remedy of containment to be implemented if a pilot-scale study of the steam injection technology could not meet its performance expectations. The pilot-scale study was conducted between October 2002 and April 2003. Numerous technical challenges were encountered, and meeting the performance expectations using this technology was determined to not be possible. EPA then began implementing the containment remedy. Components of the containment remedy include the following:

- **Groundwater extraction and treatment system—**The groundwater extraction system consists of nine recovery wells screened in the Upper Aquifer. Pumps installed in these wells draw groundwater and NAPL away from the Site perimeter and in toward the extraction wells. Pumping in the Upper Aquifer also maintains an upward vertical gradient between the Lower and Upper Aquifers. Extracted groundwater is treated in an on-Site groundwater treatment plant and then discharged to Eagle Harbor.
- **Sheet pile wall—**The steel sheet pile wall was constructed around the upland portion of the former wood-treating facility to contain contaminants during the steam injection and groundwater extraction remedy described above. The wall prevents contaminated soil from eroding into Eagle Harbor.
- **Long-term monitoring—**An ongoing monitoring program provides data on water levels in both the Upper and Lower Aquifers (for confirming hydraulic containment) and on contaminant distribution and movement in the subsurface.
- **Engineering controls—**Engineering controls (e.g., fencing) and signage are in place to restrict use of the Site and prevent direct exposure to surface soils.

The final component of the containment remedy—a cap over the former wood-treating area—was not constructed. In accordance with CERCLA requirements, Ecology assumed operation of the groundwater extraction and treatment system in 2012. This system, in combination with the sheet pile wall, is effectively containing Upper Aquifer contamination; however, it costs about $800,000 per year to run, and more than 100 years of operations is estimated to be required to meet the RAOs and cleanup levels defined in the 2000 ROD (EPA, 2000).

3.4 Previous Investigations and Cleanup Actions in East Harbor Operable Unit

In 1984, the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries) advised EPA and Ecology that sediments, fish, and shellfish from Eagle Harbor contained elevated levels of PAHs. The NOAA Fisheries study also reported that English sole (*Pleuronectes vetulus,* a type of flatfish) from Eagle Harbor had an unusually high rate of carcinogenic tumors and precancerous lesions (NOAA Fisheries, 1984).

EPA completed a remedial investigation (RI) in Eagle Harbor in 1989 (CH2M, 1989), which revealed extensive PAH contamination of surface and shallow subsurface sediments. EPA soon began planning a time-critical cleanup action, and between September 1993 and March 1994, more than 54 acres of contaminated sediments in Eagle Harbor were capped. The cap covered the contamination under a layer of clean sand. Capping was selected as the primary remedy for sediment contamination in the 1994 OU1 ROD (EPA, 1994), with MNR selected for the intertidal beaches. As shown in Figure 3-2, the original cap has been extended in several phases and now covers more than 76 acres of intertidal and subtidal sediment. Monitoring data have shown the cap to effectively isolate the contamination and protecting the environment.

In 2001, as part of cleanup actions selected for the upland area, EPA installed the perimeter sheet pile wall around the west, north, and east sides of the former wood-treating facility to stop contamination discharge to the beaches, allowing natural recovery processes to begin.

In 2005, EPA received reports from citizens about odors and sheen on West Beach (Figure 3-2), an intertidal beach west of the central processing area previously been considered uncontaminated. EPA investigated, found creosote contamination in beach sediments, and took action in 2007 to build a beach cover system on top of the contaminated sediments and to extend the subtidal cap to the new beach cover. These actions amended the 1994 cleanup decision, and were described by EPA in an ESD issued in 2007 (EPA, 2007).

SECTION 4

Site Characteristics

4.1 Physical Setting

Eagle Harbor is naturally deep, and its east-west orientation provides shelter from the predominant currents of Central Puget Sound. The former Wyckoff wood-treating facility is on the south shore of the harbor entrance. The upland portion of the Site is bounded by the steel sheet pile wall installed by EPA in 2001. The land inside the sheet pile wall, much of which is fill, sits 12 to 15 feet above the beach surface.

4.2 Current and Future Site Uses

The former Wyckoff wood-treating facility is owned by the City of Bainbridge Island, which purchased the property from EPA in 2004 for use as a park. A large portion of the land west of the Wyckoff facility's former processing area has already been converted to a park that includes walking trails through the wooded hillside above the beach. West Beach, where EPA covered contaminated sediments with a thick engineered cap, is a popular recreational area in the park used by beach walkers, stand up paddle boarders, and kayakers. At the western edge of the park, the Bainbridge Island Japanese-American Exclusion Memorial honors Japanese-Americans who were forcibly removed from their homes and sent to internment camps during World War II.

When the cleanup work is completed, most, if not all, of the remaining land will be incorporated into Pritchard Park and developed for recreational use. If necessary, a small portion of the Site may be set aside to support continued maintenance of groundwater protection measures or other portions of the remedy.

Eagle Harbor is part of the Suquamish Tribe's usual and accustomed fishing grounds, and beaches in the harbor provide habitat for several species of edible clams. Offshore of the eastern edge of the former Wyckoff facility is a commercial shellfish-growing area. Classified and monitored by the Washington Department of Natural Resources, this area supports the harvest of geoduck and other naturally occurring populations of shellfish. Figure 4-1 shows the location of the shellfish growing areas near the Site.

Groundwater within the Upper Aquifer of the Site is subject to saltwater intrusion, so it is classified as a nonpotable, Class III groundwater (total dissolved solids are greater than 10,000 milligrams per liter). Groundwater within the Lower Aquifer includes both nonpotable (Class III) and potable areas; this is discussed further in Section 4. All potable water-bearing geologic units underlying Bainbridge Island are considered part of an island-wide aquifer system, designated by EPA as a Sole Source (Class I) Aquifer (EPA, 2013). The aquifer system supplies drinking water to the island's more than 23,000 residents, and there are no economical and legally available alternative sources of water.

4.3 Natural Habitat Functions of the Site

The Site's beaches provide habitat for a rich array of marine organisms, including horse clams, butter clams, geoduck, crabs, and numerous species of fish. Sand lance, an important food source for juvenile salmon, spawn several inches below the surface in sandy portions of the beaches, and have been documented on West Beach. The deeper portions of East Beach and North Shoal support healthy beds of eelgrass. Eelgrass is an important component of the Puget Sound nearshore ecosystem, providing cover for juvenile salmon and spawning habitat for herring and other fish. Federal, Tribal, and State agencies with Natural Resource Trustee responsibilities at the Site have been working to restore eelgrass just east of the Site by filling previously dredged areas and planting eelgrass. Figure 4-2 shows the approximate extent of eelgrass beds and the eelgrass restoration areas.

4.4 Key Site Features

Several Site features will have a significant influence on selection and implementation of the remedy.

4.4.1 Perimeter Sheet Pile Wall

The perimeter sheet pile wall, constructed by EPA in 2001, is a critical upland structural feature. Without it, a significant portion of the upland soils would erode into Eagle Harbor. A perimeter retaining wall of some type will be required to maintain the anticipated future land use, as a park, and to protect water quality in Eagle Harbor. The current wall is corroding and is expected to develop pin-hole leaks and eventually fail near the mudline.

4.4.2 Aquitard

The Upper and Lower Aquifers are separated by an aquitard, which is a relatively dense layer of soils, including marine silt, glacial deposits, and clay. Figure 4-3 depicts the location and north-sloping nature of the aquitard. Over much of the former processing area, the aquitard limits the exchange of groundwater between the two aquifers. However, in some places, it is thin, more permeable, or not present, allowing contamination to move from the Upper Aquifer into the Lower Aquifer. Protecting the aquitard is an important consideration in the choice of cleanup technologies and/or the depth to which they can be used.

4.4.3 Eelgrass Beds

To the extent feasible, remedial actions on the beaches should protect existing eelgrass. Eelgrass is further described in Section 4.3 and shown on Figure 4-2. Where adverse impacts from cleanup construction activities cannot be avoided, mitigation to restore eelgrass will be required.

4.4.4 Accommodation of the Tidal Regime

Puget Sound is a tidal estuary. Except for some higher elevation areas on the west side of the former processing area, the beaches adjacent to the perimeter wall are in the intertidal zone, which means they are only exposed during low tide. The average tidal exchange at the Site (the difference in water elevation between low tide and high tide) is 7 feet. However, the daily tidal exchange can be as high as 15 feet. Any construction project in the intertidal zone is challenging. Work can be done “in the dry” at low tide, but because the low tide only lasts a few hours per day, work must be done quickly and in small areas. If the work is done at high tide, then barges and other equipment have to be moved offshore to avoid grounding when the tide changes.

SECTION 5
Nature and Extent of Contamination

5.1 Wood-Treating Chemicals Used at the Site

The primary wood preservative used at the Site was creosote—a thick, oily liquid distilled from coal tar. Creosote contains several hundred individual chemicals including benzene, naphthalene, and benzo(a)pyrene. Most creosote present in the soil and groundwater is in the form of an oily, NAPL. Some of the NAPL (called "LNAPL") is lighter than water. LNAPL is found in the top layers of the Upper Aquifer, where it moves up and down with the groundwater, creating a smear zone of contamination in the soil. Some of the NAPL (called "DNAPL") is denser than water. DNAPL sinks down through subsurface soils and groundwater and is mostly found in the deeper portions of the Upper Aquifer. In some areas, the NAPL is present in thick enough layers that it can still flow and move through the soil. In other areas, very thin layers of NAPL have coated the soil grains and the NAPL is adhered so that it no longer moves. Some chemicals have dissolved into the groundwater. Chemicals dissolved in groundwater are able to move more readily than chemicals in the NAPL, but the concentrations of chemicals are highest in the NAPL. Chemicals that make up creosote are found in Site soil, groundwater, sediment, LNAPL and DNAPL.

PCP was also used as a wood preservative at the Wyckoff Site. PCP is found in LNAPL and dissolved in the groundwater.

Contaminant concentrations measured at the Site are summarized in Table 5-1 (soil), Table 5-2 (groundwater in the Upper Aquifer), and Table 5-3 (surface sediment).

5.2 Contaminants of Concern in Upland Soil and Groundwater

The primary COCs in upland soil and groundwater were established in the 2000 ROD for the soil and groundwater OUs (EPA, 2000). In soil, the COCs are PAHs, PCP, and dioxins/furans. The term "PAH" includes a list of 16 specific chemicals, including naphthalene, fluorene, and benzo(a)pyrene, that are associated with creosote-based wood preservative. Dioxins/furans were generated at the Site as a byproduct when wood contaminated with creosote and other chemicals was burned for fuel. Dioxins/furans are also impurities in PCP. In groundwater, the COCs are PAHs and PCP.

In the 2000 ROD, EPA stated that "for the purposes of cleanup, it is assumed that other contaminants are co-located with the PAHs and PCP and will be remediated along with these primary contaminants of concern" (EPA, 2000); this assumption remains true today. Contaminants including PCP and dioxins/furans are co-located with the PAHs, and the PAHs are present primarily in NAPL.

5.3 Contaminants of Concern in Intertidal Sediments

In the beach sediments, the COCs are PAHs and PCP. The 1994 ROD for the East Harbor OU (EPA, 1994) included metals as chemicals of potential concern in subtidal sediments. However, the ROD made a clear distinction between intertidal beach sediments and subtidal sediments. Metals were not detected above background concentrations in intertidal beach sediments (EPA, 1994), so metals were not considered a COC for the North Shoal and East Beach areas being addressed in this Proposed Plan.

Individual PAH compounds in nearshore sediments are co-located with NAPL. The cleanup options presented in this plan all target NAPL. Actions that cleanup or isolate NAPL in intertidal sediments will also lower the concentration of PAHs.

5.4 Principal Threat Waste

CERCLA regulations establish the expectation that treatment will be used to address the principal threats posed by a site whenever practicable. In general, principal threat wastes are those source materials considered highly toxic or mobile that generally cannot be reliably contained. EPA has identified NAPL in the Upper Aquifer as a principal threat waste, based on the large mass present, the mobility of the NAPL, and the toxicity of the chemicals found in the NAPL.

5.5 Nonaqeous-Phase Liquid Distribution in Upland Soil and Groundwater

In 2013, EPA completed a comprehensive investigation (CH2M, 2013a) to map the extent of NAPL contamination in upland soils using Dakota Technologies' Tar-specific Green Optical Scanning Tool (TarGOST®). TarGOST was used to assess the extent of NAPL in soil borings as deep as 85 feet below the ground surface. The data were analyzed and mapped using both conventional mapping techniques and three-dimensional mapping software (EPA, 2014). This investigation showed the following results:

- Approximately 650,000 gallons of NAPL remain in the Upper Aquifer.
- The aquitard appears to be effectively restricting NAPL from migrating to deeper elevations over most of the Site; however, the aquitard is thin or absent in a few areas.
- Elevated TarGOST readings along the inside of the sheet pile wall suggest the wall is effectively retaining NAPL. The wall is keyed into the aquitard and is deep enough to prevent NAPL from moving under the bottom of the wall.
- NAPL is not distributed evenly. In general, NAPL is thickest in the center of the former processing area. Figure 5-1 shows where the NAPL is thickest.
- Approximately 80 percent of the NAPL is either in the top 25 feet of soil, or at depth within 10 feet of the aquitard. There is a thick, wedge-shaped layer of relatively clean soil between the more heavily contaminated layers above and below it.

5.5.1 Upper Aquifer Groundwater

In 2014, EPA sampled the Upper Aquifer groundwater, collecting 18 groundwater samples, 3 samples of LNAPL, and 6 samples of DNAPL (CH2M, 2016). Summary data are provided in Table 5-2. This study showed the following:

- Groundwater remains heavily contaminated with PAHs. The cleanup level from the 2000 ROD (EPA, 2000) for high-molecular weight PAHs (HPAHs) is 0.254 microgram per liter (µg/L). The cleanup level was exceeded in 15 of the 18 wells sampled, at concentrations ranging from 0.30 µg/L to 776 µg/L. The maximum concentration is more than 3,000 times the cleanup level. The concentration of HPAHs in the NAPL samples was as high as 32,445,000 micrograms per kilogram (µg/kg) (3.2 percent) in the LNAPL and 57,330,000 µg/kg (5.7 percent) in the DNAPL.
- The concentration of PCP exceeded the 2000 ROD cleanup level of 4.9 µg/L in 6 of the 18 wells sampled. PCP was not detected in DNAPL, but it was measured in LNAPL at concentrations ranging from 1,600 to 1,900 µg/kg.
- PAH concentrations in groundwater are significantly lower in the top portion of the Upper Aquifer (from the water table to a depth of 5 feet below the water table) than in deeper portions. The median concentration of total PAHs is about five times lower in this upper zone than in the groundwater below it. The cause of this difference is not specifically known. However, several mechanisms, including higher rates of volatilization and weathering of the LNAPL at the water table surface may be responsible.

5.5.2 Lower Aquifer Groundwater

EPA regularly monitors groundwater quality in the Lower Aquifer. In the most recent sampling event (CH2M, 2016) conducted in 2014, the concentration of acenaphthene, selected as the indicator constituent, exceeded the cleanup level from the 2000 ROD in 5 out of 11 wells. Four of the wells that exceeded cleanup levels were in the northern portion of the former process area, where seawater intrusion occurs in the Lower Aquifer. Other PAHs, including chrysene and fluoranthene, also exceeded cleanup levels in these northern wells. The fifth well was in the southwest corner of the Site near the fence. At that well, only acenaphthene exceeded the cleanup level. Figure

5-2 shows the locations of these wells, and the approximate location of the freshwater/saltwater boundary. Under current conditions, including continued extraction of groundwater from the Upper Aquifer, the Lower Aquifer can be summarized as follows:

- Groundwater in the northern part of the former process area is affected by saltwater intrusion and is not potable. The position of the freshwater/saltwater boundary varies seasonally.
- Groundwater contamination is not extensive and is generally limited to a small area in northern portion of the former process area.
- The contaminant distribution pattern is fairly stable; the contamination has not spread to previously uncontaminated wells.
- Contamination is not affecting areas currently used for drinking water.

5.6 Nature and Extent of Contamination in Beach Sediments

In 2011, 10 years after the perimeter sheet pile wall was installed, EPA sampled the beaches to determine whether the sediment cleanup levels had been achieved. Significant improvements were seen, including sharp declines in PAH concentrations and a decrease in the number and severity of NAPL seeps. However, cleanup levels had not been achieved everywhere on the beaches and some NAPL seeps remained. This finding prompted EPA to conduct an additional investigation to map the extent of NAPL beneath the beaches (CH2M, 2013b). The investigation, along with visual inspections of the beaches showed the following:

- NAPL is present in both East Beach and North Shoal sediments.
- NAPL is not distributed evenly. Most NAPL is in the central part of East Beach and on North Shoal near the former West Dock.
- The thickest total accumulations of NAPL occur near the sheet pile wall. The volume of NAPL and the thickness of the NAPL layers decreases with increasing distance away from the wall.
- The vast majority of the NAPL occurs below an elevation of 0 feet mean low-low water. Relatively little NAPL is present in the upper portion of the beaches.
- NAPL seeps occur in a few locations. Several of the seeps are persistent and can be found in the same location year after year. The largest seep is on East Beach.

The distribution of NAPL in beach sediments is shown in Figure 5-3.

5.7 Nature and Extent of Contamination in Shellfish Tissue

The West Beach, North Shoal, and East Beach are currently closed for shellfish harvesting. However, EPA periodically collects shellfish from the beaches to monitor the concentration of contaminants in shellfish tissue. Horse clams (*Tresus capax*, also known as Gaper clams) were collected from North Shoal and East Beach in 2011. In 2014, the sampling was repeated and the collection area was extended to include West Beach. Carcinogenic PAHs (cPAHs) were summed using a toxicity equivalency quotient (TEQ) approach. Sampling locations and total cPAH concentrations expressed as TEQ are shown in Figure 5-4. Concentrations declined between 2011 and 2014.

5.8 Background Polycyclic Aromatic Hydrocarbon Concentrations in Puget Sound Sediment

Generally, under Superfund, cleanup levels are not set at concentrations below the background level of naturally occurring chemicals (e.g., metals) or the anthropogenic (human-influenced) background levels (e.g., cPAHs). EPA considered background concentrations when selecting cPAH cleanup levels in sediment and shellfish tissue. Sediment contaminant concentrations from nonurban areas in Puget Sound were used to characterize background COC concentrations (Dredged Material Management Program [DMMP], 2009). Background cPAH concentrations in fish and shellfish tissue were developed and compiled (EPA, 2013) based on samples collected between 1991 and 2009.

Nonurban shellfish tissue background concentrations are more uncertain than sediment background concentrations. Table 5-4 summarizes the data EPA used to determine the background concentration of cPAHs in both sediment and shellfish tissue.

TABLE 5-1
Contaminant Concentrations in Soil
Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Contaminant of Concern	Cleanup Level (2000 ROD)[a] (µg/kg)	Number of Detections/ Samples[b]	Number of Samples Exceeding Cleanup Levels	Average Detected Concentration (µg/kg)	Maximum Detected Concentration (µg/kg)
Polycyclic Aromatic Hydrocarbons					
Benzo(a)anthracene	137	72/466	72	27,958	310,000
Benzo(a)pyrene	137	111/466	111	16,082	370,000
Benzo(b&k)fluoranthene	137	95/370	95	27,616	550,000
Benzo(b)fluoranthene	137	9/96	9	6,476	27,000
Benzo(k)fluoranthene	137	5/96	5	5,664	9,600
Chrysene	137	113/466	113	24,587	440,000
Dibenz(a,h)anthracene	137	38/466	38	3,094	28,000
Indeno(1,2,3-cd)pyrene	137	76/466	76	5,943	100,000
Naphthalene	320,000	36/228	8	10,778,858	250,000,000
Phenols					
Pentachlorophenol	2,500	65/462	4	21,760	440,000
Dioxin/Furans					
Dioxin (2,3,7,8-TCDD)/TEF	0.00667	30/34	7	0.345	3,226

Notes:

[a] Cleanup level = MTCA Method B Direct Contact for Unrestricted Use, presented in the 2000 ROD (EPA, 2000)
[b] Soil information from the 1997 RI (CH2M, 1997)

EPA = U.S. Environmental Protection Agency
µg/kg = microgram per kilogram
MTCA = Washington Model Toxics Control Act
RI = Remedial Investigation
ROD = Record of Decision
TCDD = Tetrachlorodibenzo-p-dioxin
TEF = toxicity equivalency factor

TABLE 5-2
Contaminant Concentrations in Upper Aquifer Groundwater
Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Contaminant of Concern	Cleanup Levels (2000 ROD)[a] (µg/L)[b]	Number of Detections/ Samples[c]	Number of Samples Exceeding Cleanup Levels	Average Detected Concentration (µg/L)	Maximum Detected Concentration (µg/L)
Total Polycyclic Aromatic Hydrocarbons[d]					
Total LPAH	NS	18/18	0	2,077	7,875
Total HPAH	0.254	18/18	14	115	776
Total PAH	NS	18/18	0	2,191	8,367
Low-Molecular Weight Polycyclic Aromatic Hydrocarbons					
Fluorene	3	16/18	13	112	510
Acenaphthene	3	16/18	13	206	750
Acenaphthylene	NS	16/18	0	4.0	11
Anthracene	9	17/18	7	19.2	100
Naphthalene	83	16/18	10	1,577	6,700
Phenanthrene	NS	16/18	0	158	920
High-Molecular Weight Polycyclic Aromatic Hydrocarbons					
Benzo(a)anthracene	0.0296	12/18	10	9.9	69
Benzo(a)pyrene	0.0296	12/18	11	2.9	20
Benzo(g,h,i)perylene	NS	9/18		0.72	4.8
Benzo[b]fluoranthene	0.0296	12/18	9	5.5	39
Benzo[k]fluoranthene	0.0296	11/18	10	1.6	12
Chrysene	0.0296	12/18	12	7.7	54
Dibenzo[a,h]anthracene	0.007	8/18	7	0.30	2.1
Indeno(1,2,3-cd)pyrene	0.0296	10/18		0.72	5.2
Fluoranthene	3	17/18	11	53	350
Pyrene	15	16/18	7	33	220
Phenol					
Pentachlorophenol	4.9	18	2	15	240

Notes:
[a] EPA (2000).
[b] 2000 ROD cleanup levels are provided for comparison purposes only. New cleanup levels are presented in Section 7.
[c] From 2014 Upper Aquifer groundwater sampling (CH2M, 2016).
[d] Total PAH, total LPAH, and total HPAH are calculated results using detected constituents and half the reporting limit for nondetect constituents.

µg/L = micrograms per liter
HPAH = high-molecular weight polycyclic aromatic hydrocarbon
LPAH = low-molecular weight polycyclic aromatic hydrocarbon
NS = none specified
PAH = polycyclic aromatic hydrocarbon
ROD = Record of Decision

TABLE 5-3
Polycyclic Aromatic Hydrocarbon Concentrations in OU-1 (intertidal) Surface Sediment
Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Contaminant of Concern	OU-1 (Intertidal) Sediment Concentrations in 2011: Number of Detections/ Samples	OU-1 (Intertidal) Sediment Concentrations in 2011: Average Detected Concentration (mg/kg)	OU-1 (Intertidal) Sediment Concentrations in 2011: Maximum Detected Concentration (mg/kg)	SQS SCO[a] (mg/kg) Organic Carbon[b]	Number of OU-1 Samples Exceeding this Level	LAET (mg/kg) Dry Weight[b]	Number of OU-1 Samples Exceeding this Level	Puget Sound Background Concentration with Nondetects[c] (mg/kg)	Number of Puget Sound Background Samples Exceeding this Level
LPAH [d, e]	37/37	0.475	4.435	370	9	5.2	4	0.017	37
–Naphthalene	35/37	0.339	3.700	99	12	2.1	2	0.002	35
–Acenaphthylene	22/37	0.017	0.180	66	3	1.3	0	0.005 [f]	NA
–Acenaphthene	27/37	0.178	3.000	16	15	0.5	4	0.005 [f]	NA
–Fluorene	21/37	0.178	2.700	23	11	0.54	2	0.005 [f]	NA
–Phenanthrene	35/37	0.410	4.700	100	8	1.5	3	0.005	29
–Anthracene	31/37	0.374	5.300	220	6	0.96	3	0.002	31
–2-Methylnaphthalene	37/37	0.134	1.800	38	7	0.67	2	0.002	27
HPAH [d, g]	37/37	1.496	16.630	960	7	12	1	0.057	23
–Fluoranthene	36/37	0.819	12.000	160	12	1.7	3	0.008	29
–Pyrene	36/37	1.571	30.000	1,000	20	2.6	3	0.007	30
–Benz(a)anthracene	32/37	0.347	7.100	110	9	1.3	2	0.004	29
–Chrysene	35/37	0.385	5.900	110	9	1.4	2	0.004	32
–Benzo(b)fluoranthene	35/37	0.150	2.300	N/A	N/A	NS	NC	0.010	22
–Benzo(k)fluoranthene	35/37	0.150	2.300	N/A	N/A	NS	NC	0.005	31
–Total benzofluoranthenes	NC	NS	NS	230	NC	3.2	NC	NC	NC
–Benzo(a)pyrene	32/37	0.126	1.900	99	7	1.6	1	0.006	19
–Indeno(1,2,3 c,d)pyrene	27/37	0.036	0.450	34	7	0.6	0	0.004	24

Contaminant of Concern	OU-1 (Intertidal) Sediment Concentrations in 2011			SQS SCO[a] (mg/kg) Organic Carbon[b]	Number of OU-1 Samples Exceeding this Level	LAET (mg/kg) Dry Weight[b]	Number of OU-1 Samples Exceeding this Level	Puget Sound Background Concentration with Nondetects[c] (mg/kg)	Number of Puget Sound Background Samples Exceeding this Level
	Number of Detections/ Samples	Average Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)						
–Dibenzo(a,h)anthracene	23/37	0.023	0.320	12	10	0.23	1	0.002	35
–Benzo(g,h,i)perylene				31	7	0.67	0	0.003	30

Notes:

Results were not OC-normalized because TOC less than 0.5 percent.

[a] SQS Chapter 173-204 WAC Benthic Criteria and Table 8 of EPA (1994).

[b] Table 3-9 of U.S. Army Corps of Engineers (2012).

[c] Background concentration calculated from DMMP (2009).

[d] Total LPAH, and Total HPAH are calculated results using detected constituents and half the reporting limit for nondetect constituents.

[e] LPAH = The total LPAH criterion represents a weighted sum of the following compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. The LPAH criterion is not the sum of the criteria values for the individual LPAH compounds listed.

[f] Due to 100 percent non-detect frequency the background concentration is based on the maximum reported detection limit.

[g] HPAH = The total HPAH criterion represents a weighted sum of the following compounds: fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. The HPAH criterion is not the sum of the individual HPAH compounds as listed.

HPAH = Total high molecular weight polycyclic aromatic hydrocarbon
LAET = lowest apparent effects threshold
LPAH = Total low molecular weight polycyclic aromatic hydrocarbon
mg/kg = milligrams per kilogram
NS = not specified
NC = not calculated
OU = operable unit
PAH = polycyclic aromatic hydrocarbon
SCO = Washington State Sediment Cleanup Objective
SQS = Sediment Quality Standards – Sediment Quality Objectives
TOC = total organic carbon
WAC = Washington Administrative Code

TABLE 5-4
Background Concentrations of Carcinogenic Polycyclic Aromatic Hydrocarbons
Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Media	Detected Samples/ Total Samples	Range of Detected Concentrations	Mean	UCL95
Sediment—cPAH TEQ (µg/kg dw)	61/70	1.3-58	7.1	9.0
Tissue—Butter clam, geoduck, horse clam, littleneck clam (whole body)—cPAH TEQ (µg/kg dw)	3/11	0.069-0.17	0.088	0.12

Note: Sediment background data from DMMP (2009). Tissue background data from EPA (2013).

µg/kg dw = micrograms per kilogram dry weight
cPAH = carcinogenic polycyclic aromatic hydrocarbon
TEQ = toxicity equivalency quotient
UCL95 = 95th Percentile Upper Confidence Limit on the Mean

SECTION 6

Summary of Site Risks

Baseline human health and ecological risk assessments were performed for the soil and groundwater OUs in the mid-1990s. The results were presented in a 1997 RI (CH2M, 1997) and summarized in the 2000 ROD (EPA, 2000).

Baseline human health and ecological risk assessments were performed for the East Harbor OU in the late 1980s. The results were presented in a 1989 RI (CH2M, 1989) and summarized in the 1994 ROD (EPA, 1994). Human health risks were reevaluated in 2007 when contamination was discovered in the sediment on West Beach. This evaluation resulted in new, lower cleanup levels to protect recreational beach users on West Beach. The new cleanup levels were included in the 2007 ESD for OU-1 (EPA, 2007).

EPA did not perform a new baseline human health or ecological risk assessment to support the recent Site characterization efforts. However, exposure pathways and COCs that were shown to contribute the most risk in the previous evaluations were reviewed using recent data. These exposure pathways included human health and ecological risks from exposure to contaminated sediments in the beaches, and human health risks from shellfish ingestion. The review confirmed that there is still unacceptable risk; therefore, there is a basis for taking action. The following summarizes the findings of the previous baseline risk assessment, and the updated assessment conducted to support the recent Site characterization work.

How Does EPA Assess Risk?

Human health and ecological risk assessments estimate the health risks to people and the environment from exposure to contaminants either now or in the future. For EPA studies, "risk" is the possible harm to people or wildlife from exposure to chemicals. Two types of health risks for people are evaluated: the risks that can cause cancer and the risks that can cause other health effects. EPA evaluates only noncancer risks to wildlife.

EPA uses the results of a risk assessment to determine whether the contamination at a site poses an unacceptable risk to human health or the environment under CERCLA. The CERCLA regulations give us a range of risk numbers to use in deciding if federal cleanup is necessary. EPA established an "acceptable" extra cancer risk range, from 1 in 10,000 (1×10^{-4}) to 1 in 1,000,000 (1×10^{-6}) of developing cancer from exposure to site contaminants at a site over a person's lifetime.

For noncancer health effects, EPA calculates a hazard quotient or hazard index for both humans and wildlife. A hazard index is the sum of the hazard quotient for several chemicals that have the same or similar effects. The noncancer hazard index has a threshold below which EPA does not expect any noncancer health effects. If the hazard quotient or hazard index is 1 or higher, then exposure to site contaminants could be a risk to humans or wildlife's health.

6.1 Risk from Exposure to Upland Soils

The 1997 human health risk assessment (CH2M, 1997) showed excess lifetime cancer risks above EPA's acceptable range of $1\text{x}10^{-4}$ to $1\text{x}10^{-6}$ for exposure (including ingestion and inhalation) to surface and shallow subsurface soils. Carcinogenic PAHs including benzo(a)anthracene, benzo(b&k)fluoranthene, and benzo(a)pyrene were identified as the most significant contaminants contributing to risk, along with dioxins/furans. Noncancer risks were identified for naphthalene and dioxin/furans. Human health risks from exposure to contaminants in soils are presented in Table 6-1; values in this table were initially presented in Table 10 in the 2000 ROD (EPA, 2000).

Site soils remain contaminated with NAPL. In some portions of the upland, NAPL can be seen on the soil surface. Other than a 1-acre area in the middle of the former process area where a pilot study was conducted in 2003, no remedial actions have been implemented to remove or treat contaminated soils. Therefore, the concentrations over much of the upland soil and the associated risks are not expected to have changed appreciably since the 1997 risk assessment.

6.2 Risks from Exposure to Upper Aquifer Groundwater

The Upper Aquifer is not a drinking water aquifer, therefore, exposure to groundwater via ingestion is unlikely. The more likely exposure pathway to humans and aquatic organisms would be upwelling of groundwater onto the beaches adjacent to the upland, or through leaks or a catastrophic failure of the perimeter sheet pile wall. As described in Section 5.5, the Upper Aquifer is contaminated with PAHs present in soil, groundwater, and NAPL. If a catastrophic failure of the perimeter sheet pile wall occurred, then there would be a significant release of contaminants to Eagle Harbor as the soil and groundwater inside the wall are up to 18 feet above the beach surface. Soil would slump and erode into Eagle Harbor with every outgoing tide. The biggest threat to people and the marine environment would the uncontrolled release of NAPL. If people came into direct contact with NAPL, then it could cause chemical burns on their skin. A release of NAPL would also increase PAH concentrations in beach sediments.

6.3 Risks from Exposure to Beach Sediments

People could be exposed to contaminants in the beach sediments through recreational beach use, when harvesting shellfish, and when consuming shellfish from the beaches. EPA reevaluated this risk using beach sediment chemistry data from samples collected in 2011 (EPA, 2016c). EPA considered both typical recreational beach users and Tribal shellfish harvesters. The Site is within the usual and accustomed fishing area of the Suquamish Tribe, so EPA used Suquamish Tribal shellfish consumption rates in the risk calculations (Suquamish Tribe, 2000). The greatest risk was determined to be from cPAHs to people who both collect and eat shellfish. This scenario includes dermal exposure to sediment, incidental ingestion of sediment, and ingestion of clams. The total risk using a Tribal scenario is 4×10^{-1}; the total risk using a non-Tribal recreational scenario is 1×10^{-2}. For both Tribal and recreational beach users, most of the calculated risk comes from shellfish consumption, rather than dermal exposure. The risk calculations are summarized in Table 6-2.

Contamination in the beach sediments also poses an unacceptable risk to benthic invertebrates—worms, clams, and other organisms that live in the sediment. To evaluate this risk, COC concentrations were compared to the Washington Sediment Management Standards (SMSs). The SMSs include two sets of sediment contaminant concentration goals for protecting benthic invertebrates. The Sediment Cleanup Objectives (SCOs) represent a “no adverse effect level,” below which adverse impacts on benthic organisms are unlikely. The higher Cleanup Screening Levels represent a “minor adverse effect level,” above which adverse impacts are more likely to occur.

In the top 10 centimeters of sediment in the North Shoal and East Beach, there were few exceedances of the SMS. Out of five sampling locations on North Shoal, one location had COC concentrations in excess of the SCOs. On East Beach, one out of fifteen sampling locations had COC concentrations in excess of the SCOs. More extensive contamination was found below the beach surface. In samples collected 10 centimeters below the surface and deeper, four out of eight stations on East Beach had COC concentrations above the SCOs. A higher number of chemicals exceeded SCO criteria than in the surface, and many chemicals exceeded both the SCOs and the Cleanup Screening Levels.

6.4 Basis for Amending the Remedy

It is EPA’s judgment that the Preferred Alternatives identified in this Proposed Plan, or one of the other active measures considered in this Proposed Plan, are necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

In the Soil and Groundwater OUs, a significant volume of NAPL remains in subsurface soils and groundwater. Should the containment system fail, the risks to Eagle Harbor would be significant. The primary basis for taking action in the Upper Aquifer is to protect the Lower Aquifer and Eagle Harbor by preventing further releases of NAPL, PAHs, and PCP. East Beach and North Shoal have not met the cleanup levels specified in the 1994 ROD (EPA, 1994), despite more than 10 years of MNR following the installation of the perimeter sheet pile wall in 2001. Persistent NAPL seeps on the beaches, bulk sediment PAH concentrations that exceed numeric cleanup goals, and continued risk from shellfish consumption all support the need for additional cleanup action on the beaches.

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TABLE 6-1

Reasonable Maximum Exposure Concentration and Associated Risk Values for Chemicals of Concern in Soil

Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Chemical of Concern	Exposure Concentration (mg/kg)	Hazard Quotient	Cancer Risk
Naphthalene	250,000	22.8	
Benzo(a)anthracene	310		3.53×10^{-4}
Chrysene	352		4.01×10^{-6}
Benzo(b)fluoranthene	214		2.44×10^{-4}
Benzo(k)fluoranthene	89.6		1.02×10^{-5}
Benzo(b&k)fluoranthene	550		6.27×10^{-4}
Benzo(a)pyrene	370		4.21×10^{-4}
Indeno(1,2,3-cd)pyrene	100		1.14×10^{-4}
Dibenzo(a,h)anthracene	38.6		4.40×10^{-5}
Dibenzofuran	1380	1.26	
Pentachlorophenol	108		2.02×10^{-5}
2,3,7,8-TCDD/TEF	0.0001077		2.52×10^{-5}
1,2,3,7,8-PeCDF/TEF	0.00075	2.73	1.76×10^{-4}
1,2,3,4,6,7,8-HpCDD/TEF	0.0008	2.92	1.87×10^{-4}
1,2,3,4,7,8-HxCDD/TEF	0.000098		2.30×10^{-5}
2,3,4,6,7,8-HxCDF/TEF	0.000043		1.01×10^{-5}
1,2,3,6,7,8-HpCDD/TEF	0.000067		7.57×10^{-5}
1,2,3,7,8,9-HpCDD/TEF	0.0003	1.09	7.03×10^{-5}
OCDD/TEF	0.00092	3.35	2.15×10^{-4}

Note: Values in this table are from Table 10 of EPA (2000).

HpCDD = heptachlorodibenzo-p-dioxin
HxCDF = hexachlorodibenzofuran
mg/kg = milligrams per kilogram
OCDD = octachlorodibenzodioxin
PeCDF = pentachlorodibenzofuran
TCDD = tetrachlorodibenzo-p-dioxin
TEF = toxicity equivalency factor

TABLE 6-2

Tribal and Recreational Cancer Risks from Direct Exposure to Beach Sediments and Ingestion of Clams

Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

	Tribal Scenario						
			Direct Contact, Incidental Ingestion				
Chemical of Concern	**Sediment Exposure Concentration (µg/kg)**	**Shellfish Exposure Concentration (µg/kg)**	**Clamming (with Boots)**	**Clamming (without Boots)**	**Consumption of Shellfish**	**Total Risk (with Boots)**	**Total Risk (without Boots)**
Benzo(a)pyrene	688	1.7	4.E-06	9.E-06	2E-01	2E-01	2E-01
Benzo(a)anthracene	2,361	5.5	1.E-06	3.E-06	5E-02	5E-02	5E-02
Benzo(b)fluoranthene	814	5.5	4.E-07	1.E-06	5E-02	5E-02	5E-02
Benzo(k)fluoranthene	814	1.3	4.E-08	1.E-07	1E-02	1E-03	1E-03
Chysene	2,297	12.5	1.E-08	3.E-08	1E-03	1E-03	1E-03
Dibenz(a,h)anthracene	80	0.9	4.E-07	1.E-06	9E-02	9E-02	9E-02
Indeno(1,2,3-c,d)pyrene	121	1.9	6.E-08	2.E-07	2E-02	2E-02	2E-02
					Total	**4E-01**	**4E-01**

	Recreational Scenario						
			Direct contact, Incidental Ingestion				
Chemical of Concern	**Sediment Exposure Concentration (µg/kg)**	**Shellfish Exposure Concentration (µg/kg)**	**Clamming (with boots)**	**Clamming (without boots)**	**Consumption of Shellfish**	**Total Risk (with boots)**	**Total Risk (without boots)**
Benzo(a)pyrene	688	1.7	8.E-07	2.E-06	4E-03	4E-03	4E-03
Benzo(a)anthracene	2,361	5.5	3.E-07	7.E-07	1E-03	1E-03	1E-03
Benzo(b)fluoranthene	814	5.5	1.E-07	2.E-07	1E-03	1E-03	1E-03
Benzo(k)fluoranthene	814	1.3	1.E-08	2.E-08	4E-05	4E-05	4E-05
Chysene	2,297	12.5	3.E-09	7.E-09	3E-05	3E-05	3E-05
Dibenz(a,h)anthracene	80	0.9	1.E-07	2.E-07	2E-03	2E-03	2E-03
Indeno(1,2,3-c,d)pyrene	121	1.9	1.E-08	4.E-08	5E-04	5E-04	5E-04
					Total	**1E-02**	**1E-02**

µg/kg = micrograms per kilogram

SECTION 7

Remedial Action Objectives and Preliminary Remediation Goals

7.1 Remedial Action Objectives

In accordance with the NCP, EPA developed RAOs to describe what the cleanup is expected to accomplish in order to protect human health and the environment. RAOs help focus the development and evaluation of remedial alternatives and form the basis for establishing preliminary remediation goals (PRGs).

7.1.1 Remedial Action Objectives for Soil and Groundwater Operable Units

This section presents the RAOs for the Soil and Groundwater OUs. The final RAOs will be included in the forthcoming ROD Amendment. Once final, the RAOs will supersede the RAOs from the 2000 ROD (EPA, 2000).

- **Upland RAO 1—Reduce human health risks associated with direct contact, ingestion, or inhalation of contaminated soil to levels that allow unrestricted outdoor recreational use.** Reducing contaminant concentrations or physically preventing the direct contact with contaminated soil will reduce human exposure to COCs in the soil.
- **Upland RAO 2—Prevent use of Upper Aquifer groundwater for irrigation or industrial purposes that would result in unacceptable risks to human health.** Ensuring that only appropriate uses of groundwater are allowed will minimize contact with contaminants in the groundwater thereby reducing risks.
- **Upland RAO 3—Reduce risks associated with discharge of contaminated Upper Aquifer groundwater to Eagle Harbor and Puget Sound to levels that protect aquatic life and human consumption of resident fish and shellfish.** Preventing or minimizing contaminated groundwater from migrating into Puget Sound reduces COC concentrations in surface water, sediment, fish, and shellfish, which reduces human health and ecological risks.
- **Upland RAO 4—Prevent further degradation of the Lower Aquifer, and prevent use of Lower Aquifer groundwater that would result in unacceptable risk to human health**. EPA is not proposing cleanup actions in the Lower Aquifer at this time. Minimizing NAPL and contaminated groundwater migration from the Upper Aquifer into the Lower Aquifer will facilitate any cleanup actions needed in the Lower Aquifer in the future.

7.1.2 Remedial Action Objectives for East Harbor Operable Unit

This section presents the RAOs for intertidal sediment in the East Harbor OU. The final RAOs will be included in the forthcoming ROD Amendment. Once final, the RAOs will supersede the RAOs from the 2007 ESD for intertidal sediment (intertidal sediment is sediment at or above an elevation of 0 feet mean lower low water [EPA, 2007]). RAOs for subtidal sediment were selected in the 1994 ROD and will not change. The objective for subtidal sediment was and will remain to meet the chemical concentrations that protect benthic invertebrates in surface sediment (the top 10 centimeters). The concentrations considered protective are the “no adverse effect level” concentrations from the Washington SMSs. Following are the RAOs for East Harbor OU intertidal sediment:

- **Nearshore RAO 1—Prevent risk to human health posed by direct contact with NAPL in surface sediments (defined as the top 10 centimeters) of intertidal beach areas.** Once this RAO is achieved, the beaches could be opened for limited recreational use (with no shellfish collection) until such time as the other RAOs are achieved.
- **Nearshore RAO 2—Reduce to protective levels the risk to human health posed by dermal contact and incidental ingestion of contaminated sediments in the top 2 feet of**

intertidal areas that provide habitat for shellfish. Meeting this RAO will ensure that people can collect shellfish safely.

- **Nearshore RAO 3—Reduce levels of COCs in the top 10 centimeters of sediments to concentrations that protect benthic community health.** Meeting this RAO will protect worms, clams, and other sediment-dwelling organisms. This RAO was included as a conceptual target condition in the 1994 ROD.
- **Nearshore RAO 4—Reduce levels of COCs in shellfish tissue to concentrations that protect Tribal shellfish consumers.** This RAO will be met through the removal of contaminated sediments, capping, and MNR. Contaminant concentrations in shellfish tissue are expected to decline over time in response to lowered exposure concentrations.
- **Nearshore RAO 5—Prevent risks from consumption of shellfish until protective levels are achieved.** This RAO will be met through continued use of shellfish consumption advisories and warnings until they are no longer needed.

7.2 Preliminary Remediation Goals

PRGs are numeric contaminant-specific concentrations for environmental media (such as groundwater or sediment) that serve as target goals during the initial development, analysis, and selection of cleanup alternatives. PRGs are developed during the Site investigation and cleanup planning process, and are based on Applicable or Relevant and Appropriate Requirements (ARARs). Where standards do not exist, risk based levels are developed. ARARs are discussed in Section 9.2.2.

PRGs are intended to protect human health and the environment by achieving risk reductions associated with each RAO. New or different requirements may be identified during the public review process that may modify the PRGs. PRGs are preliminary until the ROD, at which time they may be revised or adopted as final cleanup levels.

7.2.1 Preliminary Remediation Goals for Soil and Groundwater Operable Units

The following PRGs for the Soil and Groundwater OUs are designed to reduce risks due to contact with soils and comply with ARARs:

- **Soils—**The PRGs for soil in the Soil and Groundwater OUs are listed in Table 7-1. These PRGs are the Washington Model Toxics Control Act (MTCA) Method B soil cleanup levels. They are considered safe for unrestricted use. EPA identified MTCA Method B as the soil cleanup levels in the 2000 ROD. EPA is proposing to update the PRGs for soil so they are consistent with updated MTCA Method B requirements. Both the old and proposed new levels are shown in Table 7-1. The upland cap will prevent exposure to soils beneath it that remain contaminated above the PRGs following the cleanup. Institutional controls will be put in place to prohibit excavation below the cap.
- **Upper Aquifer groundwater—**Because the Upper Aquifer is not a drinking water aquifer and is contained within the perimeter sheet pile wall, maximum contaminant levels (drinking water levels) do not apply. EPA is not establishing PRGs for Upper Aquifer groundwater. Some groundwater likely will need to be discharged from the Upper Aquifer in the future. EPA will establish effluent limits for groundwater that is collected and discharged to Eagle Harbor consistent with the substantive requirements of Section 402 of the Clean Water Act and Washington Administrative Code 173-220.

7.2.2 Preliminary Remediation Goals for East Harbor Operable Unit

The PRGs for intertidal sediment in the East Harbor OU consider both human and ecological risk. People can be exposed to contaminants in beach sediments through direct contact, incidental ingestion, and ingestion of shellfish collected from the beaches. Ecological risks consider the impact of contaminants to benthic organisms, including worms and clams that live in the beaches. Following are the PRGs for the intertidal beaches of the East Harbor OU:

- **Intertidal sediments and human health—** Concentrations that protect Tribal shellfish collectors are provided in Table 7-2. These levels assume both incidental ingestion of sediment and dermal exposure while collecting shellfish. These concentrations will be met in the top 2 feet of sediment, which is the maximum depth at which horse clams are found on the impacted beaches. In addition, EPA will consider RAO 1 (direct contact risks) addressed when no NAPL is observed on the surface of the beaches during three consecutive annual low tide inspections.
- **Intertidal sediments and benthic invertebrates—**Concentrations that protect benthic organisms are provided in Table 7-3. These values are from the Washington SMSs. The RAO will be met when contaminant concentrations in the top 10 centimeters of the sediment are at or below these values.

7.2.3 Shellfish Target Tissue Concentration for East Harbor Operable Unit Beaches

EPA's proposed cleanup actions will lower contaminant concentrations in sediment and porewater. Shellfish tissue concentrations are expected to decline over time in response. However, the relationship between contaminant concentrations in sediment and clam tissue is poorly understood. Because EPA cannot confidently predict contaminant concentration declines in shellfish tissue, EPA is establishing a target tissue concentration for shellfish, rather than a PRG.

The target tissue concentration for carcinogenic PAHs is 0.12 μg/kg [benzo(a)pyrene] TEQ in the edible tissue of horse clams. This concentration represents the background concentration of carcinogenic PAHs in clam tissue collected from nonurban locations in Puget Sound. This concentration is higher than the risk-based concentration of 0.01 μg/kg [benzo(a)pyrene] TEQ that would protect Suquamish Tribal shellfish consumers. EPA is selecting the background concentration because achieving tissue concentrations below background may not be possible. The data set used to generate the background concentration is small, so the background concentration is uncertain. EPA will continue to monitor tissue concentrations at the site and collect horse clams from background locations to develop a more robust background data set.

Tissue concentration data collected following cleanup actions on the beaches will be used for informational purposes to assess the success of the cleanup in reducing ongoing risks to people who may consume shellfish from Eagle Harbor. Tissue monitoring data will also inform the content or degree of potential future shellfish advisories.

TABLE 7-1
Preliminary Remediation Goals for Soil
Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Contaminant of Concern	2000 ROD Remedial Goal[a] (mg/kg)	Preliminary Remediation Goal—MTCA Method B for Unrestricted Use[b] (mg/kg)
Naphthalene	3,200	1,600 (nc)
Acenaphthylene	NS	NS
Acenaphthene	4,800	4,800 (nc)
Fluorene	3,200	3,200 (nc)
Phenanthrene	N/S	N/S
Anthracene	24,000	24,000 (nc)
Fluoranthene	3,200	3,200 (nc)
Pyrene	2,400	2,400 (nc)
Benz(a)anthracene	0.137	1.37 (c)
Chrysene	0.137	137 (c)
Benzo(b)fluoranthene	0.137	1.37 (c)
Benzo(k)fluoranthene	0.137	137 (c)
Benzo(a)pyrene	0.137	0.137 (c)
Indeno(1,2,3 c,d) Pyrene	0.137	1.37 (c)
Dibenzo (a,h) Anthracene	0.137	0.137 (c)
Benzo(g,h,i)perylene	N/A	N/A
Pentachlorophenol	8.33	2.50 (c)
Dioxin (2,3,7,8- Tetrachlorodibenzo-p-dioxin)	0.000007	0.0000013 (c)

Notes:
[a] EPA (2000).
[b] Lowest concentration of noncancer (nc) or cancer (c) listed. Value shown corresponds to excess lifetime cancer risk of 1 x 10^{-6} and has not been adjusted downward to meet the requirements of 1 x 10^{-5} for multiple carcinogens per WAC 173-340-708 (5).

c = cancer
EPA = U.S. Environmental Protection Agency
mg/kg = milligrams per kilogram
MTCA = Washington Model Toxics Control Act
N/A = not applicable
nc = noncancer
N/S = none specified
ROD = Record of Decision
WAC = Washington Administrative Code

TABLE 7-2
Preliminary Sediment Remediation Goals for the Protection of Human Health (RAO 2)[a]
Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Chemical Parameter	Risk-based Concentration, ppb (µg/kg) Dry Weight[b]	Puget Sound Background Concentration ppb (µg/kg) Dry Weight[c]	Sediment PRG ppb (µg/kg) Dry Weight
Benz(a)anthracene	631	4.29	631
Chrysene	63,083	4.44	63,038
Benzo(b)fluoranthene	631	10.22	631
Benzo(k)fluoranthene	6,308	4.81	6,308
Benzo(a)pyrene	63	6.17	63
Indeno(1,2,3 c,d)pyrene	631	3.99	631
Dibenzo(a,h)anthracene	63	1.62	63
cPAHs (sum TEQ)	63	10	63

[a] These PRGs would be compared to the average concentrations of COCs in the top two feet of beach sediment

[b] From EPA risk evaluation (EPA, 2016c). These values are protective of Suquamish tribal shellfish collectors, and assumes shellfish are collected in bare feet (no boots). The combined risk of incidental ingestion and dermal update was used to generate these values.

[c] From Bold Study (DMMP, 2009), values are the 95th percentile upper confidence limit on the mean (UCL 95).

µg/kg = micrograms per kilogram
COC = contaminant of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbons
DMMP = Dredged Material Management Program
EPA = U.S. Environmental Protection Agency
ppb = parts per billion
PRG = preliminary remediation goal
TEQ = toxicity equivalent quotient
UCL = upper confidence limit

TABLE 7-3
Preliminary Sediment Remediation Goals for the Protection of Benthic Organisms (RAO 3)
Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Chemical Parameter	SMS SCO[a] mg/kg (ppm) Organic Carbon[b]	LAET[c] µg/kg (ppb) Dry Weight[b]
LPAH	370	5,200
Naphthalene	99	2,100
Acenahpthylene	66	5,600
Acenaphthene	16	500
Fluorene	23	540
Phenanthrene	100	1,500
Anthracene	220	960
2-Methylnaphthalene	38	670
HPAH	960	12,000
Fluoranthene	160	1,700
Pyrene	1000	2,600
Benz(a)anthracene	110	1,300
Chrysene	110	1,400
Total Benzofluoranthenes	230	3,200
Benzo(a)pyrene	99	1,600
Indeno(1,2,3 c,d)pyrene	34	600
Dibenzo(a,h)anthracene	12	230
Benzo (g,h,i)perylene	31	670

[a] From SMS Table III Marine Sediment Cleanup Objectives and Cleanup Screening Levels for protection of benthic organisms (WAC 173-204-562).
[b] These PRGs are for the protection of benthic organisms, and would apply on a point-by point basis
[c] LAET values are applicable to samples with less than 0.5 percent TOC. These values are from Ecology (2015). Where the TOC concentration is ≥ 0.5 percent, the PRG is the SMS SCO. Where TOC is < 0.5 percent, the PRG is the LAET. In the nearshore beaches at the Wyckoff site, most sediment has a TOC concentration lower than 0.5 percent.

µg/kg = micrograms per kilogram
DMMP = Dredged Material Management Program
Ecology = Washington State Department of Ecology
HPAH = high-molecular weight polycyclic aromatic hydrocarbon
LAET = lowest apparent effects threshold
LPAH = low-molecular weight polycyclic aromatic hydrocarbon
mg/kg = milligrams per kilogram
ppb = parts per billion
ppm = parts per million
PRG = preliminary remediation goal
RAO = remedial action objective
SCO = Sediment Cleanup Objective
SMS = Sediment Management Standard
TOC = total organic carbon
WAC = Washington Administrative Code

SECTION 8
Remedial Alternatives

This section presents and describes the remedial alternatives evaluated by EPA. Alternatives for the Soil and Groundwater OUs (upland) are presented first, followed by East Harbor OU (nearshore) alternatives.

Cost Estimates and Discount Rates

The cost estimates in this Proposed Plan are present value costs, calculated using a 7 percent discount rate, as required by EPA policy and guidance. Applying a discount rate to calculate the present value of future construction costs impacts the overall cost estimate and has the greatest effect on alternatives with high costs in the future. To see how present value calculations impact these cost estimates, see Table 9-4, which presents estimated costs for each alternative using nondiscounted (2016) dollars, as well as present value costs using both a 7 percent discount rate and the current recommended discount rate of 1.4 percent.

8.1 Upland Soil and Groundwater Operable Units

Starting with a baseline No Further Action Alternative (Upland Alternative 1), EPA initially developed six upland alternatives for the Soil and Groundwater OUs, employing a range of remedial technologies. A seventh upland alternative that includes a phased or iterative approach was developed and evaluated. Because many of the upland alternatives would require O&M beyond the standard period of 30 years, the cost analysis in this Proposed Plan includes O&M for 100 years. A considerable amount of preparatory and general construction work will be required to implement any of the alternatives. Because they are included in many if not all of the upland alternatives, these "common elements" are described first.

8.1.1 Upland Common Elements

Following are remedial components that are common to all upland alternatives:

- **Preconstruction activities—**Obtain permits, develop health and safety and other work plans, mobilize and demobilize equipment, and develop 100-percent remedial design drawings.
- **Access road—**Realign, regrade, and resurface the current access road. The road between Eagle Harbor Drive and the former wood-treating facility has curves that are too sharp for large semitrailer trucks to navigate, and the 15 percent grade is too steep.
- **Concrete demolition, decontamination, and reuse—**Remove buried concrete that impedes implementing the upland alternatives. Although most aboveground structures have been removed, many old building foundations and other below ground structures, such as sumps, remain.
- **Sitewide debris removal—**Remove, as needed, other buried utilities and debris (for example, storm drains, electrical conduit) that are blocking access to subsurface soils.
- **Other and miscellaneous demolition—**Decommission and dispose of the steam pilot plant area and the associated equipment and infrastructure. Under Upland Alternative 2, some of the equipment could be left in place.
- **Stormwater infiltration trench—**Install a stormwater infiltration trench to provide an infiltration area for surface water collected during remedial action construction activities.
- **Bulkhead removal—**Remove the former facility bulkhead and other debris inside the sheet pile wall, where necessary. When the perimeter sheet pile wall was constructed, it was built in the water, just offshore of the former facility bulkhead. The area between the wall and the former shoreline has since been filled, mostly with rock and debris from demolition activities along West Beach. This material must be removed to make room for the replacement bulkhead wall (another common element, discussed below).
- **Additional sheet pile wall—**Install a second sheet pile wall parallel to the existing wall. This would allow the concrete perimeter bulkhead

to be installed as described below. The existing perimeter sheet pile wall could fail within 10 to 20 years due to corrosion at and above the mud line.

- **Concrete perimeter and bulkhead wall—** Construct a new reinforced concrete wall on the inside of the existing sheet pile wall. The new concrete wall would provide geotechnical support to accommodate additional soil loading and promote post-remediation stability of the shoreline. The depth would vary depending on the alternative. Under Upland Alternative 4, the wall would be shallower (and less expensive) than under other alternatives.
- **Final upland cap—**Construct a cap with a low-permeability layer to minimize surface water infiltration and prevent exposure to residual contaminants.
- **New outfall pipe—**Install a new outfall pipe to convey stormwater from the surface of the cap to a discharge point in Eagle Harbor or Puget Sound. The discharge point and alignment of the new outfall pipe would be selected during design.
- **Passive groundwater drainage with treatment—**Install a passive drainage system through the perimeter wall to allow water to drain to discharge points below the surface of the beaches. Although the final Site cap would minimize infiltration, water may still move into the Upper Aquifer, primarily from the Lower Aquifer. Therefore, to prevent flooding inside the perimeter wall, water may need to be drained through the perimeter wall. Treatment (for example, activated carbon filters) may be included in the drainage system if additional treatment is needed to meet effluent discharge requirements.
- **Groundwater monitoring—**Conduct regular groundwater sampling during and after construction to ensure RAOs are met.

Accuracy of Cost Estimates

Cost estimates in this Proposed Plan are based on conceptual designs and have an accuracy range of -30 to + 50 percent. For an item with an estimated cost $100,000, this means the actual cost is expected be between $70,000 and $150,000.

Project Costs and Construction Timelines

Timelines and cost estimates presented in this section of the Proposed Plan assume no delays in funding and no limit on the amount of money available in any given year. In reality, funding delays are likely. If annual funding amounts are limited, then the overall construction timelines will be longer than presented here, and the total project costs will increase. Because predicting future funding availability is difficult, EPA did not adjust the ideal construction timelines provided for each alternative. Funding limitations would have the largest impact on Alternative 4, which has a relatively short initial construction period and high up-front costs.

- **Institutional Controls—**Establish uniform environmental covenant and/or deed restrictions, as needed, to prevent the withdrawal of any contaminated groundwater remaining after construction, to protect the final Site cap, and to prevent excavation into treated soils left in the upland. The nature and geographic extent of restrictions that may be needed will depend on the cleanup alternative selected.
- **Inspections, Monitoring, and Reporting—** Require periodic inspections and reporting every 5 years for all alternatives.

Table 8-1 shows which common elements are needed for each upland alternative and provides cost estimates for each of the common elements.

8.1.2 Upland Alternatives

This section describes the upland alternatives evaluated by EPA.

8.1.2.1 Upland Alternative 1—No Further Action

Estimated Capital Costs: $0

Estimated O&M Costs: $0

Total Estimated Present Value: $0

Estimated Construction Timeframe: 0 years

Estimated Time to Achieve RAOs: Not applicable

As required under the Superfund law, a “no action” alternative is evaluated to compare cleanup alternatives with baseline Site conditions. Under

Upland Alternative 1—No Further Action would be taken for the Wyckoff Soil and Groundwater OUs. The existing groundwater extraction wells and groundwater treatment plant would be shut down, and this equipment would not be decommissioned. The perimeter sheet pile wall would be left in place and over time, it would probably fail near the mudline due to corrosion. If that happened, the wall would tip over onto the beach. The portion of the wall that is currently below the mudline would remain in place, and it would continue to provide partial containment of subsurface NAPL and dissolved-phase contaminants. However, contaminated soils and NAPL above the beach surface would be washed onto the beaches. Upland Alternative 1 is not considered protective and does not meet ARARs or achieve RAOs.

8.1.2.2 Upland Alternative 2—Containment

Estimated Capital Costs: $44,500,000

Estimated O&M Costs: $7,600,000

Total Estimated Present Value: $52,100,000

Estimated Construction Timeframe: 2 years

Estimated Time to Achieve RAOs: 2 years, but would require more than 100 years of groundwater extraction and treatment

Upland Alternative 2 was included as the contingency remedy in the 2000 ROD (EPA, 2000). After a pilot study completed in 2003 (U.S. Army Corps of Engineers, 2006) showed that the thermal treatment remedy failed to meet performance expectations, some, but not all, contingency remedy components were implemented. Under this alternative, the remaining components of the contingency remedy specified in the 2000 ROD would be completed, and the remedy would be operated for 100 years. In addition to the common elements, Upland Alternative 2 would include the following:

- Replacing the perimeter sheet pile wall
- Upgrading the groundwater extraction and treatment system, including installing four new recovery wells, rehabilitating the nine existing recovery wells, and upgrading the existing groundwater treatment plant

O&M would include continued operations of the groundwater extraction and treatment system for a minimum of 100 years. The system would operate 24 hours a day, 7 days a week, except during maintenance and repair periods. Recovered NAPL would be transported off Site for incineration in a hazardous waste incinerator.

Consistent with the other alternatives, Upland Alternative 2 includes 100 years of operations and maintenance. Although accurate prediction is difficult, it is estimated that more than 100 years of groundwater extraction and treatment would be needed to protect Eagle Harbor from unacceptably high levels of contamination in discharging groundwater. Therefore, the cost estimate may underestimate operations and maintenance costs.

Figure 8-1 provides an overview of Upland Alternative 2.

8.1.2.3 Upland Alternative 3—Excavation, Thermal Desorption, and In-Situ Chemical Oxidation

Upland Alternative 3 was developed because EPA wanted to include an alternative that would remove contaminants to the maximum extent practicable. However, during preliminary engineering, the degree of shoring and dewatering necessary to excavate soils to the planned depth was determined to be technically impracticable without incurring significant geotechnical risk. Alternative 3 is discussed here briefly for the sake of completeness, but because it was dropped from consideration, it is not included in the analysis of alternatives.

Upland Alternative 3 included excavating contaminated soils from most of the upland to depths as great as 55 feet. The excavated soils would be treated in a medium temperature thermal desorption unit to destroy the contaminants, then reburied within the excavation. Contaminated areas deeper than 55 feet would have been treated by injecting chemical oxidants, such as permanganate or hydrogen peroxide. Enhanced aerobic biodegradation (EAB) would have been used as a “polishing” step to further reduce contaminant concentrations in the top portion of the aquifer. In the EAB phase, air would have been injected into the ground, providing oxygen to naturally-occurring organisms in the soils that break down contaminants.

8.1.2.4 Upland Alternative 4—In-Situ Solidification/Stabilization

Estimated Capital Costs: $87,000,000

Estimated O&M Costs: $1,500,000

Total Estimated Present Value: $88,500,000

Estimated Construction Timeframe: 4 years active construction, followed by 8 years of passive groundwater treatment

Estimated Time to Achieve RAOs: 12 years

Under Upland Alternative 4, NAPL-contaminated soil and groundwater would be treated in-situ by immobilizing it in a cement-type matrix. ISS is common in the construction industry, where it is used to strengthen weak soils, divert groundwater, or stabilize steep slopes. ISS is being used with increasing frequency in environmental cleanup projects, including sites contaminated with NAPL. ISS traps NAPL contaminants in a stable soil/concrete matrix. In addition to the common elements, this alternative includes the following activities:

- Testing contaminated soils from the upland to determine the best mix of reagents and the amount of reagent needed—Typical reagents include Portland cement, slag cement, bentonite, and oleophilic clay.
- Excavating the treatment area to a depth of approximately 7 feet, creating room for the soil to swell when the reagents are added—Excavated soils would be stockpiled and then solidified using above-ground reagent mixing for incorporation in the upland grading plan.
- Constructing a temporary cement batch plant in the upland area to mix the reagents into a slurry before mixing it in-situ with the soil.
- Mixing the reagents into the soils over most of the upland using large augers that inject reagent slurry as they advance down into the soil—This technology would be used to treat soils down to a depth of about 50 feet. Auger-mixing creates round vertical columns of treated material. The columns are overlapped to ensure all the target soils are treated.
- Delivering reagents into deeper portions of the upland using jet-grouting—Jet-grouting relies on pressure rather than mechanical mixing to fluidize subsurface soils and reagent.
- Using auger-mixing and jet-grouting to treat approximately 352,000 cubic yards of soil.
- Groundwater would be treated in filters in the passive drain system (common to all alternatives except Alternatives 1 and 2) until the groundwater is clean enough to discharge without treatment. EPA estimates that 8 years of treatment would be needed. Once treatment is no longer needed, the filters would be removed from the passive drain system.

O&M would consist of passive groundwater treatment until treatment is no longer needed.

Figure 8-2 provides and overview of Upland Alternative 4.

8.1.2.5 Upland Alternative 5—Thermal-Enhanced Extraction and In-Situ Solidification/Stabilization

Estimated Capital Costs: $118,300,000

Estimated O&M Costs: $1,300,000

Total Estimated Present Value: $119,600,000

Estimated Construction Timeframe: 10 years of active construction, followed by 17 years of passive groundwater treatment

Estimated Time to Achieve RAOs: 27 years

Upland Alternative 5 would remove most NAPL from the upland through a combination of NAPL recovery wells and thermal-enhanced extraction. The remedial work would happen in several stages:

- Treating DNAPL in deep portions of the northern part of the upland using ISS—Because of the depth, the ISS would be accomplished with jet-grouting. This technology is also proposed for this area under Alternative 4.
- Extracting NAPL from an array of approximately 147 new extraction wells—NAPL and water would be separated by an oil-water separator. Water would be treated in the existing groundwater treatment plant. The treated water would be injected into the ground to

help push NAPL towards the extraction wells. By removing a large amount of NAPL early on, this stage would reduce the time and cost to implement thermal-enhanced extraction. Recovered NAPL would be transported offsite for incineration in a hazardous waste incinerator.

- Injecting steam into the wells during a thermal-enhanced extraction phase—The steam would cause contaminants in the soil and groundwater to transfer into the vapor phase. A vapor barrier would be constructed over the treatment area to enhance contaminated soil vapor recovery. Recovery wells would extract vapors, and additional dewatering wells would be used to extract NAPL and groundwater. Recovered NAPL would be transported offsite for incineration in a hazardous waste incinerator. Contaminated vapors would be treated in a thermal oxidation unit. Because of the dense array of wells needed, thermal-enhanced extraction would be conducted over a smaller portion of the upland, which would be isolated by vertical sheet pile walls. It is estimated that five such treatment zones may be needed to cover the targeted treatment area.
- Using EAB to treat areas with lower levels of contamination and as a polishing step following thermal-enhanced extraction.

Steam injection was pilot tested in the upland between 2002 and 2003 (U.S. Army Corps of Engineers, 2006). At that time, EPA concluded that the technology alone could not meet the RAOs in the 2000 ROD. Lessons learned from the pilot were considered when developing this alternative. Upland Alternative 5 has several features, including aggressive NAPL recovery prior to steam injection, that would help ensure the success of this alternative, should it be selected. More importantly, the groundwater cleanup goals and the primary means of protecting surface water in Eagle Harbor have changed. In the 2000 ROD, EPA was seeking to reduce contaminant concentrations in groundwater sufficiently to allow groundwater to discharge without further treatment to Eagle Harbor. EPA is now proposing to permanently manage and contain contaminated soil and groundwater behind the perimeter wall and beneath the final upland cap, which would allow higher concentrations to be left in place.

O&M would consist of passive groundwater treatment until treatment is no longer needed.

Figure 8-3 provides an overview of Upland Alternative 5.

8.1.2.6 Upland Alternative 6—Excavation, Thermal Desorption, and Thermal-Enhanced Extraction

Estimated Capital Costs: $160,100,000

Estimated O&M Costs: $1,400,000

Total Estimated Present Value: $161,500,000

Estimated Construction Timeframe: 12 years of active construction, followed by 15 years of passive groundwater treatment

Estimated Time to Achieve RAOs: 27 years

Upland Alternative 6 is a hybrid of Upland Alternatives 3 and 5, and it uses excavation and thermal desorption in the center of the former process area where NAPL concentrations are particularly high, but only to a depth of 20 feet, thus avoiding the geotechnical problems of Upland Alternative 3. This alternative employs thermal-enhanced extraction below 20 feet. Unlike Upland Alternative 5, Upland Alternative 6 would use thermal-enhanced extraction to treat deep contamination in the northern part of the upland. Like Upland Alternative 5, this alternative would rely on EAB to treat lower levels of contamination in the periphery of the upland and as a polishing step following thermal-enhanced extraction.

O&M would consist of passive groundwater treatment until treatment is no longer needed.

Figure 8-4 provides and overview of Upland Alternative 6.

8.1.2.7 Upland Alternative 7—In-Situ Solidification/Stabilization of Core Area and Thermal-Enhanced Recovery

Upland Alternative 7 would break the remedy into two distinct phases, separated by a 5-year period of monitoring (see box). Phase 1 actions alone could be sufficient to meet cleanup goals; however,

	Phase 1 Only	Phase 1 and Phase 2
Estimate Capital Costs	$70,800,000	$81,600,000
Estimated O&M Costs	$500,000	$900,000
Total Estimated Present Value	$71,300,000	$82,500,000
Estimated Construction Timeframe	10 years of active construction, followed by up to 5 years of monitoring with continued groundwater extraction and treatment, then 16 years of passive groundwater treatment	13 years of active construction spread over 18 years (with a "pause" for monitoring after year 10), followed by 16 years of passive groundwater treatment
Estimated Time to Achieve RAOs	31 years	34 years

if Phase 2 is needed, then it would be employed only in those areas of the upland where cleanup goals are not met following Phase 1.

In addition to the common elements, **Phase 1** would consist of three treatment technologies:

- ISS would be the primary remedial technology in Phase 1. The ISS footprint would be smaller than in Upland Alternative 4, but it would encompass the most heavily contaminated areas in the center of the former process area. The top 7 to 10 feet of soil within the ISS treatment area would excavated first, to allow room for soil swelling. Auger-mixing would be used to treat subsurface soils within the ISS footprint to the depth of contamination. Soil excavated from the top 7 to 10 feet would be treated with above-ground mixing. ISS would be used to treat approximately 144,000 cubic yards of soil.
- NAPL recovery (using new extraction wells but no steam or other heat) would be used to treat two areas north of the ISS footprint where the thickness of the NAPL suggests it would be amenable to recovery. Recovered NAPL would be transported offsite for incineration in a hazardous waste incinerator.
- EAB would be used to treat contamination along the inside of the perimeter wall. The passive groundwater drainage system, a common element in all of the alternatives, would collect groundwater from inside the wall and allow it to drain to Eagle Harbor. EAB would be used to treat water in this zone, reducing the need for treatment in the passive groundwater drainage system.

Post Phase 1 monitoring would involve the following activities:

- The Site would be monitored for 5 years following Phase 1. Solidifying soils in the center of the upland will affect groundwater, NAPL, and dissolved contaminant concentrations in groundwater, but it is difficult to fully predict these effects. Groundwater levels, any continued NAPL recovery in groundwater wells, and dissolved contaminant concentrations would all be monitored, and the data used to determine whether Phase 2 actions are needed and if so, where. A 5-year monitoring period is planned, but if it becomes clear that cleanup goals will not be met in that timeframe, then the decision to implement Phase 2 actions could be made earlier.
- Key factors that would trigger Phase 2 actions include the continued presence of mobile NAPL in and around the passive drainage collection system, and dissolved concentrations of contaminants that are too high to treat cost-effectively with passive filters. Either condition would suggest that Phase 2 actions are needed.

Following are **Phase 2** technologies:

- EPA would use thermal-enhanced NAPL recovery in Phase 2. Thermal-enhanced NAPL recovery is different from the thermal-enhanced NAPL extraction technology included in Upland Alternatives 5 and 6. In this alternative, less heat and energy would be required than in Upland Alternatives 5 and 6. The steam injected in the ground would not be hot enough to cause the contaminants to move into the vapor phase. This lower energy “wet steam” would not remove contaminants as effectively, but it would increase the mobility of the NAPL, allowing for a greater recovery rate. Recovered NAPL would be transported offsite for incineration in a hazardous waste incinerator.

- The cost estimate assumes that thermal enhanced NAPL recovery would be employed everywhere outside the Phase 1 ISS footprint. However, Phase 2 actions would only be implemented in those areas of the upland where cleanup goals were not met during Phase 1. Therefore, actual Phase 2 costs may be less than estimated.
- Based on the efficacy of Phase 1 actions, and the extent of contamination remaining after Phase 1, Phase 2 could be modified to include other technologies such as additional ISS using auger-mixing and/or jet-grouting as needed, or in-situ chemical oxidation. The decision to use any of these additional technologies in Phase 2 would be documented in a future CERCLA decision document.

The construction schedule would depend on the success of Phase 1 actions.

- If Phase 1 actions are sufficient and Phase 2 is not needed, active construction would take 10 years.
- If Phase 2 is needed, an additional 3 years of construction would be needed.

O&M activities would include continued operation of the groundwater extraction and treatment system until contaminant concentrations in the groundwater are low enough to switch to passive treatment, and then passive treatment until concentrations are low enough to discharge without treatment.

Figure 8-5 provides an overview of Upland Alternative 7.

8.2 Nearshore East Harbor Operable Unit

Remedial technologies available to address contamination in the beach sediments are more limited than for the upland area. The alternatives below rely upon standard sediment cleanup technologies—dredging, capping, and MNR.

8.2.1 Nearshore Common Elements

Following are remedial components that are common to all nearshore alternatives:

- **MNR—**MNR relies on natural processes to reduce ecological and human health risks, while monitoring the natural recovery over time. At the Wyckoff Site, both dilution facilitated by tidal exchange and aerobic biodegradation are occurring. MNR has been shown to be effective in Eagle Harbor; the beaches are in considerably better condition than they were before the perimeter sheet pile wall was installed. EPA assumes that MNR will continue, facilitated by the additional source control measures recommended in this Proposed Plan. The existing Operations, Maintenance, and Monitoring Plan for OU-1 (HDR, et al., 2011) would be modified to include the newly remediated intertidal beach areas and the MNR areas. The monitoring program includes surveys to assess the physical stability of the beaches and visual assessment of NAPL seeps, clam tissue, and sediment sampling.
- **Offsite disposal—**Offsite landfill disposal of excavated sediment is assumed for all of the active alternatives. Sediment removed from the beaches would be placed on a pad in the upland and allowed to drain and “dewater.” The material would be tested to see whether it meets requirements for truck transport and disposal in a nonhazardous (subtitle D) landfill. If the sediment remains too wet to transport or releases oily contamination, Portland cement would be mixed into the sediment. The Portland cement would trap excess water and oily contamination, resulting in a loose soil-like mixture dry enough to stack in a pile. The sediment would then be transported offsite for disposal.

- **Institutional controls—**A uniform environmental covenant and/or deed restrictions would be established, as needed, to prevent future marine construction projects from impacting the portion of the beaches that are capped.
- **Shellfish advisories and warnings—**Until such time as contaminant concentrations in shellfish are low enough to support unrestricted harvest and consumption, EPA would continue to work with the Washington Department of Health to issue and publicize shellfish consumption advisories.

8.2.2 Nearshore Alternatives

EPA considered a range of remedial alternatives to address contamination in the beaches, beginning with no action and ending with the most aggressive remedy—dredging to the maximum extent practicable. The alternatives in between these two extremes would employ permeable reactive capping over varying sized beach areas.

8.2.2.1 Nearshore Alternative 1—No Further Action

Estimated Capital Costs: $0

Estimated O&M Costs: $0

Total Estimated Present Value: $0

Estimated Construction Timeframe: N/A

Estimated Time to Achieve RAOs: More than 20 years

Under Nearshore Alternative 1, no further actions would be taken to address the NAPL contamination remaining in the beaches. The current remedy for the beaches, MNR, would remain in place. The cleanup goals would remain unchanged from the 1994 ROD, as amended by the 2007 ESD. Monitoring of all of OU-1, including both the subtidal sediment cap and the intertidal beaches would continue. MNR is expected to continue, resulting in further declines in contaminant concentrations. However, the beaches are unlikely to meet the RAOs within 10 years, particularly on East Beach, where the most significant and persistent NAPL seeps remain.

8.2.2.2 Nearshore Alternative 2—Seep Capping

Estimated Capital Costs: $2,610,000

Estimated O&M Costs: $500,000

Total Estimated Present Value: $3,110,000

Estimated Construction Timeframe: 2 months

Estimated Time to Achieve RAOs: 15 to 20 years

Nearshore Alternative 2 includes small cap "patches" approximately 40 feet by 40 feet in size over active seep areas in the beaches; there are four known active seep areas. These four areas would be remediated, and potentially up to two additional seeps may be addressed, should they be discovered during predesign sampling. Therefore, for cost-estimating purposes, a total of six seeps would be remediated, which would result in active remediation over 0.3 acre of beach habitat. The remaining 10.5 acres would be addressed through MNR.

Seep areas would be remediated by removing the top 30 inches of sediment and replacing the material with a permeable reactive cap. The cap would consist of three layers:

- A 4- to 6-inch thick layer of reactive materials at the bottom of the excavated area
- A demarcation layer
- Clean sand above the demarcation layer

Specific materials for the reactive layer and the demarcation layer would be evaluated and identified during remedial design. For now, EPA assumes that the reactive layer would contain oleophilic clay with or potentially without activated carbon. These materials would intercept and adsorb NAPL and PAHs flowing upward through the cap. The demarcation layer would discourage digging below it and provide a visual reference that would be helpful during future replacement or repair efforts, should they be needed. Coarse gravel or cobbles are possible demarcation layer materials. The clean sand would be approximately two feet thick, and it would be graded to match the beach around it so that there would be no change in the beach elevation as a result of the remedy.

The seep patches would be constructed during low tide. Sump pumps or temporary well points would be used to keep water out of the excavation areas during construction.

O&M activities would include monitoring to ensure the capped areas remain in place and that they effectively prevent exposure to remaining subsurface contamination. The reactive layer of the cap may require replenishing if breakthrough is observed. For cost estimating purposes, it is assumed that 25 percent of the capped area in the North Shoal and 25 percent of the capped area in the East Beach would require replacement in Year 9, and 25 percent of the capped area in the East Beach would require replacement in Year 30. The additional replacement event for the East Beach is due to the greater number of seeps observed.

The time to meet sediment cleanup levels is uncertain. MNR is occurring on the beaches today, but EPA does not know how the rate of recovery will change over time. The timeline for meeting shellfish tissue cleanup levels is also uncertain. Even when the cleanup levels for sediment are achieved throughout the beaches, it may take additional time for shellfish concentrations to decline.

Figure 8-6 provides an overview of Nearshore Alternative 2.

8.2.2.3 Nearshore Alternative 3—Partial Excavation and Capping

Estimated Capital Costs: $8,920,000

Estimated O&M Costs: $2,850,000

Total Estimated Present Value: $11,770,000

Estimated Construction Timeframe: 4 months

Estimated Time to Achieve RAOs: 10 to 15 years

Nearshore Alternative 3 would apply the same technology and construction technique as Alternative 2, but over a much larger area. Contaminated sediment would be removed to a depth of 30 inches. These areas would then be backfilled with a reactive layer, a demarcation layer and clean gravelly sand. Caps approximately 40 feet x 40 feet in size would be built next to one another and overlapped slightly to cover larger, contiguous areas of the beaches. The target areas for remediation were selected based on presence of NAPL in the top two feet of sediment. Additional sampling and observations would be used to refine the target area on the North Shoal prior to construction. Additional sampling is not needed on East Beach. This alternative would actively remediate approximately 1.6 acres; the remaining 9.2 acres would be remediated through MNR. The estimated sediment excavation volume is approximately 6,600 cubic yards.

In four specific areas of the beach (at FFS sampling locations 2, 8, 27, and 110), NAPL extends slightly below the general excavation depth of 30 inches. In these areas, the excavation would be extended, if feasible, to the depth of NAPL contamination. Removing all the NAPL from these areas would reduce the need for replenishment of the cap's reactive layer in the future.

O&M would be as described for Nearshore Alternative 2.

Figure 8-7 provides an overview of Nearshore Alternative 3.

8.2.2.4 Nearshore Alternative 4—Vertical Containment with Partial Excavation and Capping

Estimated Capital Costs: $12,840,000

Estimated O&M Costs: $2,380,000

Total Estimated Present Value: $15,220,000

Estimated Construction Timeframe: 4 months

Estimated Time to Achieve RAOs: 10 to 12 years

Nearshore Alternative 4 is similar to Nearshore Alternative 3, but with an added remedial component—vertical containment walls. Vertical containment walls would prevent further lateral movement of NAPL, which is slowly moving outward, away from the existing sheet pile wall to the outer portions of the beaches. Reducing the flow of NAPL increases the recovery rate in the areas of the East Harbor OU1 nearshore areas managed using MNR.

The vertical containment walls would be constructed of interlocking steel sheet piles that would extend from just below the surface of the beach to a depth of 20 feet. They would encircle areas of subsurface NAPL and attach to the existing perimeter wall. Areas inside the vertical containment walls would be capped. Capping would consist of the same permeable reactive cap design proposed for Nearshore Alternatives 2 and 3 and would be constructed during low tide. This alternative would actively remediate approximately 1.6 acres; the remaining 9.2 acres would be remediated through MNR. The estimated sediment excavation volume is approximately 6,600 cubic yards.

O&M activities would include monitoring and replenishing capped areas where breakthrough is observed, as described for Nearshore Alternative 2. In addition, it would include one event to replace the vertical sheet pile walls, which are expected to corrode and degrade over a period of approximately 30 years.

Figure 8-8 provides an overview of Nearshore Alternative 4.

8.2.2.5 Nearshore Alternative 5—Dredging

Estimated Capital Costs: $28,960,000

Estimated O&M Costs: $420,000

Total Estimated Present Value: $29,370,000

Estimated Construction Timeframe: 8 months

Estimated Time to Achieve RAOs: 10 years

Nearshore Alternative 5 would involve dredging and removing contaminated sediment and NAPL to a depth of 10 feet in selected North Shoal and East Beach areas. This would remove most NAPL from the beaches. Conventional, barge-mounted, mechanical dredging equipment would be used in the North Shoal. Along East Beach, land-based excavators would be staged in the upland, adjacent to the sheet pile wall. This alternative would actively remediate approximately 1.6 acres; the remaining 9.2 acres would be remediated through MNR. The estimated excavation volume is 26,000 cubic yards. Excavated areas would be backfilled to grade with clean sand. To address NAPL left below the 10-foot excavation depth, a layer of oleophillic clay would be placed at the bottom of the excavation prior to backfilling.

Nearshore Alternative 5 is very different from the other alternatives. Removing even a modest fraction of the sediment volume between tidal cycles is not possible, so this work would be completed using a regular work schedule. To protect both the integrity of the excavation and water quality outside the work areas, heavy sheet pile coffer dam enclosures would be built around the dredging areas. The enclosures would retain water at all times, even during low tides when the beaches are normally exposed. This would allow barges to remain afloat in North Shoal throughout the dredging and backfilling process. The steel sheets would need to extend deep into the sediment, deeper than the proposed 10-foot dredging depth, to withstand the changing pressure of the tides.

O&M costs for Nearshore Alternative 5 would be limited to monitoring. EPA assumes that no long term actions would be needed to repair or maintain the 10-foot thick layers of backfill material included in Nearshore Alternative 5.

Figure 8-9 provides an overview of Nearshore Alternative 5.

TABLE 8-1
Common Elements for Soil and Groundwater Operable Units Remedial Actions
Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

		Upland Alternatives						
Common Element	**Estimated Cost**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Preconstruction Activities	$879,000		X	X	X	X	X	X
Access Roads	$306,000		X	X	X	X	X	X
Concrete Demolition, Decontamination/Reuse	$2,324,000			X	X	X	X	X
Debris Removal	$3,195,000			X	X	X	X	
Other Demolition	$1,276,000		X					
	$2,832,000			X	X	X	X	X
Stormwater Infiltration Trench	$214,000			X	X	X	X	X
Bulkhead Debris Removal	$8,764,000		X	X	X	X	X	X
New Perimeter Sheet Pile Wall	$13,362,000		X	X		X	X	
Concrete Perimeter Wall	$11,363,000		X	X		X	X	X
	$8,029,000				X			
Upland Cap	$4,100,000		X	X	X	X	X	X
New Outfall	$3,294,000		X	X	X	X	X	X
Passive Groundwater Discharge/Treatment	$1,306,000			X	X			
	$1,149,000					X	X	X
Institutional Controls	Included in annual/ periodic costs		X	X	X	X	X	X
5-year reviews[a]	Included in annual/ periodic costs		X	X	X	X	X	X

[a] 5-year reviews provided here for completeness. For this Proposed Plan, the cost of 5-year reviews are assumed to be included within the scope of the remedial action alternative.

SECTION 9

Comparative Analysis

This section describes the criteria used by EPA to compare the alternatives, and the relative performance of each alternative against the criteria. More detailed analyses can be found in the FFS reports for the upland (EPA, 2016b) and nearshore (EPA, 2016a) areas.

9.1 Evaluation Criteria

The Superfund law and regulations, Section 121(b) of CERCLA and NCP §300.430(f)(5)(i), require EPA to evaluate remedial alternatives using the nine criteria listed below:

- **Threshold Criteria—**These criteria specify what an alternative must meet to be eligible for selection as a remedial action:
  1. **Overall protection of human health and the environmen**t**—**Determines whether a remedial action eliminates, reduces, or controls threats to public health and the environment through treatment, engineering controls (such as fencing), or institutional controls (such as deed restrictions).
  2. **Compliance with ARARs—**In addition to ensuring that human and ecological receptors are protected, remedial actions to cleanup a site must attain legally applicable, or relevant and appropriate federal, and state standards and requirements.
- **Balancing Criteria—**These criteria represent technical considerations upon which the detailed analysis is based:
  3. **Long-term effectiveness and permanence—**Considers the ability of a remedial alternative to maintain protection of human health and the environment over time and the reliability of such protection.
  4. **Reduction of toxicity, mobility, and volume through treatment—**Evaluates using treatment to reduce the harmful effects of contaminants and the ability of contaminants to move in the environment. More specific considerations include the amount of hazardous substances that would be destroyed, treated, or recycled; the degree to which treatment is irreversible; and the degree to which treatment reduces the inherent hazards posed by principal threat waste.
  5. **Short-term effectiveness—**Considers both the length of time required to implement a remedial alternative and the risk that constructing the remedy would pose to workers, residents, and the environment.
  6. **Implementability—**Considers the technical and administrative feasibility of implementing a remedial alternative, such as relative availability of goods and services. This criterion also considers whether the technology has been used successfully at other similar sites.
  7. **Cost—**Considers both estimated capital costs and long-term operations and maintenance costs. Costs are expected to be accurate within a range of +50 to -30 percent.
- **Modifying Criteria—**These criteria are evaluated at the end of the public review and comment period; they are not discussed in this Proposed Plan.
  8. **State acceptance—**Considers whether the state supports EPA's analyses and recommendations of the FFS reports and the Proposed Plan.
  9. **Community acceptance—**Considers whether the local community agrees with EPA's analyses and recommendations of the FFS reports and the Proposed Plan.

9.2 Upland Soil and Groundwater Operable Units

This section summarizes the comparative analysis of upland alternatives, using the threshold and balancing criteria listed previously.

9.2.1 Overall Protection of Human Health and the Environment

All alternatives, except Upland Alternative 1, would protect human health and the environment through varying combination of treatment and containment of contaminated soils and groundwater and by restricting land and groundwater use and using a perimeter bulkhead and cap to prevent exposure to contaminated soils. Upland Alternative 2 would protect human health and the environment by pumping groundwater from the Upper Aquifer to prevent it from moving down into the Lower Aquifer or into Puget Sound. Upland Alternatives 4 through 7 would reduce both the mass of mobile NAPL and COC concentrations in groundwater, thereby ensuring the remedy remains protective in the future. Because NAPL in the Upper Aquifer is the source of contamination to the Lower Aquifer, Upland Alternatives 4 through 7 would also protect the Lower Aquifer from further degradation in the long term.

9.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Table 9-1 summarizes potential ARARs for the Site and shows the key ARARs that would apply to each remedial alternative considered in this Proposed Plan. More detailed lists may be found in Appendix A of the FFS for Soil and Groundwater OUs (EPA, 2016b) and in Table 4-2 of the FFS for East Harbor OU (EPA, 2016a). Identifying ARARs is an iterative process, which will continue until final ARAR determinations are made by EPA during preparation of the ROD Amendment.

Upland Alternatives 4 through 7 would achieve chemical-specific ARARs for groundwater discharged to the intertidal area from the passive discharge/treatment systems, within timeframes that are estimated at 4 years for Alternative 4, 10 years for Alternative 5, 12 years for Alternative 6, and 10 to 18 years for Alternative 7. Upland Alternative 2 would comply with chemical-specific ARARs while the hydraulic containment system remains in operation, but it is expected that it would take 100 years or more to attain ARARs without active containment.

Upland Alternatives 2 through 7 would achieve chemical-specific ARARs including the Washington MTCA soil standards through varying degrees of treatment and by preventing exposure to the soil through continued use of the perimeter wall, an upland cap, and institutional controls.

9.2.3 Long-Term Effectiveness and Permanence

With respect to this criterion, Upland Alternatives 4, 5, 6, and 7 provide for greater long-term effectiveness and permanence because they address, to varying levels, the NAPL mass remaining in the upland. Upland Alternative 2 does not provide for significant treatment of the NAPL mass remaining and therefore does not provide for long-term effectiveness and permanence as well as the other alternatives.

The percentage of NAPL source material treated by each alternative varies, with Upland Alternative 2 estimated to treat 30 percent and Upland Alternatives 4, 5, 6, and 7 treating from 93 to 84 percent. The remainder of the NAPL source material would be addressed using passive treatment and natural attenuation processes. The magnitude of residual risk present at the end of remedial action would be greatest under Upland Alternative 2, because an estimated 70 percent of the NAPL source material would remain untreated after 100 years. Upland Alternatives 5, 6, and 7 would have a comparable level of residual risk, with Upland Alternative 4 expected to have the least amount of risk because it treats the most volume of NAPL.

Under Upland Alternatives 4 and 7, the ISS technology would use vertical augers and jet-grouting equipment to homogenize the NAPL and the cement-based reagent, resulting in a high level of treatment that is expected to perform very well over time. Upland Alternatives 5 and 6 would rely on thermal enhanced extraction to remove the NAPL and EAB to biodegrade any residual NAPL. The performance of thermal-based technologies could be influenced by the presence of subsurface heterogeneities that may influence heat distribution and NAPL recovery, which could result in partially treated zones. Therefore, while Upland Alternatives 5 and 6 perform well against this criteria, Upland Alternatives 4 and 7 perform better.

9.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

With respect to this criterion, all Upland Alternatives reduce toxicity, mobility, or volume through treatment in various degrees. Upland Alternative 2 leaves the largest volume of NAPL untreated at the end of construction. Upland Alternatives 5 and 6 include a thermal-based technology component that results in a high level of NAPL toxicity, mobility, or volume reduction, including thermal destruction of NAPL brought to the surface. The ISS technology used in Upland Alternatives 4 and 7 would further reduce NAPL mobility of material left in place, however, they would not reduce the volume of contaminants contained in NAPL-impacted soil. ISS is expected to perform very well at this Site because the treated soils would be further contained within the perimeter wall and protected by the soil cap, minimizing migration of contaminants. However, no performance data are available to show that the ISS columns can hold up for multigenerational timeframes, so the ISS technology cannot be considered irreversible.

9.2.5 Short-Term Effectiveness

The remedial design for each alternative would include measures to minimize impacts to workers, community, and environment during the implementation phase. The primary difference between alternatives is the time until RAOs are achieved. Upland Alternative 4 achieves RAOs in the shortest timeframe (12 years) with Upland Alternatives 5, 6, and 7 achieving RAOs in a timeframe estimated at 27 to 34 years. Upland Alternative 2 received a lower rating due to the long time frame (more than 100 years) of groundwater extraction and treatment operations that would be required to attain cleanup goals.

9.2.6 Implementability

All alternatives pose technical challenges. For Upland Alternative 2, the primary implementation challenge would be the overall O&M timeframe of more than 100 years, which would require replacing extraction wells and portions of the groundwater treatment plant every 30 years, long-term staffing, offsite NAPL disposal, and offsite change-out or disposal of the water treatment media.

For Upland Alternative 4 and 7, one implementation challenge would be the scale of ISS treatment. This project would be one of the largest ISS treatment projects to date. Vertical auger-mixing to depths of 55 feet and jet-injection to depths of approximately 70 feet represent the upper limit for this equipment type, so treatment rates could be lower than estimated. Another challenge would be managing soil swell, which is the change in soil volume that results from adding treatment reagents and physically mixing the soils. EPA's current assumption is that ISS would cause 20-percent swell, meaning that 100 cubic yards of soil would occupy 120 cubic yards after treatment. However, swell is difficult to predict and other projects have experienced higher rates of swell. Under both Upland Alternatives 4 and 7, swell would change the upland profile, resulting in a final, capped surface elevation that is 5 to 8 feet than the current elevation. The treated soils would be graded prior to capping to encourage rain to drain to a collection area in the center of the upland. If the final swell rate is higher than predicted, then managing all swell in the upland could be difficult; this would be particularly true for Upland Alternative 4 due to its larger treatment volume.

A challenge common to all alternatives (except Upland Alternative 1 would be removing subsurface debris. Debris would be a particular concern along the inside of the perimeter sheet pile wall, where both the former facility bulkhead and other construction debris are buried. EPA estimates that an additional $8 million would be needed to remove this debris, but this estimate is uncertain. Debris in this area would need to be removed to install a new perimeter bulkhead inside the existing sheet pile wall.

For Upland Alternatives 5, 6, and 7, the complexity of implementing a thermal-based remedy in terms of the number of wells, piping, treatment equipment, and sequencing of the treatment across the upland would pose unique implementation and logistical challenges.

9.2.7 Cost

Table 9-2 presents costs for all of the upland alternatives. This table shows the present value cost of each alternative, calculated using a 7-percent discount rate.

9.3 Nearshore East Harbor Operable Unit

9.3.1 Overall Protection of Human Health and the Environment

All alternatives except Nearshore Alternative 1 would protect human health and the environment. Nearshore Alternatives 2 through 5 would protect human health and the environment by combining capping (Nearshore Alternative 2, 3, 4, and 5), vertical barriers (Nearshore Alternative 4), and excavation and dredging (Nearshore Alternative 5) of NAPL-contaminated sediment in the East Beach and North Shoal. The remainder of East Harbor OU would be treated through MNR. The timeframe to achieve RAOs is expected to be shortest for Nearshore Alternative 5 and longest for Nearshore Alternative 2, because these would largely depend upon the degree of source control and/or removal that is achieved in areas that are actively remediated.

9.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Nearshore Alternatives 2 through 5 would achieve chemical-specific ARARs, including the Washington State SMSs, through varying degrees of treatment, permeable reactive capping, containment, and excavation.

Because Alternative 1 would not meet either of the threshold criteria, it is not analyzed further.

9.3.3 Long-Term Effectiveness and Permanence

Nearshore Alternative 2 is expected to be effective in the long run, but it would take longer than Alternatives 3, 4, and 5 to meet RAOs because it relies more on MNR. Nearshore Alternatives 3 and 4 would both provide long-term effectiveness and permanence as they both contain contaminated sediment and NAPL. However, the vertical barrier included in Alternative 4 would provide an additional source control that facilitates MNR.

Removing contaminated sediment and NAPL by Nearshore Alternative 5 would reduce the source material remaining and increase MNR effectiveness. Therefore, Alternative 5 would provide greater long-term effectiveness and would be more permanent than the other alternatives.

9.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Capping under Nearshore Alternative 2 would provide some degree of treatment through the reactive layer. Alternatives 3 and 4 would offer the same treatment as Alternative 2, but over a larger area. Alternative 5 would address the same area as Alternatives 3 and 4 but would remove more contaminated material from the marine environment.

All alternatives would add Portland cement to excavated sediment, which EPA assumes would provide sufficient treatment to meet offsite Subtitle D (nonhazardous) landfill disposal requirements. Blending in the Portland cement would reduce contaminant mobility, but it would not reduce toxicity and would increase the volume through both mixing and reagent addition. Alternative 5 would treat a much greater volume of material than the other alternatives.

9.3.5 Short-Term Effectiveness

The potential risks to the community, workers, and the environment for Nearshore Alternatives 2 through 5 would be generally similar, except that Nearshore Alternatives 4 and 5 also would include potential vibration and noise concerns associated with the sheet pile installation.

Nearshore Alternative 2 was ranked high with respect to short-term effectiveness due to a construction duration of approximately 2 months and comparatively small area of beach disrupted (estimated to be 0.3 acre). Nearshore Alternatives 3 and 4 were similar as both alternatives would take approximately 4 months, and the area disrupted would be approximately 1.6 acres. Nearshore Alternative 5 would also disrupt approximately 1.6 acres of beach habitat for an estimated 8 months; however, due to the nature of the work (excavation to depth of 10 feet), the actual area of disturbance likely would be greater. Alternative 5 would remove a substantial volume of NAPL but would have greater impacts on the benthic community and intertidal habitat functions. Nearshore Alternative 5 would include risks of contaminant releases, including potential surface water impacts, when installing and removing the sheet piles and when dredging and backfilling activities.

Nearshore Alternatives 3, 4, and 5 are more aggressive than Nearshore Alternative 2 and would likely achieve RAOs faster. Nearshore Alternative 2 would rely more heavily on MNR, which would lengthen the time needed to meet RAOs.

9.3.6 Implementability

Technical challenges associated with the nearshore alternatives include limited working windows due to the tide cycle, the small upland area available for material and equipment staging, the ability to dewater the excavation areas and manage that water, and the stability of the existing sheet pile wall around the upland area.

Nearshore Alternative 2 is also readily implementable. The proposed seep areas could be remediated within the tidal window, and the relatively small amount of sediment to be excavated could be temporarily staged and managed in the upland portion of the Site.

Nearshore Alternatives 3 and 4 share similar implementation challenges. The areas to be remediated would be larger than Nearshore Alternative 2, and construction sequencing based on the tide cycles would be needed to maximize production and transportation of the dredged material to the upland staging area. Nearshore Alternative 4 would be slightly more difficult to implement, relative to Nearshore Alternative 3, because sequencing and installing the new sheet pile containment wall would result in slightly greater logistical complexity.

Nearshore Alternative 5 is considered to be the most difficult to implement because installing the sheet pile wall dredge cells and associated logistical management would pose significant engineering challenges. The stability of the existing sheet pile wall around the upland also would be a critical component of the overall implementability of this alternative; if the wall requires additional bracing or support during sediment removal, then engineering and implementation challenges would increase.

Shellfish consumption advisories are a component of all remedial alternatives to manage human health risks from consuming clams before achieving PRGs. Shellfish consumption advisories are difficult to monitor, are not enforceable, and have limited effectiveness. Alternative 2 would rely most on fish advisories because it would take longest to meet PRGs.

9.3.7 Cost

Table 9-3 presents costs for all of the nearshore alternatives. This table shows the present value cost of each alternative, calculated using a 7-percent discount rate. Nondiscounted costs are shown on Table 9-4.

TABLE 9-1

Key Potential Federal and Washington State Applicable or Relevant and Appropriate Requirements

Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

ARAR	Description	Application for Wyckoff	ARAR Category	Upland Alternatives to Which ARAR May Apply	Nearshore Alternatives to Which ARAR May Apply
FEDERAL					
Clean Water Act: Section 304(a)(1)	Surface water quality criteria for the protection of aquatic life and human health	Discharge of groundwater to Eagle Harbor through passive drains system.	Chemical Specific	4, 5, 6, 7	N/A
Clean Water Act: Section 401	Protection of water quality from discharge of pollutants into waters of the United States	Dredging and capping sediments may cause dispersion of contaminated sediments causing contamination to move through the water column during cleanup activities.	Action Specific	N/A	2, 3, 4, 5
Clean Water Act: Section 402	Requirements for point source discharges to water of the U.S.	Discharge of stormwater collected from the surface of the proposed cap. Also discharge of Upper Aquifer groundwater through the proposed passive drainage system	Action Specific	2, 4, 5, 6, 7	N/A
Clean Water Act: Section 404(b)(1)	Protection of aquatic ecosystems by dredging or filling waters of the U.S.	Construction of a new perimeter bulkhead wall (depending on alignment) and remedial construction on the beaches	Action Specific	7x (see Section 10)	2, 3, 4, 5
Endangered Species Act	Protection of endangered or threatened species and critical habitat	Remedy may affect endangered species such as salmon and bull trout.	Action Specific	N/A	2, 3, 4, 5
Magnuson-Stevens Fisheries Conservation and Management Act	Protection of essential fish habitat	Remedy may affect essential fish habitat for rock fish or other species in Eagle Harbor.	Action Specific	N/A	2, 3, 4, 5
Clean Air Act	Protection of air quality	Dust from general construction activities, discharges to air from thermal desorption or other remedial actions	Chemical Specific	2, 4, 5, 6, 7	N/A
Native American Graves Protection and Repatriation Act	Procedures for handling human remains or sacred objects if discovered	Construction that impacts subsurface soils, particularly in previously undisturbed areas	Location Specific	2, 3, 5, 6, 7	N/A
Resource Conservation and Recovery Act Land Disposal Restrictions	Disposal of hazardous waste generated during cleanup activities	Disposal of creosote contaminated debris, NAPL recovered from groundwater, spent treatment media (such as carbon filters)	Action Specific	2, 4, 5, 6, 7	Potentially 2, 3, 4, 5 if sediment is determined to be listed waste

ARAR	Description	Application for Wyckoff	ARAR Category	Upland Alternatives to Which ARAR May Apply	Nearshore Alternatives to Which ARAR May Apply
Resource Conservation and Recovery Act Requirements for Incinerators	Requirements for operation of incinerators to protect air quality	Thermal oxidation of contaminated soil vapor. Also, Medium temperature thermal desorption of contaminated soils	Action specific	5, 6	N/A
STATE					
Hazardous Waste Management Act Dangerous Waste Regulations	Generation, management and offsite disposal of hazardous waste	Hazardous wastes will likely be generated during remedy implementation that may be designated as a characteristic or listed hazardous waste.	Action Specific	2, 4, 5, 6, 7	Potentially 2, 3, 4, 5 if sediment is determined to be listed waste
Solid Waste Management Reduction and Recycling Act Solid Waste Handling Standards	Requirements for the management and disposal of solid waste	Requirements for upland management of remediation waste designated as a solid waste (e.g., excavated soil, dredged sediments).	Action Specific	2, 4, 5, 6, 7	2, 3, 4, 5
Model Toxics Control Act	Cleanup standards for soil, groundwater, surface water, and air	If MTCA cleanup standards are more stringent than the federal standards or risk-based concentrations, the promulgated MTCA standards will be used.	Chemical Specific	2, 4, 5, 6, 7	2, 3, 4, 5
Model Toxics Control Act SMSs	Cleanup standards for freshwater sediments	If SMS cleanup standards are more stringent than the federal standards or risk-based concentrations, the promulgated SMS standards will be used.	Chemical Specific		2, 3, 4, 5
Washington State Water Pollution Control Act Water Quality Standards for Surface Waters of the State of Washington	Surface water quality criteria for the protection of aquatic life and human health	If state WQC standards are more stringent than the federal standards or risk-based concentrations, the promulgated state WQC will be used.	Chemical Specific	2, 4, 5, 6, 7	N/A 5
Washington State Water Pollution Control Act National Pollutant Discharge Elimination System	Standards for discharge of pollutants into waters of the United states	The remedial action will include the discharge of treated water and stormwater to surface water.	Chemical Specific	2, 4, 5, 6, 7	N/A
Washington Underground Injection Control Program	Establishes criteria and standards for an underground injection control program for class V injection wells	Remedial activities that involve underground injection such as steam injection for thermal enhanced extraction; injection of oxidants for ISCO treatment; injection of Portland cement and bentonite for ISS	Action Specific	4, 5, 6, 7	N/A

ARAR	Description	Application for Wyckoff	ARAR Category	Upland Alternatives to Which ARAR May Apply	Nearshore Alternatives to Which ARAR May Apply
Washington State Shoreline Management Act	Establishes wetland and shoreline protection measures for work in the shoreline zone.	Remedial activities on the intertidal beaches	Action Specific	7X (see Section 10)	2, 3, 4, 5
Washington Clean Air Act	Regulations for air pollution sources, also Puget Sound Clean Air Agency Regulations	Remedial Actions that result in the emission of hazardous air pollutants, including decontamination, demolition and excavation, and thermal desorption	Chemical Specific	2, 4, 5, 6, 7	N/A

ARAR = applicable or relevant and appropriate requirement
ISCO = in situ chemical oxidation
ISS = in situ solidification/stabilization
MTCA = Model Toxics Control Act
N/A = not applicable
NAPL = nonaqueous-phase liquid
SMS = Sediment Management Standards
WQC = water quality criteria

TABLE 9-2
Costs for the Soil and Groundwater Operable Units (Upland) Alternatives
Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Item	Upland Alternative 2	Upland Alternative 4	Upland Alternative 5	Upland Alternative 6	Upland Alternative 7, Phase 1	Upland Alternative 7, Phases 1 and 2
Common elements	$41,700,000	$33,900,000	$47,400,000	$41,600,000	$39,900,000	$39,900,000
Remedial construction	$2,700,000	$53,100,000	$70,900,000	$118,600,000	$30,900,000	$41,700,000
Operations and maintenance	$7,500,000	$1,500,000	$1,300,000	$1,300,000	$500,000	$900,000
Inspections and reporting	$70,000	$70,000	$70,000	$70,000	$40,000	$70,000
Total Present Value (ROUNDED)	**$52,000,000**	**$88,600,000**	**$119,700,000**	**$161,600,000**	**$71,300,000**	**$82,600,000**

TABLE 9-3
Costs for the East Harbor Operable Unit (Nearshore) Alternatives
Proposed Plan for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Item	Nearshore Alternative 2	Nearshore Alternative 3	Nearshore Alternative 4	Nearshore Alternative 5
Remedial construction	$2,610,000	$8,920,000	$12,840,000	$28,960,000
Operations and maintenance	$500,000	$2,850,000	$2,380,000	$420,000
Total present value using 7.0 percent discount rate	**$3,110,000**	**$11,770,000**	**$15,220,000**	**$29,370,000**

Note: Common elements and Inspections and reporting are included in these cost estimates. Costs for these items are so small that they were not broken out separately, as was done for the Upland Alternatives.

TABLE 9-4
Impact of Using 1.4 Percent or 7 Percent Discount Rate
Proposed Plan for the Wyckoff /Eagle Harbor Superfund Site, Bainbridge Island, Washington

Alternative	Cost in 2016 Dollars (nondiscounted)	Cost Using 1.4 Percent Discount Rate	Cost Using 7 Percent Discount Rate
Upland Alternative 2	$111,000,000	$79,800,000	$52,000,000
Upland Alternative 4	$95,400,000	$93,700,000	$88,600,000
Upland Alternative 5	$149,600,000	$142,100,000	$120,100,000
Upland Alternative 6	$210,000,000	$197,700,000	$161,500,000
Upland Alternative 7, Phase 1 only	$94,700,000	$89,000,000	$71,300,000
Upland Alternative 7, Phases 1 and 2	$124,600,000	$113,000,000	$82,400,000
Nearshore Alternative 2	$4,800,000	$3,900,000	$3,100,000
Nearshore Alternative 3	$16,900,000	$14,900,000	$11,800,000
Nearshore Alternative 4	$19,800,000	$18,000,000	$15,200,000
Nearshore Alternative 5	$30,900,000	$30,100,000	$29,400,000

SECTION 10

Preferred Alternatives

This section presents EPA's Preferred Alternatives for the Upland Soil and Groundwater OUs and Nearshore East Harbor OU, and the rationale and basis for the agency's choices. This section also explains how the remedies for the two portions of the Site would be combined and discusses how combining upland and nearshore construction would impact the project's cost and overall schedule.

10.1 Upland and Nearshore Preferred Alternatives

EPA proposes a modified version of Upland Alternative 7, In-Situ Solidification/Stabilization of Expanded Core Area and Thermal-Enhanced Recovery, as the Upland Preferred Alternative. For the Nearshore East Harbor OU, EPA proposes Nearshore Alternative 3, Partial Excavation and Capping, with an option to modify to allow for sediment disposal in the upland portion of the Site. Modifications to the Upland and Nearshore Preferred Alternatives are described in Section 10.2.

10.1.1 Upland Preferred Alternative: Upland Alternative 7—In-Situ Solidification/Stabilization of Core Area and Thermal-Enhanced Recovery

EPA's preferred alternative provides the opportunity to consider new information and changing Site conditions observed over the remedy implementation life-cycle. Phase 1 performance monitoring data would be used to determine whether Phase 2 actions are needed and, if so, where. Performance monitoring data would also be used to determine when groundwater pump and treat operations could shift to lower-cost passive drainage with treatment, and when passive treatment is no longer needed. Upland Alternative 7 is described in Section 8.1.2.7 and summarized in Figure 8-5.

10.1.2 Nearshore Preferred Alternative: Nearshore Alternative 3—Partial Excavation and Capping

EPA's preferred alternative to address contamination in the beaches is partial excavation and capping. This alternative would remove contaminated sediment from the beach, reducing exposure for both human and ecological receptors. It would utilize reactive materials in the base of the caps to minimize upward migration of contamination present below the excavation footprint. It would provide clean sandy habitat in the top two feet of the remediated area, which would lower contaminant concentrations in shellfish over time. The remedy could be constructed at low tide, which would minimize impacts to eelgrass outside of the remedial footprint. Nearshore Alternative 3 is described in Section 8.2.2.3 and summarized in Figure 8-7.

10.2 Combining the Upland and Nearshore Remedies

After identifying the Upland and Nearshore Preferred Alternatives, EPA's project team considered how the remedies could best be combined. In developing a plan to phase and sequence the numerous construction activities needed to implement both alternatives, EPA identified two modifications that would provide cost savings or other efficiencies. These selected modifications are described below.

10.2.1 Modification to Upland Alternative 7

The FFS for the Soil and Groundwater OUs (EPA, 2016b) assumes that the perimeter bulkhead wall will be built on the inboard (land side) of the existing sheet pile wall. However, as described in Section 9.2.6, a large amount of debris is buried along the inside of the perimeter sheet pile wall and it would need to be removed to install a new bulkhead wall inside the existing wall. An outboard bulkhead wall alignment would obviate the need for debris removal, lowering both construction costs and uncertainty in the project schedule and budget. Debris along the inside of the existing sheet pile wall would only be removed where necessary to allow the Upland Alternative 7 remedial technologies to be implemented, which include NAPL extraction, EAB, and if Phase 2 is needed, thermal-enhanced NAPL extraction. All of these technologies rely on installing wells that could be moved to avoid debris or, if necessary, drilled through debris. An outboard bulkhead wall alignment would also provide a newer and potentially more attractive outer wall surface than the existing sheet pile wall. The primary disadvantage of an outboard bulkhead wall alignment is that it would permanently fill approximately 0.2 acre of beach habitat, which would require mitigation. Assuming beach mitigation costs of $1.7 million, the outboard wall alignment would save approximately $10.6 million.

10.2.2 Optional Modification to Nearshore Alternative 3

In developing remedial alternatives to address contamination in the beaches, EPA assumed that sediment removed from the beaches could be disposed of in a nonhazardous (Subtitle D) landfill. However, it is not known whether the material would meet all of landfill disposal criteria. To ensure the cleanup plan includes a viable disposal option, EPA also evaluated the potential for upland disposal.

Under an upland disposal scenario, sediments from the beaches would be treated with the solidification-stabilization technology along with upland surface soils, then buried beneath the final upland cap. Upland disposal would save landfill space and reduce truck traffic, but it would pose logistical challenges, because the nearshore work would need to be timed to coincide with the later stages of ISS treatment in the upland. Upland disposal would also increase the total volume of material that would need to be capped, thereby increasing the cost of the final upland cap. This modification would add approximately $1.0 million to the overall project cost. EPA is including upland disposal of the nearshore sediments as an option to ensure that the cost estimate includes sufficient funds. However, landfill disposal in a nonhazardous waste landfill remains EPA’s preferred option. The final disposal site will be selected following waste characterization testing.

10.3 Rationale for the Preferred Remedies

10.3.1 Upland Soil and Groundwater Operable Units Preferred Alternative

To address contamination in upland soils and groundwater, Upland Alternative 7 is preferred because it protects human health and the environment, meets ARARs, and provides the best balance of tradeoffs among the balancing criteria.

Upland Alternative 1, No Action, would not meet RAOs and is not protective. Upland Alternative 2, Containment, would meet RAOs, but it is not as permanent as other alternatives and would require operations to continue beyond 100 years. The long and uncertain timeline and the high cost of continued groundwater extraction and treatment are significant drawbacks to Alternative 2.

In comparing the more active treatment alternatives, Upland Alternatives 4 and 7 quickly rose to the top of the list. Upland Alternatives 5 and 6 provide similar levels of risk reduction but are considerably more expensive and take longer to implement than Upland Alternative 4. Upland Alternatives 5 and 6 are also more energy intensive because they require heating the ground through steam injection (Upland Alternative 5) or in an onsite kiln (Upland Alternative 6).

Both Upland Alternatives 4 and 7 have numerous benefits. Upland Alternative 4 has a shorter time frame, is cheaper than both phases of Upland Alternative 7, and treats more NAPL. The disadvantages of Upland Alternative 4 include the cost and difficulty of removing subsurface debris, the potential for incomplete treatment if deeply buried debris cannot be removed, and the potential for excess swell.

Upland Alternative 7 has two distinct construction phases, with a period of monitoring between the two phases. It would generate less swell than Upland Alternative 4, because it would treat less soil with ISS. Upland Alternative 7 provides the most flexibility, allowing the results of Phase 1 to guide the selection and application of remedial technologies in Phase 2. Predicting how Phase 1 actions will affect contaminant concentrations outside the Phase 1 treatment area is difficult. However, Phase 1 actions alone could be sufficient to meet the upland cleanup levels, and Phase 2 actions might not be needed. Upland Alternative 7 will allow EPA to "right-size" the remedy, ensuring sufficient cleanup work to meet RAOs, while not investing more time or resources (including human capital, energy and construction materials) than needed. This flexibility tipped the scales in favor of Upland Alternative 7.

10.3.2 Nearshore Eagle Harbor Operable Unit Preferred Alternative

In the Eagle Harbor OU, Nearshore Alternative 3 quickly rose to the top of the list. Nearshore Alternative 2 was judged to be insufficient, because it would treat too small of an area to make a substantial difference in contaminant concentrations. The subsurface containment wall in Nearshore Alternative 4 raised many concerns (for example, that erosion would expose the tops of the walls, leaving a hazard to boaters and beachgoers and affecting natural sediment transport patterns). In EPA's judgement, the increased contaminant removal benefit of Nearshore Alternative 5 was not commensurate with its high cost, significant implementation challenges, and short-term damage to eelgrass beds and other intertidal habitat features.

10.4 Summary

For the Soil and Groundwater OUs, Upland Alternative 7 is the Preferred Alternative, modified with an outboard design for the replacement bulkhead wall. For the Eagle Harbor OU, Nearshore Alternative 3 is the Preferred Alternative, modified with the option for upland, rather than offsite (landfill), disposal of the sediments removed from the beaches. Together, these remedies would substantially reduce human health and environmental risks at the Site. Remedial actions in the Soil and Groundwater OUs would also substantially reduce long-term O&M costs by eliminating the need for active groundwater extraction and treatment.

The cost for the combined upland and nearshore remedies would be between $70,400,000 and $81,300,000, depending on whether both Phase 1 and Phase 2 are needed in in the upland, and on the disposal location for the nearshore sediments.

Based on the information currently available, EPA believes the Upland and Nearshore Preferred Alternatives meet the threshold criteria and provide the best balance of tradeoffs among the other alternatives with respect to the balancing criteria. EPA expects both Preferred Alternatives to satisfy the following statutory requirements of CERCLA §121(b) for the portions of the remedy address by this ROD: 1) protect human health and the environment; 2) comply with ARARs; 3) be cost-effective; 4) use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and 5) satisfy the preference for treatment as a principal element.

SECTION 11

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Figures

LEGEND

Approximate Operable Unit (OU) Boundaries

- OU-1 Proposed Cleanup Area
- OU-2/OU-4 Proposed Cleanup Area
- Harbor Boundary
- Fence

Sources:
Operable Units approximated from Superfund Fact Sheet Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington (USEPA, 1999).

N

0 250 500 1,000 Feet

Figure 2-1
Site Location and Operable Units

EPA

LEGEND

Approximate 1907 Shoreline

Sheet Pile Wall

Source:
U.S. Coast & Geodetic Survey, 1907. Nautical Chart.
Scale 1:20000. Image: 6445-03-1907.
http://historicalcharts.noaa.gov/historicals/preview/image/6445-3-1907

N

0 100 200 400 Feet

Figure 3-1
Historic 1907 Shoreline and Current Site Features

EPA

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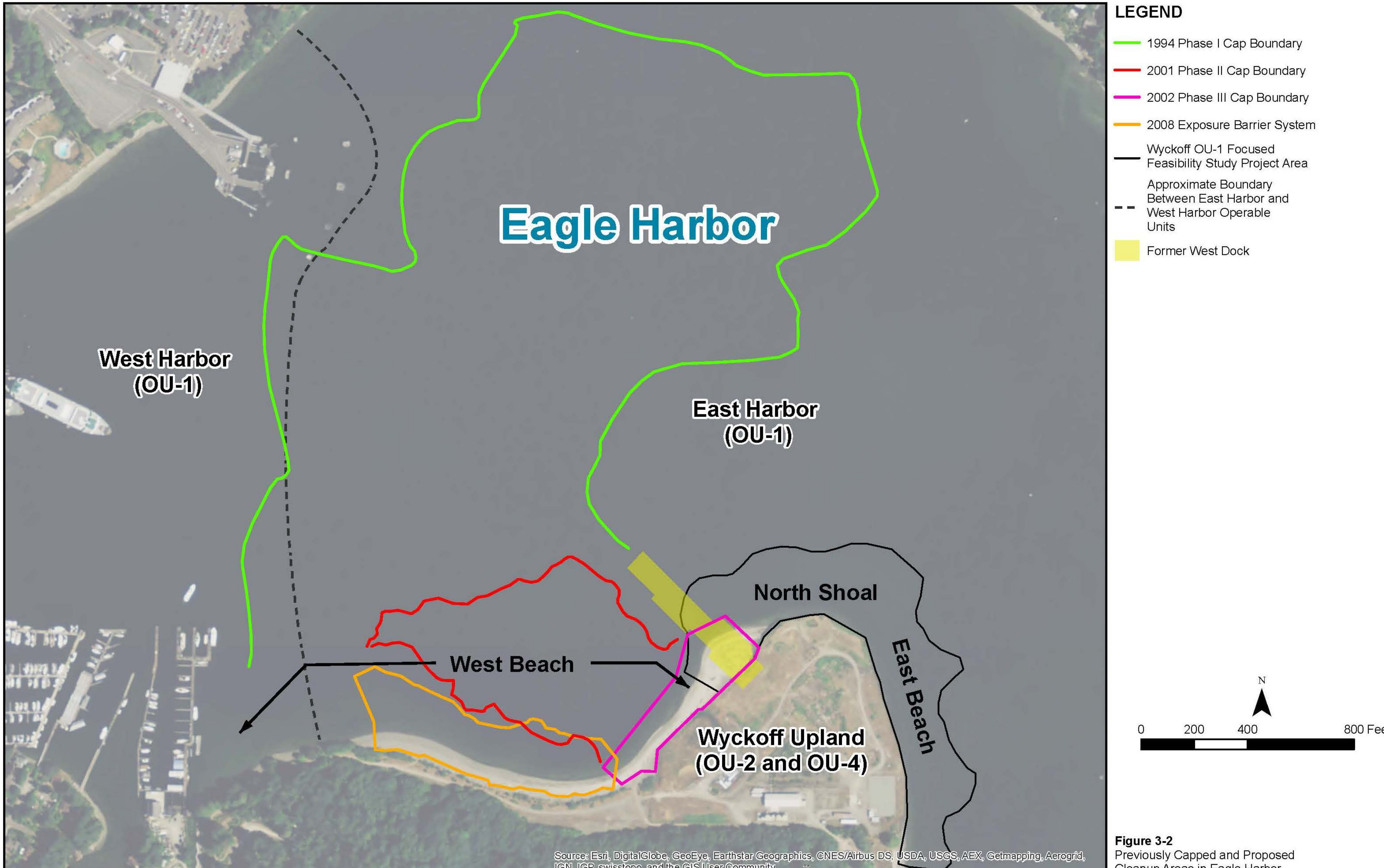
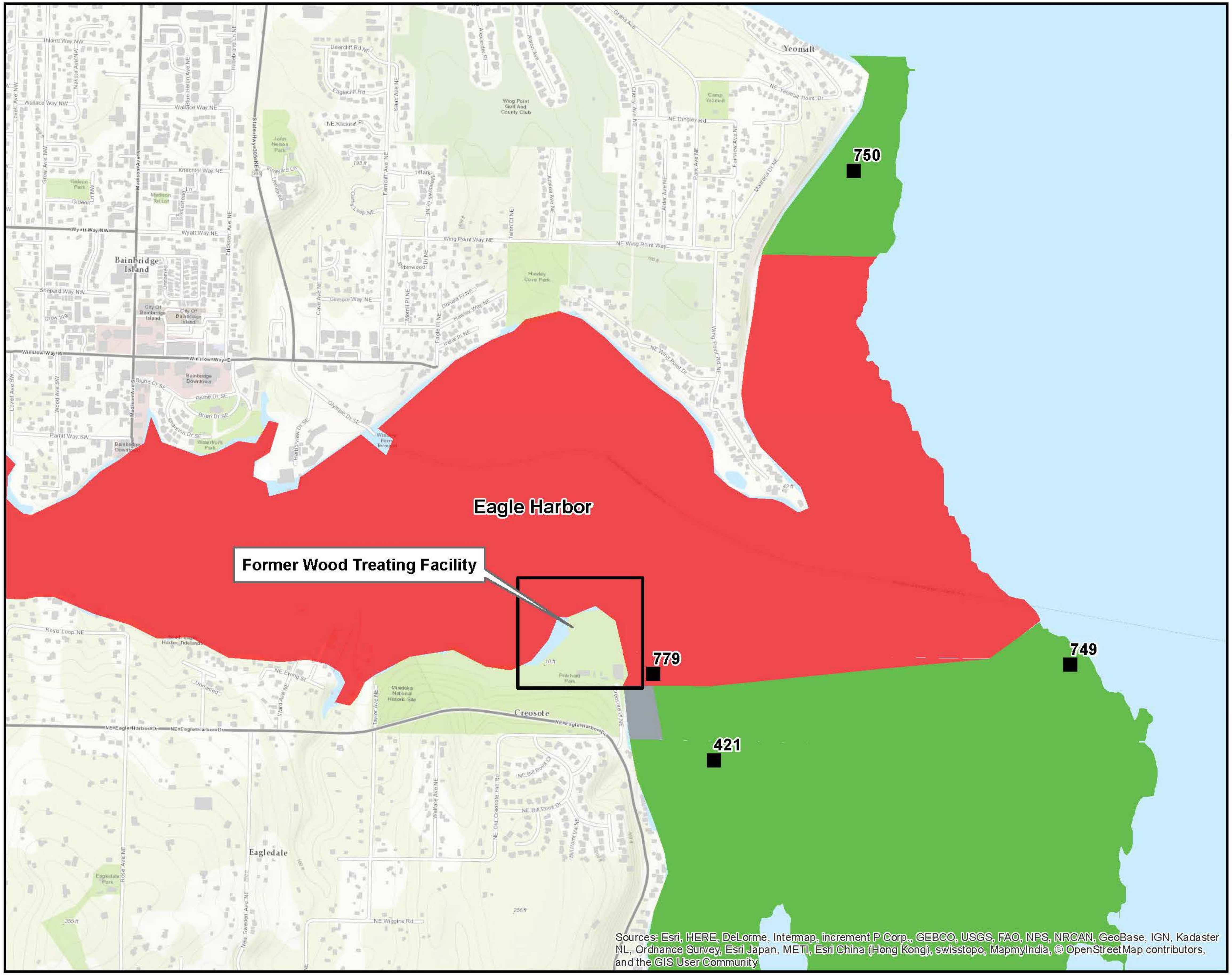


Figure 3-2
Previously Capped and Proposed Cleanup Areas in Eagle Harbor

EPA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2016\OFFSHORE\PROPOSED PLAN\REVISED_032216\FIGURE3-2_OU1CAPPINGCLEANUP.MXD GGEE 3/22/2016 10:10:56 AM



LEGEND

- Marine Monitoring Locations

Shellfish Commerical Growing Areas

- Approved
- Conditional
- Prohibited
- Restricted
- Unclassified

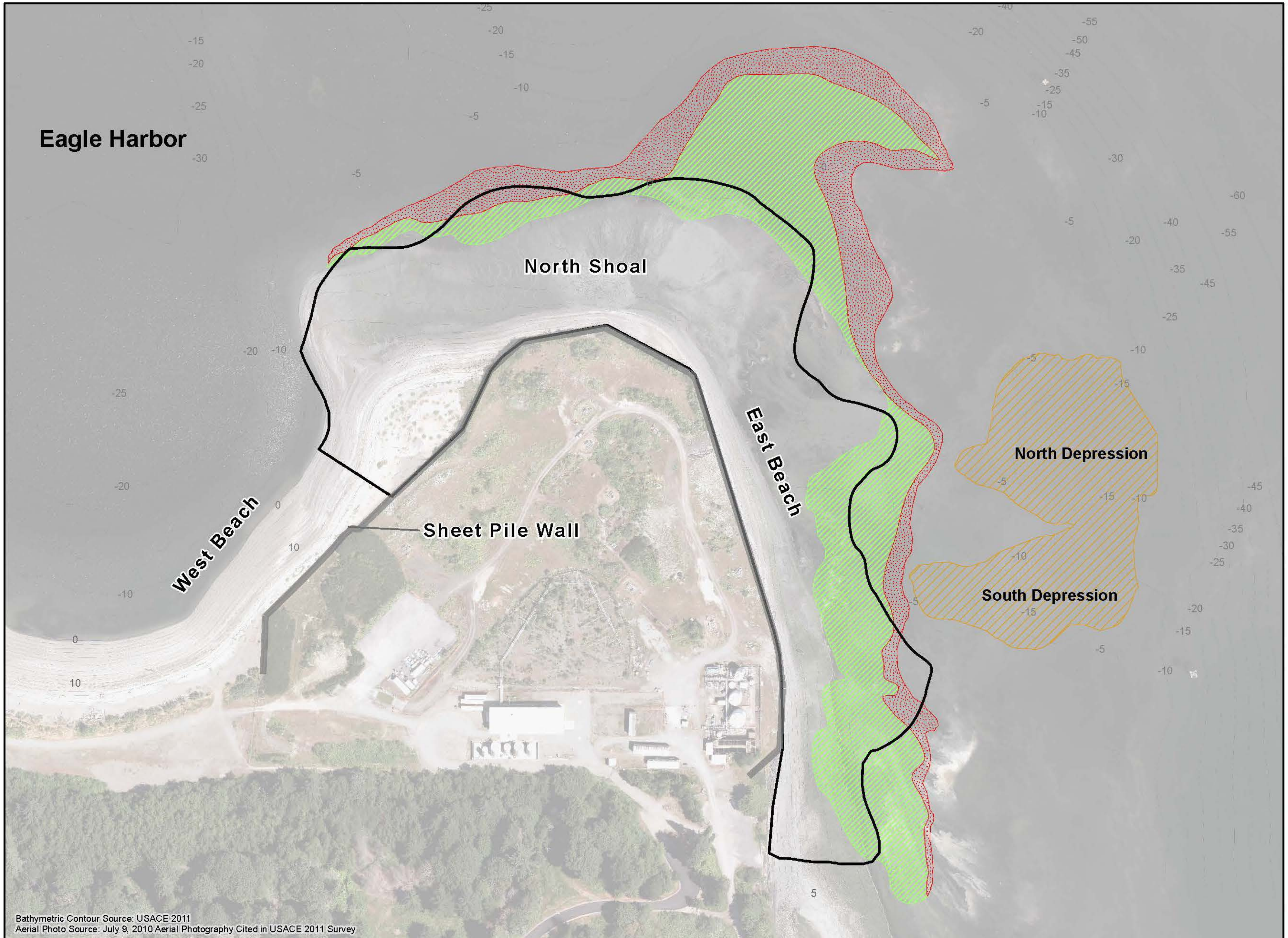
Source:
Shellfish Commercial Growing Areas, Washington State Department of Health, 2016.
http://www.doh.wa.gov/DataandStatisticalReports/DataSystems/GeographicInformationSystem/DownloadableDataSets
Accessed January 7, 2016.
Addendum to the 2010 Sanitary Survey of the Port Blakely Shellfish Growing Area, Washington State Department of Health, 2015.
Prepared by: Jean Snyder, Public Health Advisor, December 2015.

N

0 500 1,000 2,000 Feet

Figure 4-1
2015 Classification in the Port Blakely Shellfish Growing Area

EPA



LEGEND

- Wyckoff OU-1 Focused Feasibility Study Project Area
- Eelgrass Restoration Areas
- Eelgrass
- Probable Eelgrass (unconfirmed)
- Surface Elevation Contours in Feet (MLLW)
  1-foot contour intervals were generated using USACE interpolation methods

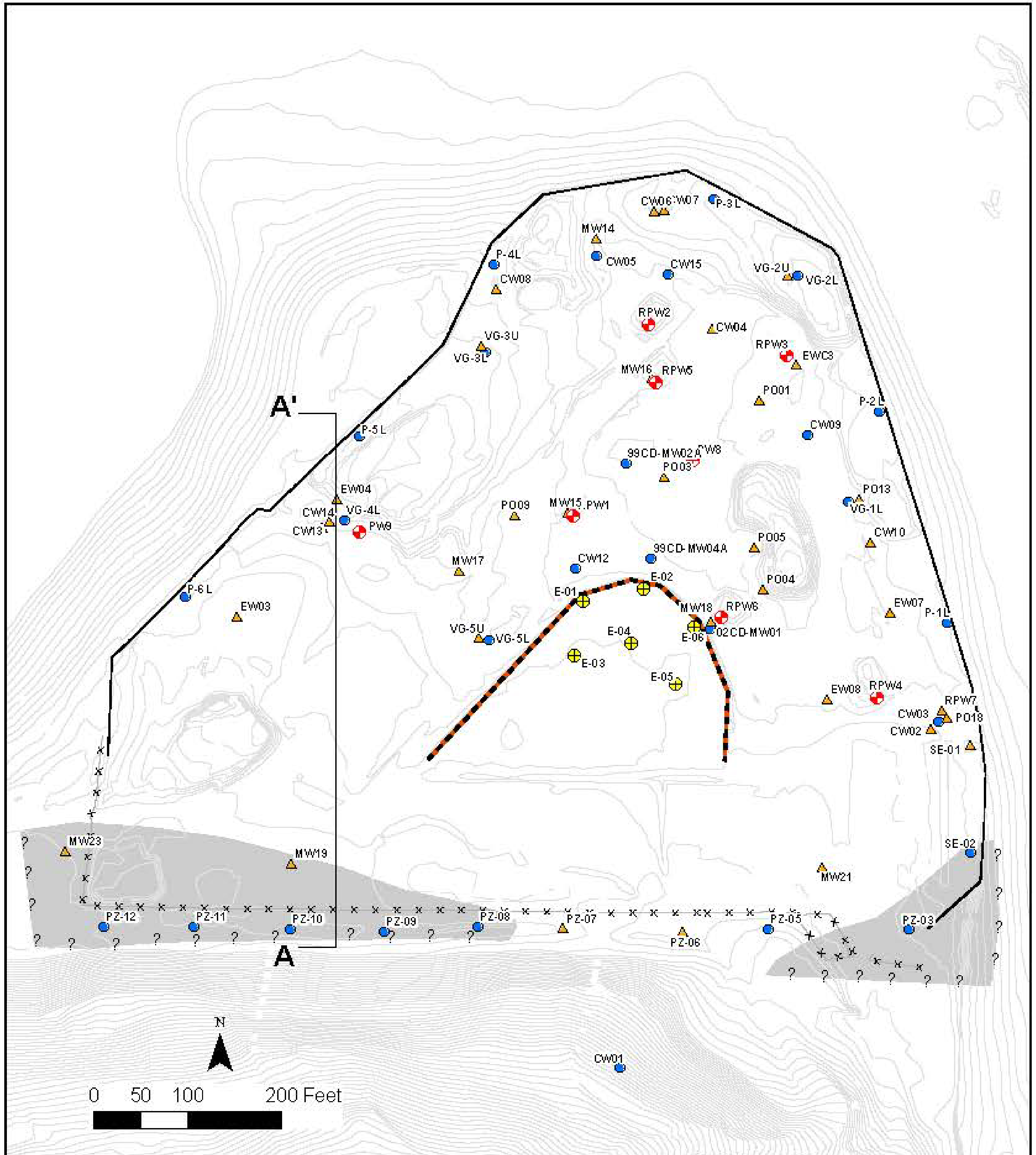
Note:
Eelgrass Restoration Area locations taken from a combination of the north and south depressions as documented in the "FY10 Milwaukee Dock Eelgrass Restoration" - "FY14 Milwaukee Dock Eelgrass Restoration". Both completed by the US Army Corps of Engineers.

N

0 50 100 200 Feet

Figure 4-2
Eelgrass and Eelgrass Restoration Areas

EPA



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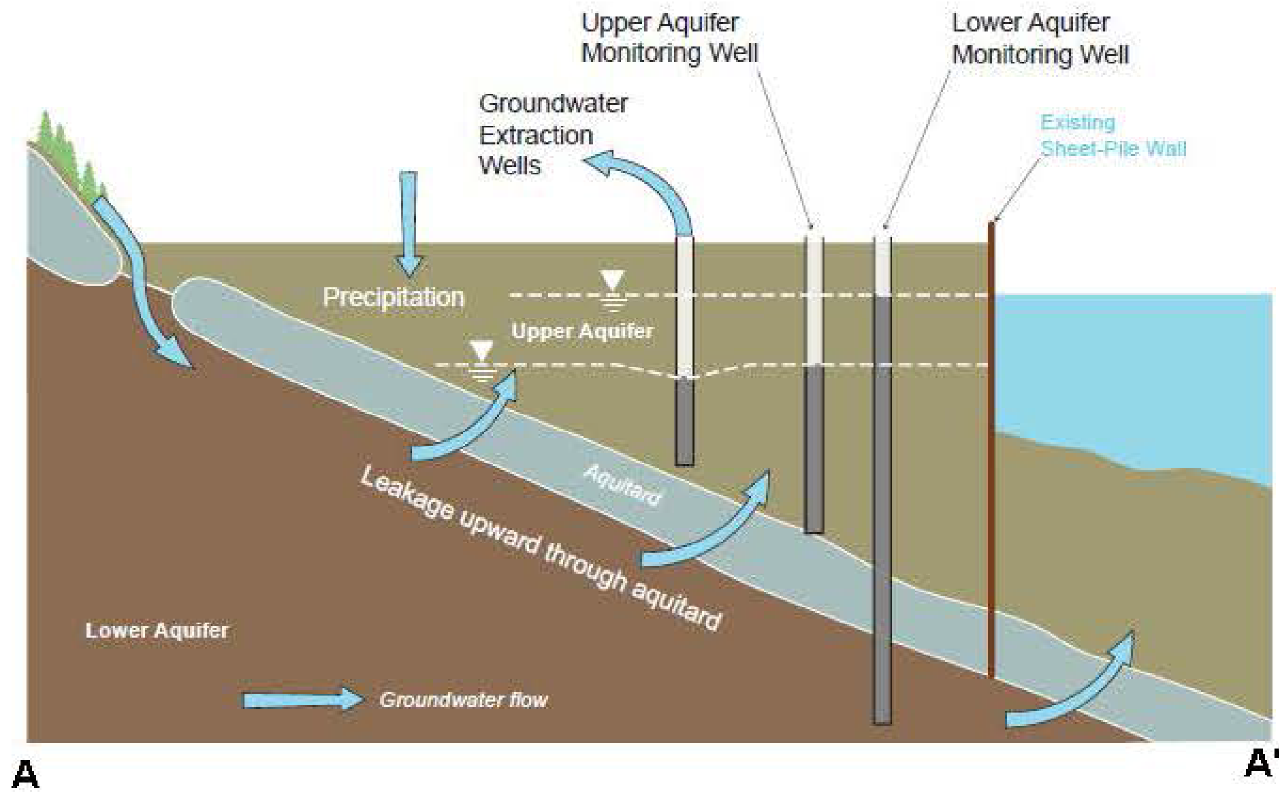


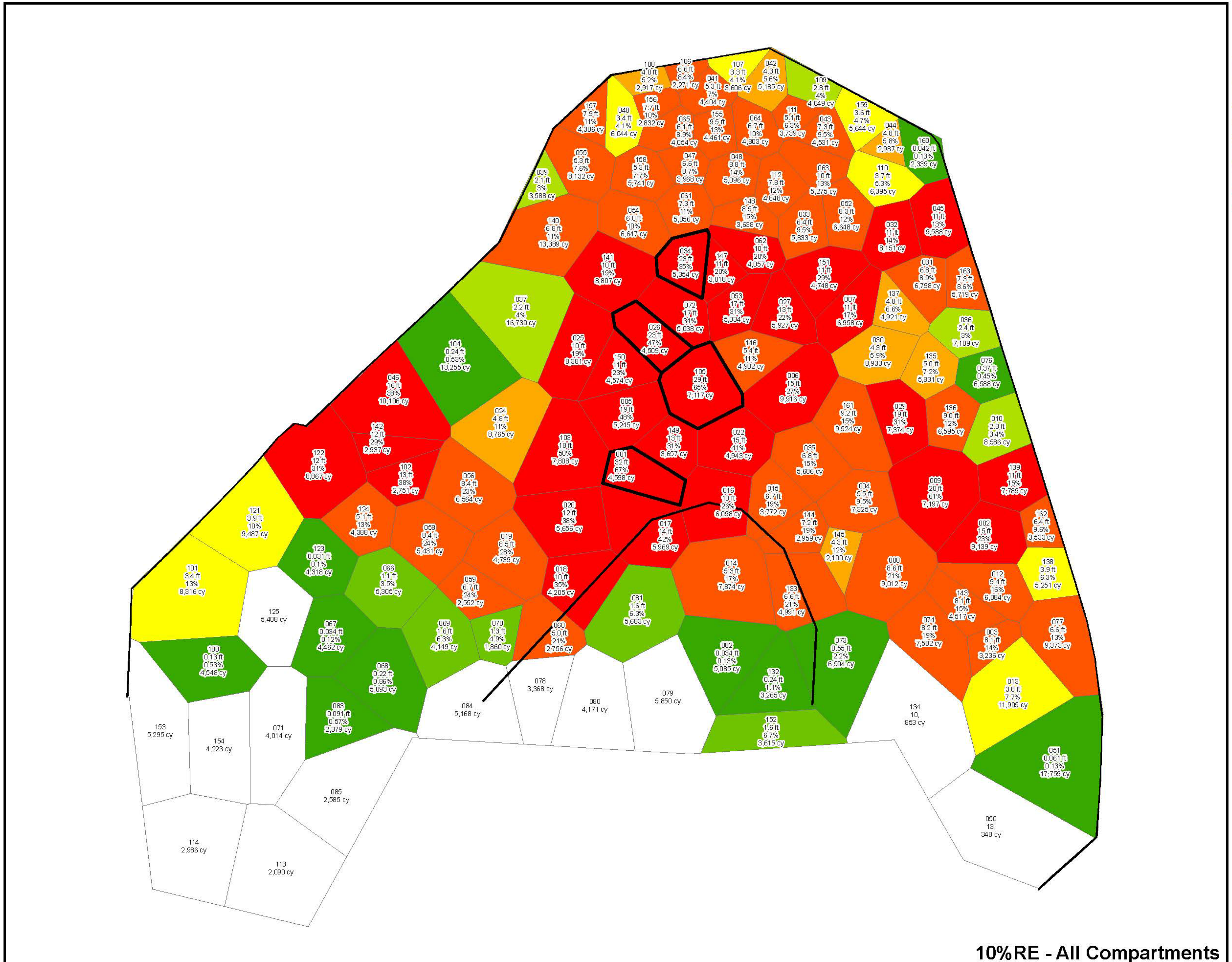
LEGEND

Well Locations

- Monitoring Well, Upper Aquifer
- Monitoring Well, Lower Aquifer
- Extraction Well, Upper Aquifer
- Steam Pilot Well, Upper Aquifer
- Fence
- Sheet Pile Wall
- Pilot Study Containment Wall
- Ground Surface Contours (ft MLLW)
- Aquitard Thin (<4 ft) to Absent

Figure 4-3
Upper Aquifer, Lower Aquifer, and Aquitard and Current Groundwater Conditions

EPA



LEGEND

Thickness of Affected TarGOST Sample (ft)

- >0 - 1.0 (1.4 acres)
- 1.0 - 2.0 (0.5 acres)
- 2.0 - 3.0 (0.4 acres)
- 3.0 - 4.0 (0.7 acres)
- 4.0 - 5.0 (0.4 acres)
- 5.0 - 10 (2.9 acres)
- >10 (2.7 acres)
- Thickness of Affected TarGOST Sample Greater than 20 ft
- No impacts above 10%RE

Labels:

135	TarGOST sample ID number
3.6 ft	Length of TarGOST core with NAPL measured above 10%RE
17%	Percentage of soil in polygon impacted by NAPL
1,765 cy	Total volume of polygon (cubic yards)

Figure 5-1
Thickness of NAPL in the Upper Aquifer

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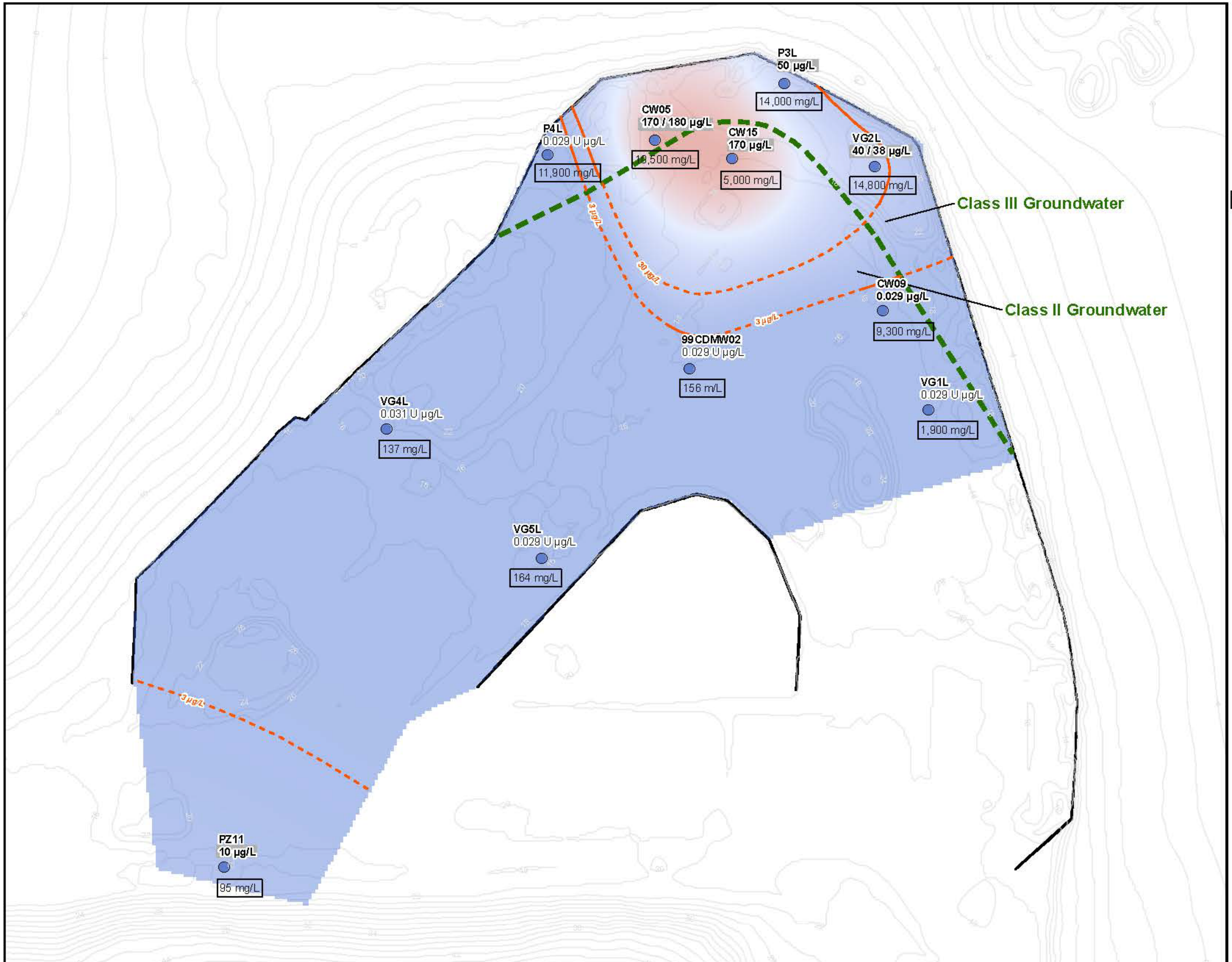

LEGEND

Acenaphthene Measured October 2014 (µg/L)

Lower Aquifer Monitor Well

Acenaphthene Isopleth (3 and 30 µg/L)

Inferred Acenaphthene Isopleth

Interpolated Acenaphthene Concentration (µg/L)

172

0

Fresh Water/Salt Water Boundary

156 mg/L Total Dissolved Solids Concentration (mg/L)

TDS 10,000 mg/L Isopleth

Ground Surface Contours (2 ft CI, ft MLLW)

Notes:
/ ## indicates parent and duplicate samples
Bold values = Acenaphthene was detected in well.
Shaded/Bold values = Acenaphthene exceeds groundwater cleanup level of 3.0 µg/L established in the Wyckoff ROD 2/2000.
mg/L = milligrams per Liter
µg/L = micrograms per Liter
CI = contour interval
U = The analyte was not detected at or above the reported value.
TDS = Total Dissolved Solids

N

0 50 100 200 Feet

Figure 5-2
Extent of Saltwater Intrusion and Acenaphthene in the Lower Aquifer

EPA

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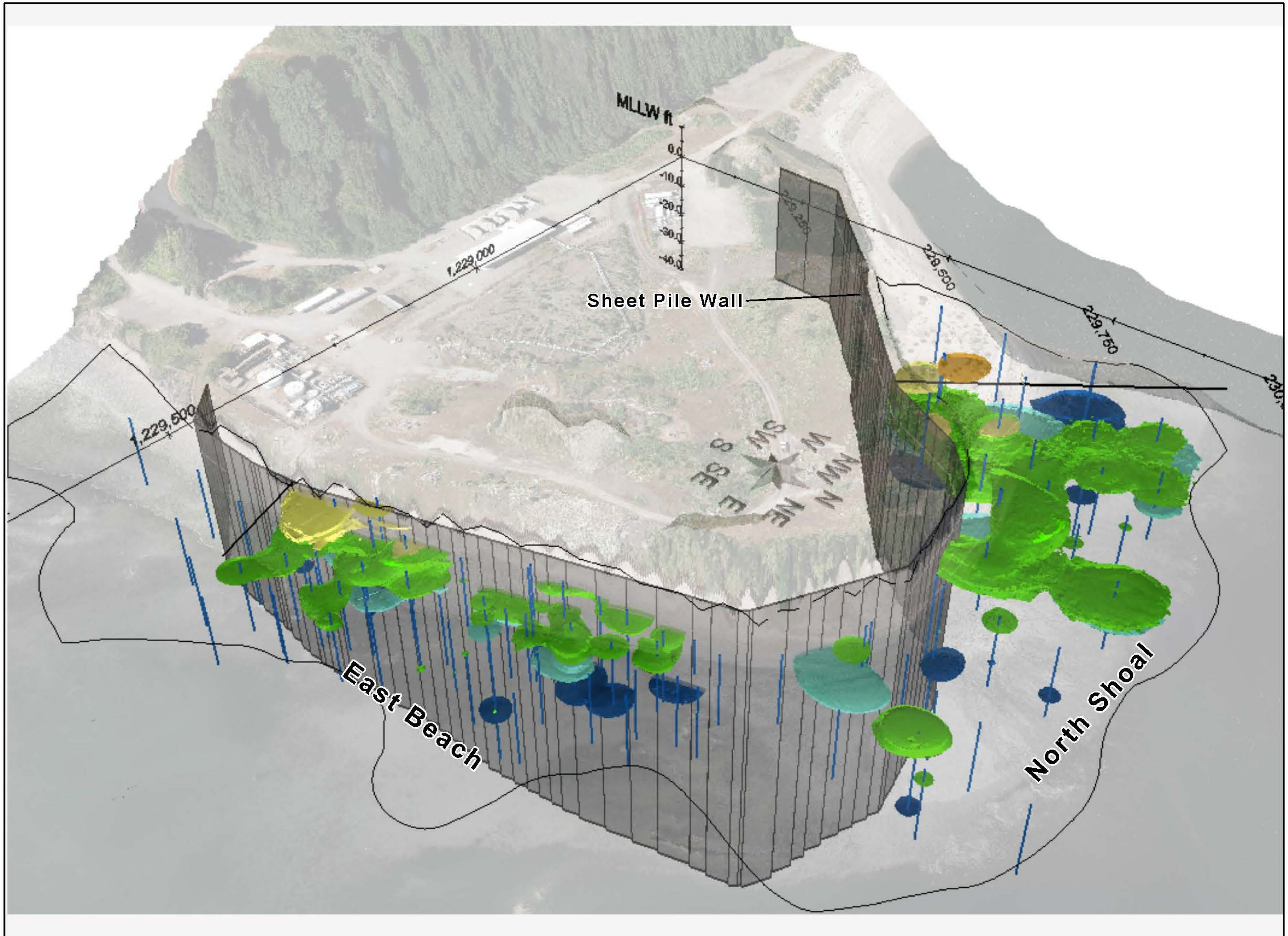


LEGEND
Elevation of NAPL in Nearshore Sediment, relative to MLLW (Feet)

- > 14.5
- 14.5 to 10.5
- 10.5 to 2.8
- 2.8 to -5.0
- -5.0 to -10.0
- < -10.0
- Wyckoff OU-1 Focused Feasibility Study Project Area
- Location of TarGOST Sample

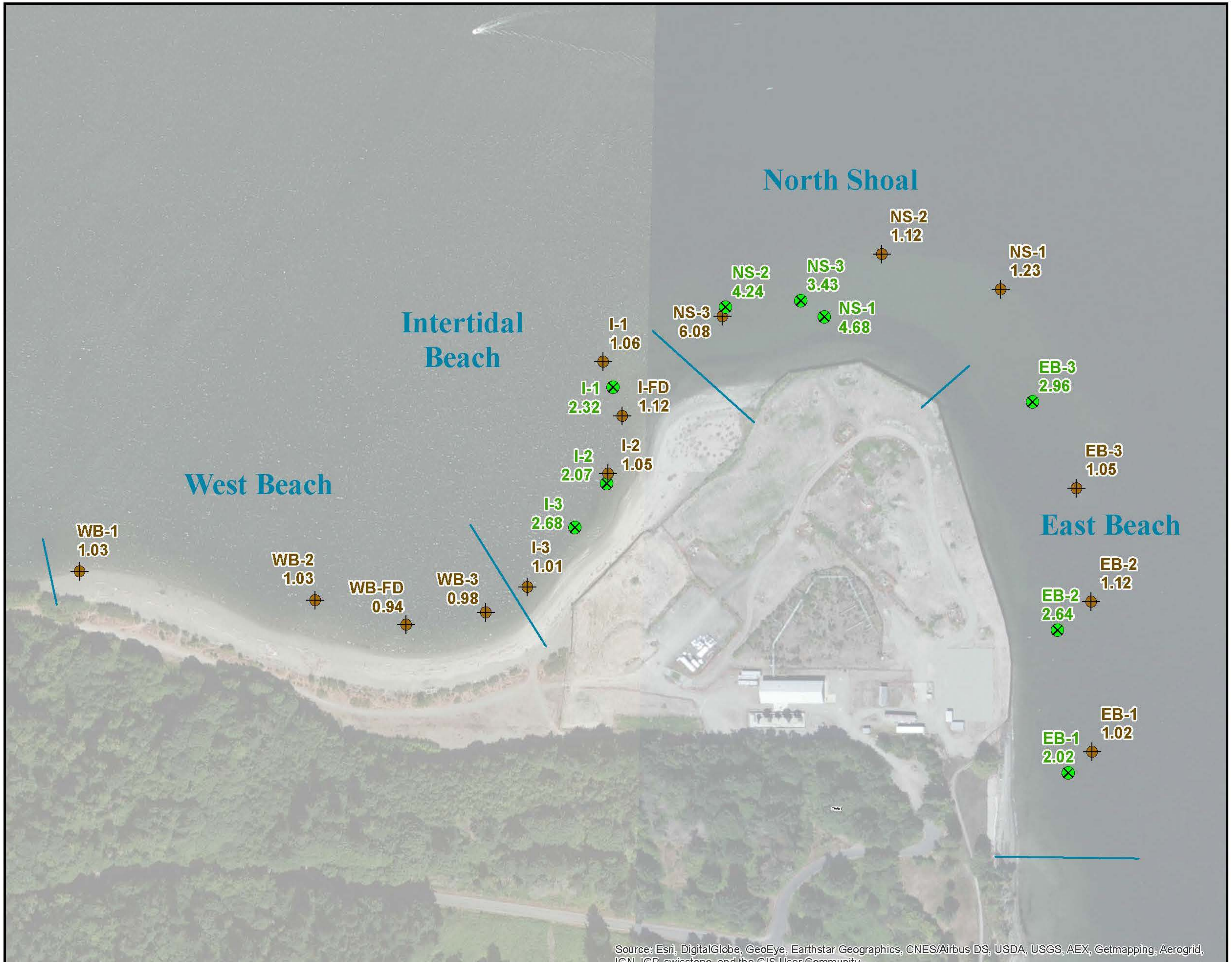
Isosurface indicates 50% or greater chance of encountering NAPL. Based on TarGOST Response > 10% RE

Vertical exaggeration = 5x

MLLW = Mean Lower Low Water

Figure 5-3
NAPL Distribution in Sediment

EPA



LEGEND

Clam Sampling Locations with BAP TEQ

- 2011 Sampling Year
- 2014 Sampling Year

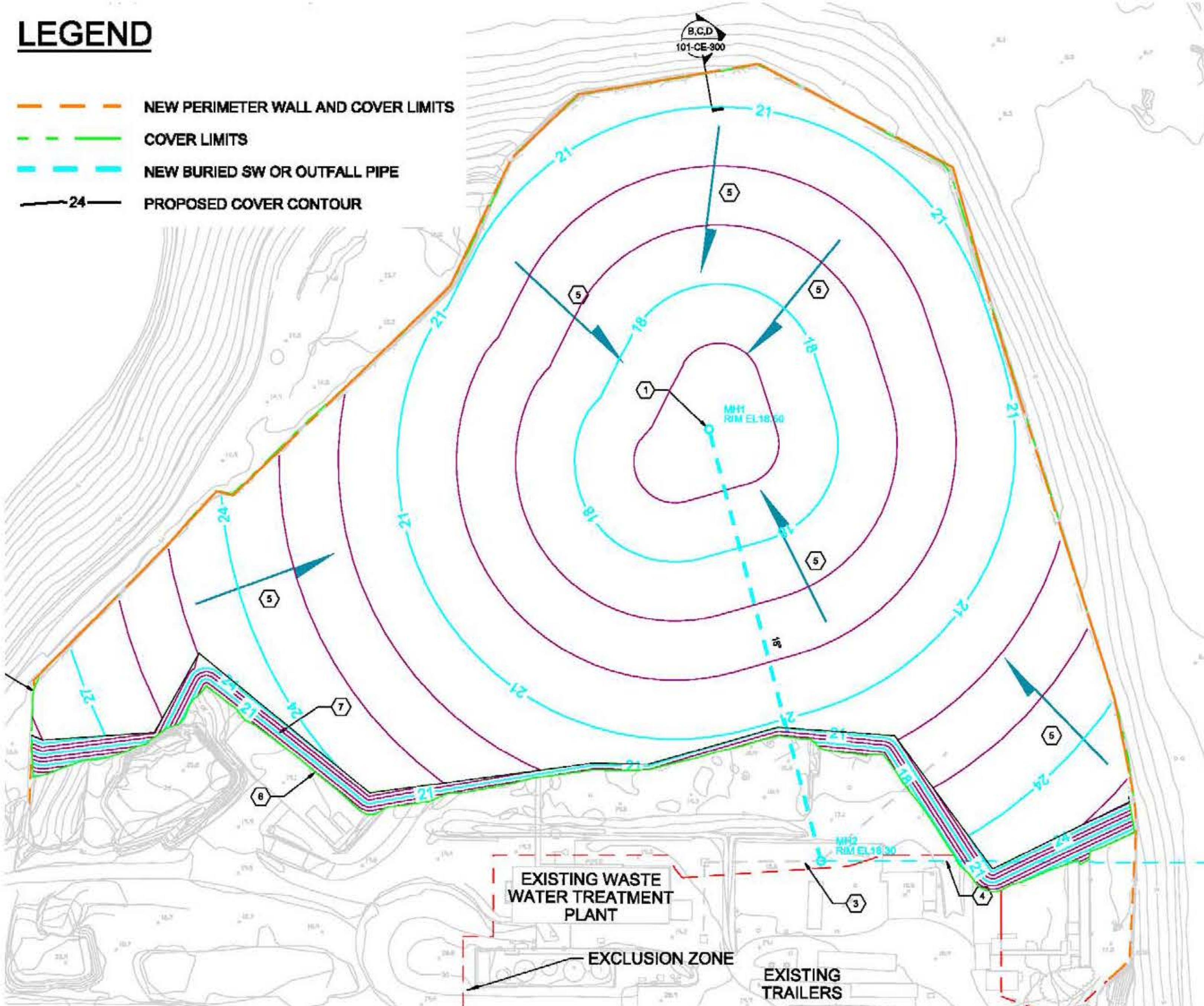
Notes:
1. BAP TEQ - Benzo(a)pyrene Toxicity Equivalents (µg/kg)
2. PAH - Polycylic Aromatic Hydrocarbon
3. Sample locations were obtained from Figure 1 of the Clam Tissue Collection Report Wyckoff Eagle Harbor Superfund Site.
4. For non-detect carcinogenic PAHs, a value of 1/2 the detection limit was used for the BAP TEQ concentration calculation.

N

0 125 250 500 Feet

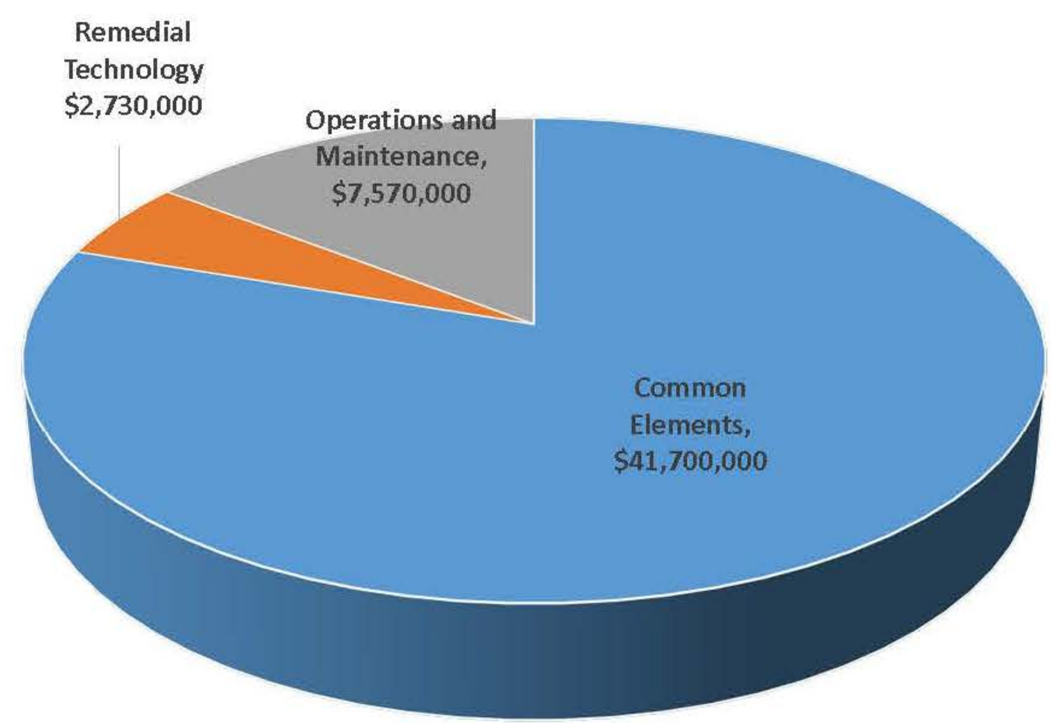
Figure 5-4
Horse Clam Sampling Locations and Clam Tissue Carcinogenic PAH Concentrations Expressed in BAP TEQ

EPA



Percent of NAPL Treated by Technology	
Natural Attenuation	70%
Hydraulic Containment	30%

Upland Alternative 2: $52,000,000



Implementation Sequence

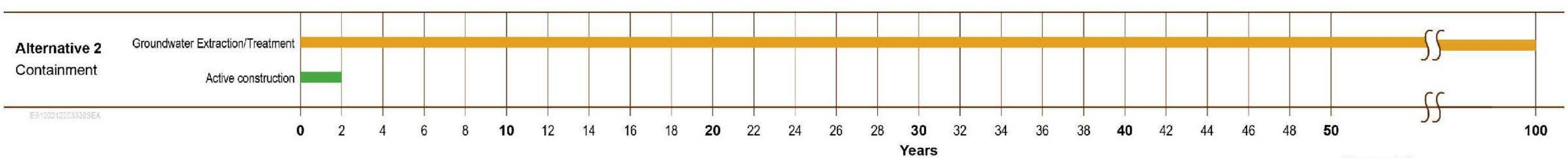
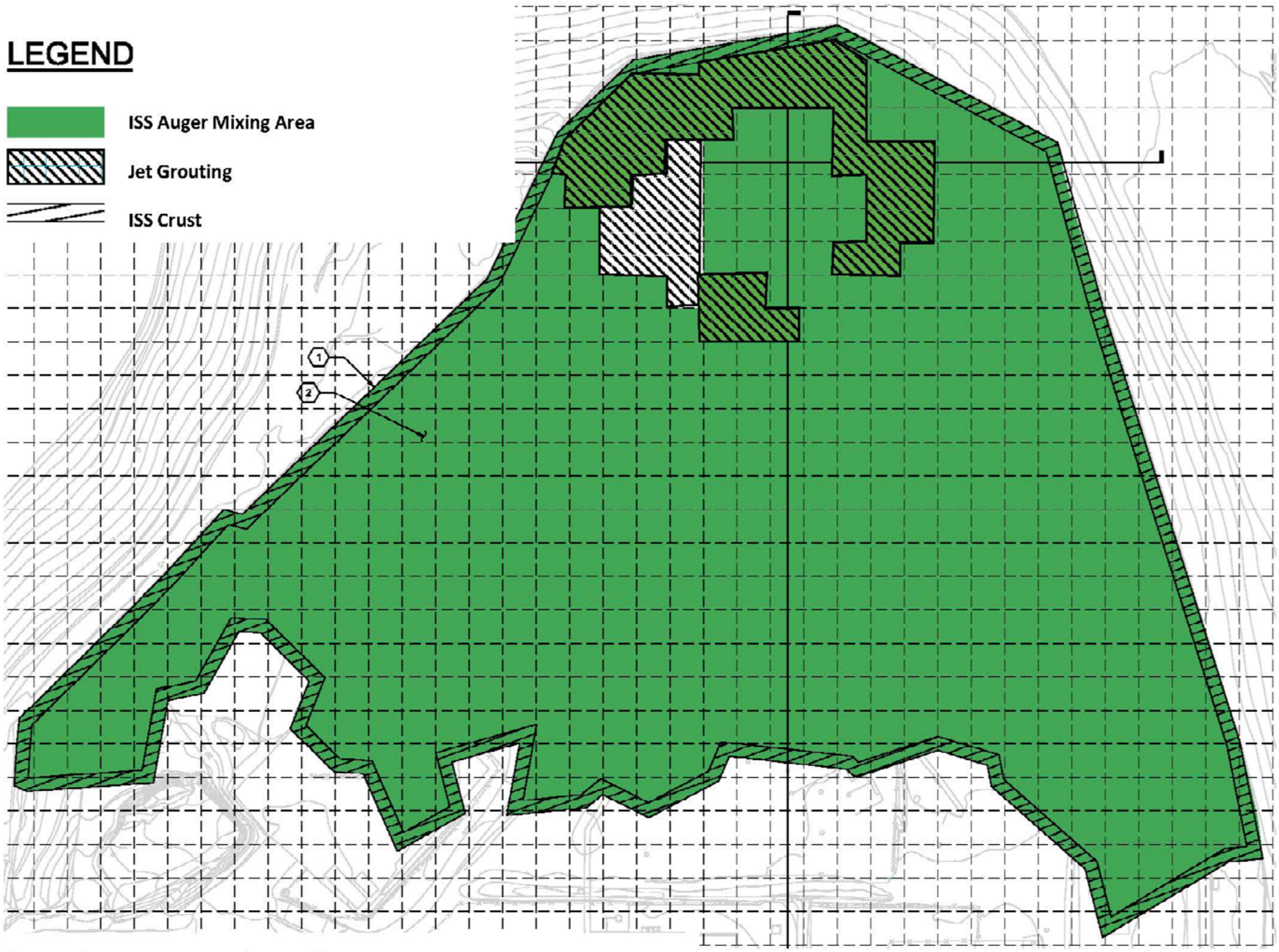
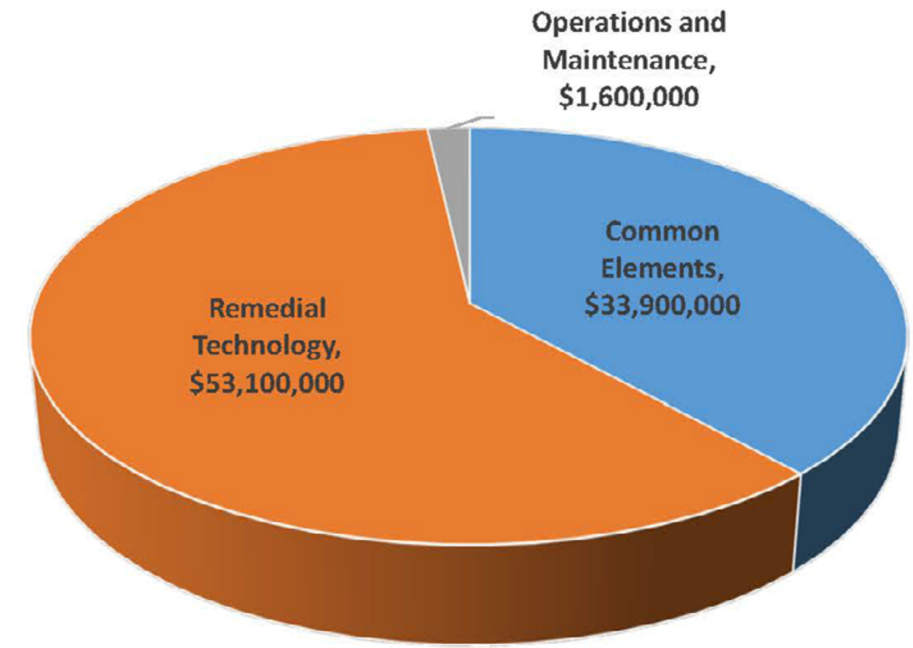


Figure 8-1
Upland Alternative 2 – Containment



Percent of NAPL Treated by Technology	
Passive Treatment	7%
ISS	93%

Upland Alternative 4: $88,600,000



Implementation Sequence

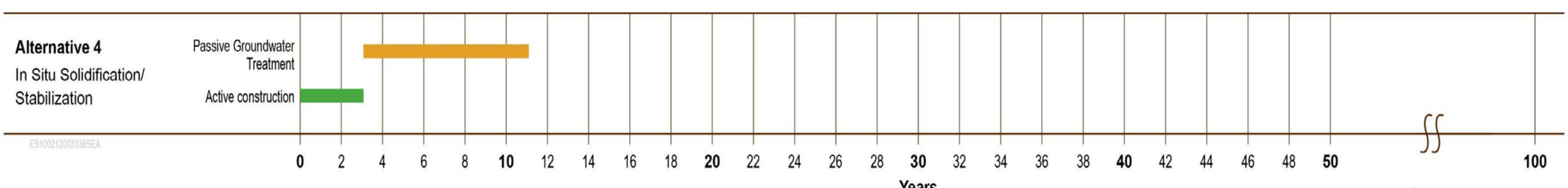
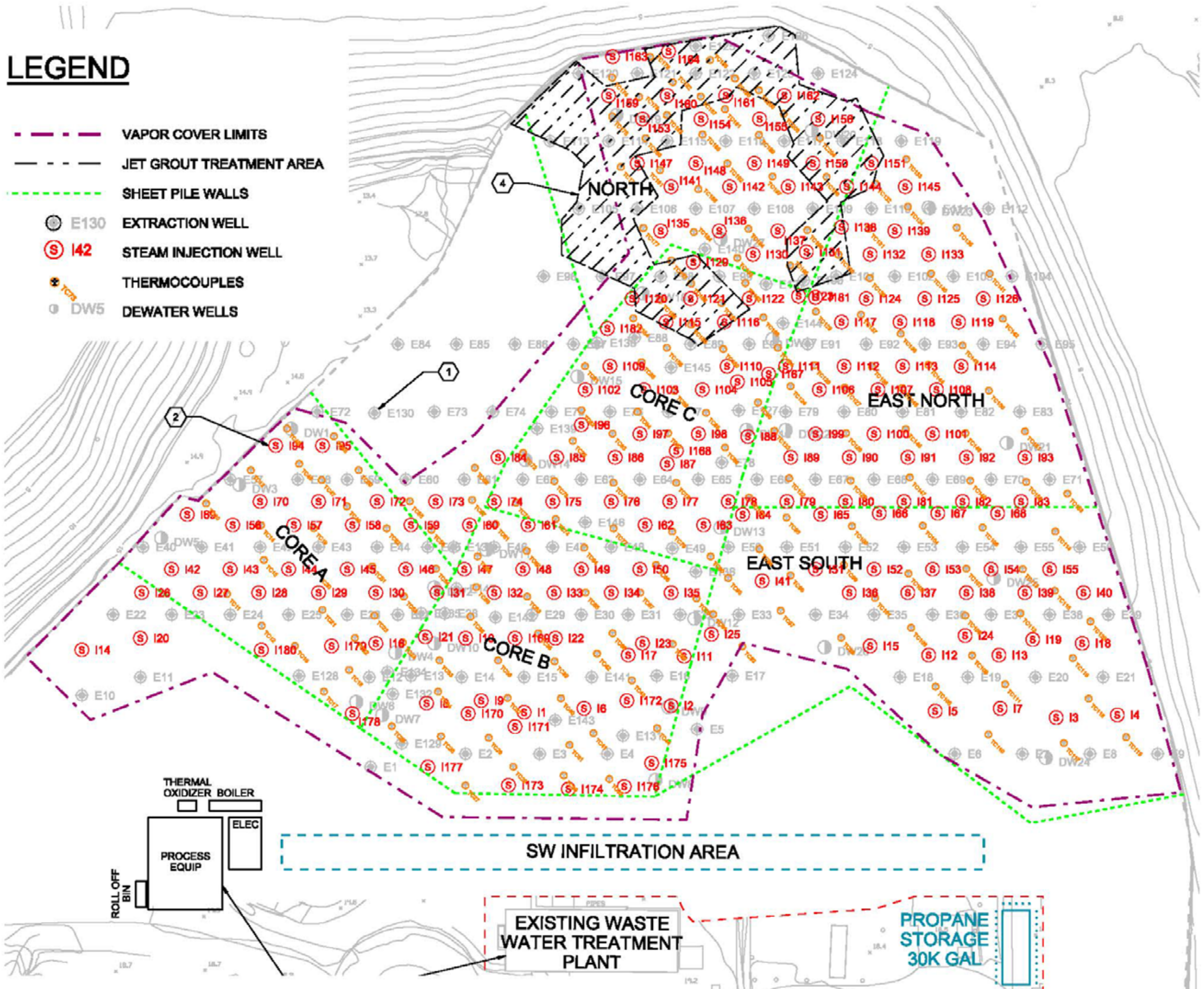


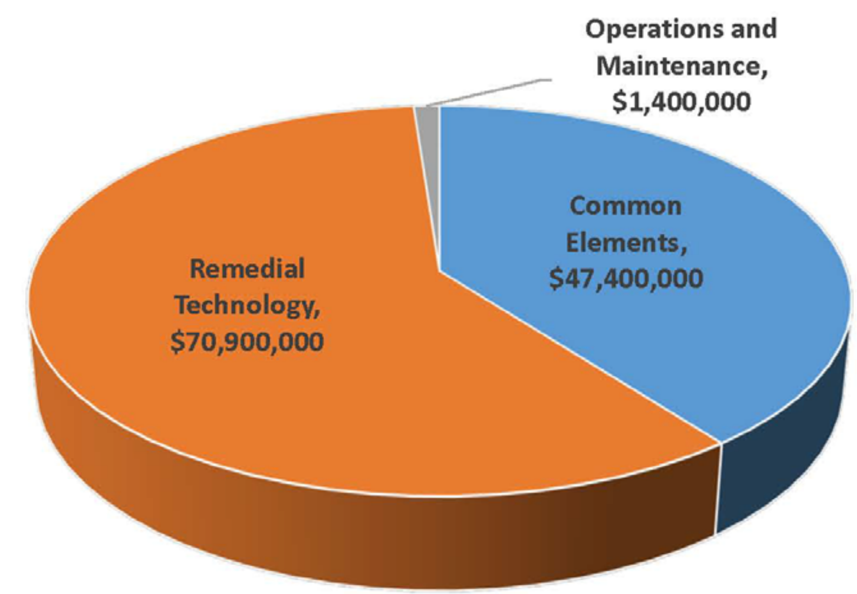
Figure 8-2

Upland Alternative 4 – In-situ Solidification/Stabilization



Percent of NAPL Treated by Technology	
Passive Treatment	16%
Thermal Enhanced Extraction/ISS	84%

Upland Alternative 5: $119,700,000



Implementation Sequence

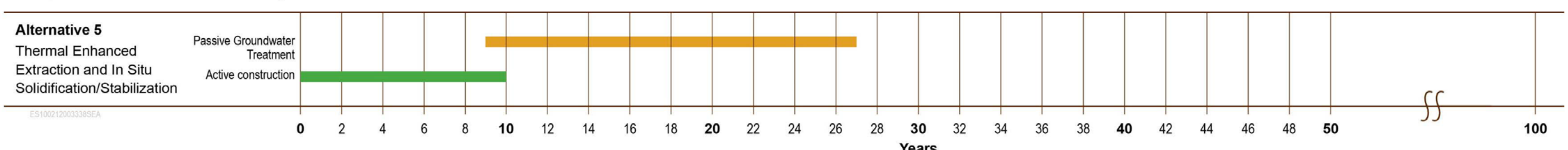
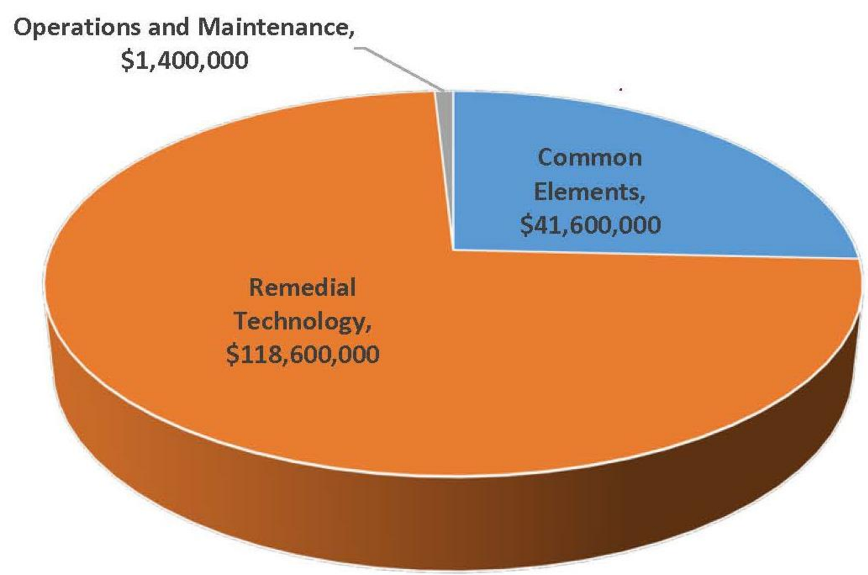


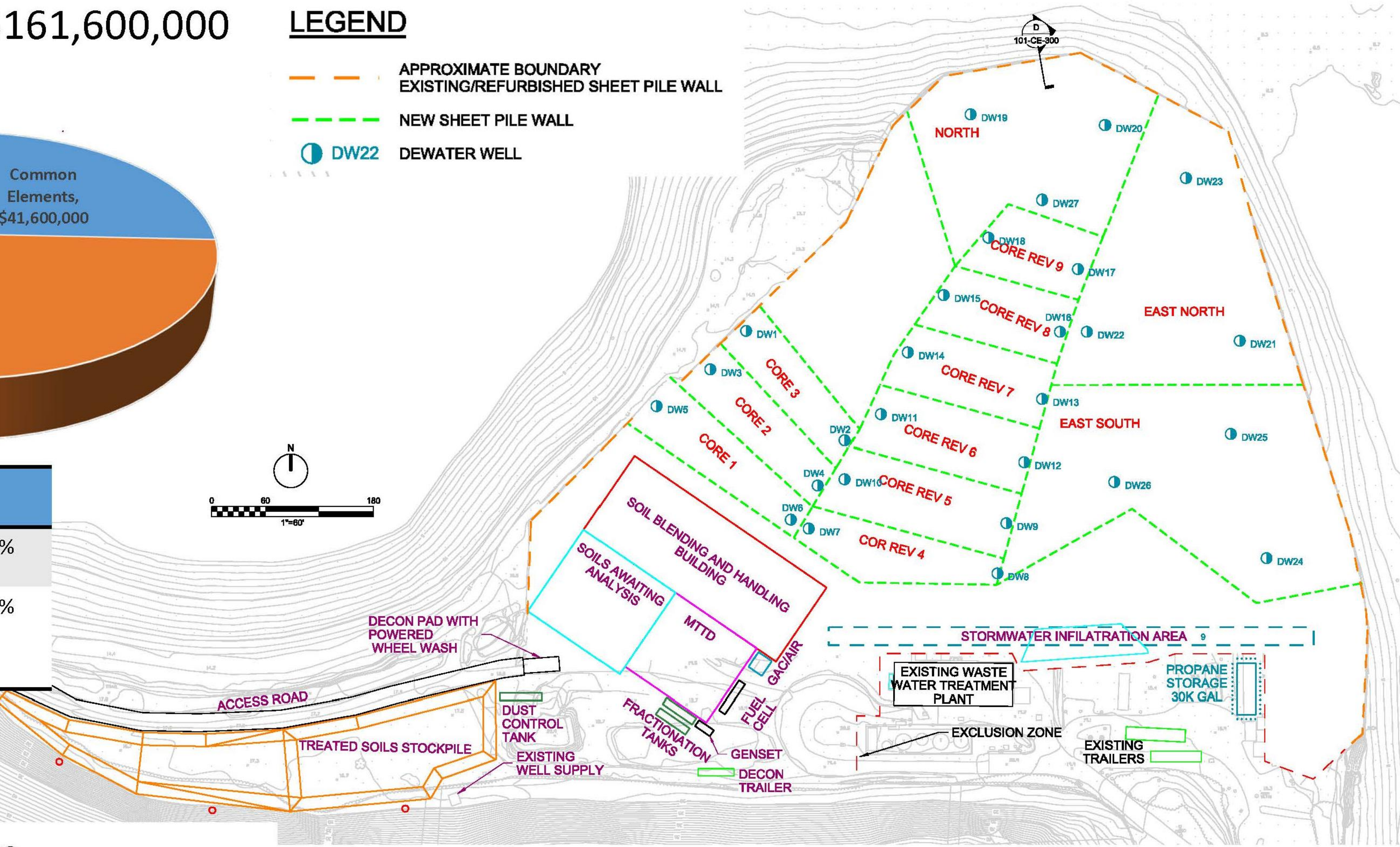
Figure 8-3

Upland Alternative 5 – Thermal-Enhanced Extraction and In-situ Stabilization/Solidification

Upland Alternative 6: $161,600,000



Percent of NAPL Treated by Technology	
Passive Treatment	15%
Excavation/Thermal Desorption/Thermal Enhanced Extraction	85%



Implementation Sequence

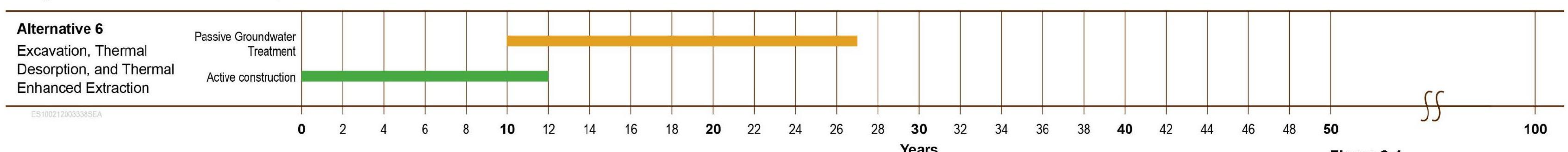
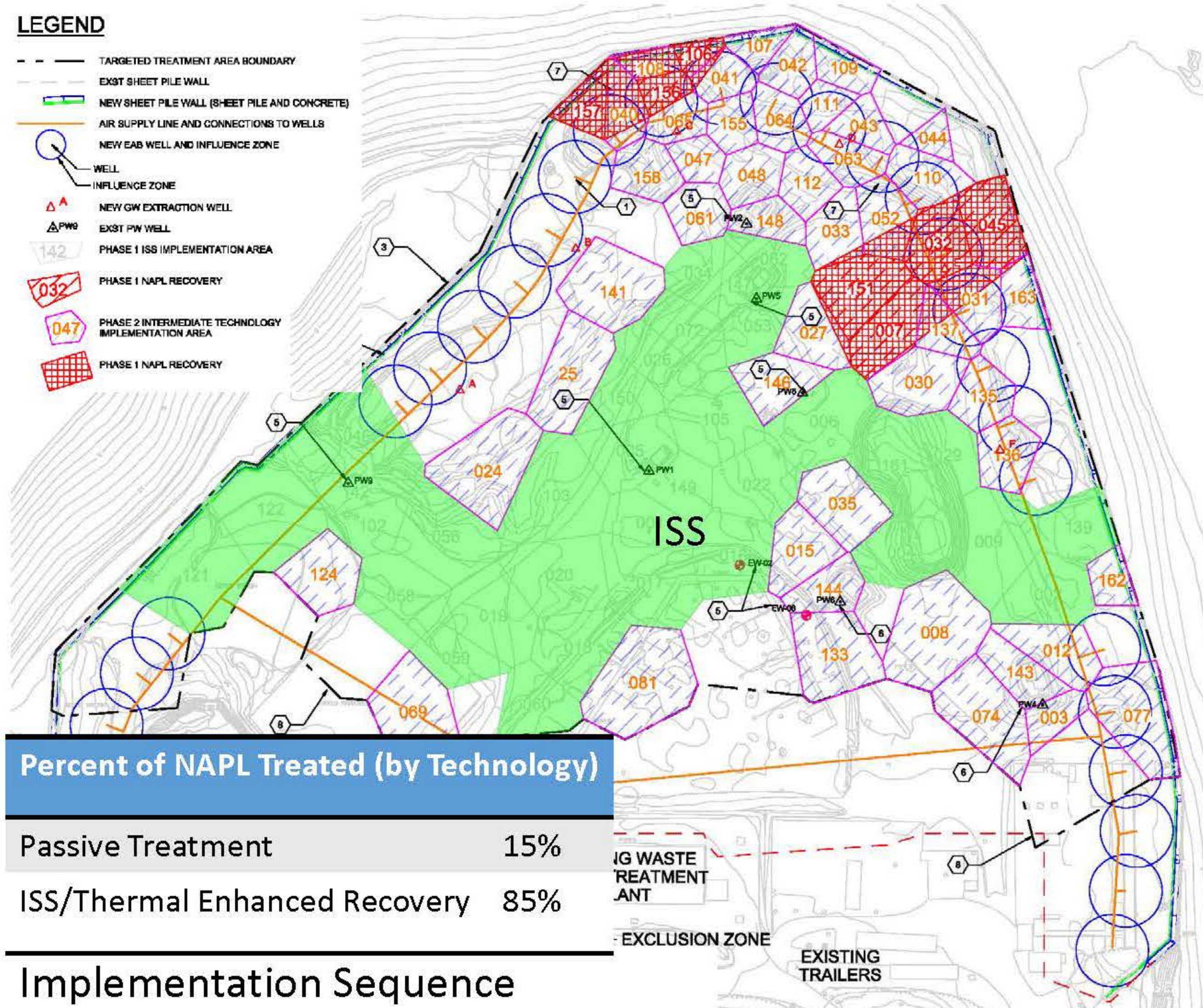


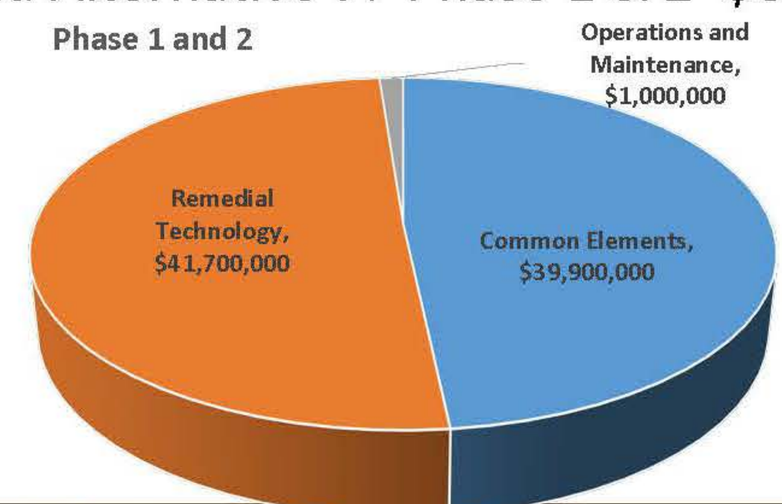
Figure 8-4

Upland Alternative 6 – Excavation, Thermal Desorption, and Thermal-Enhanced Extraction



Percent of NAPL Treated (by Technology)	
Passive Treatment	15%
ISS/Thermal Enhanced Recovery	85%

Upland Alternative 7: Phase 1 & 2 -$82,600,000



Implementation Sequence

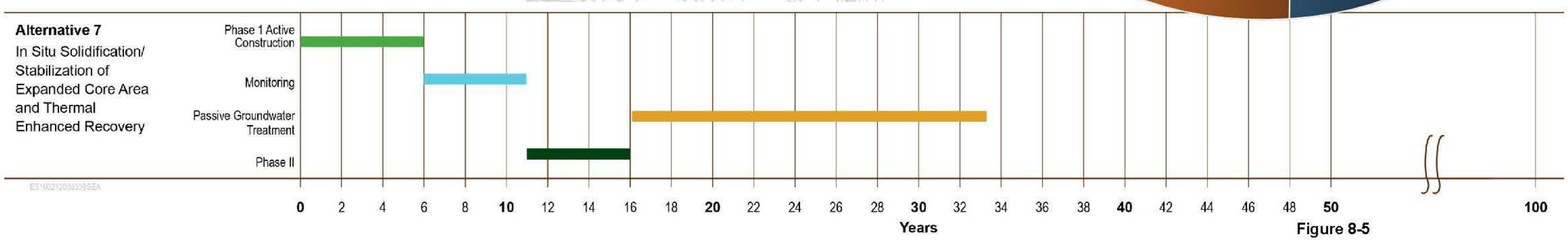
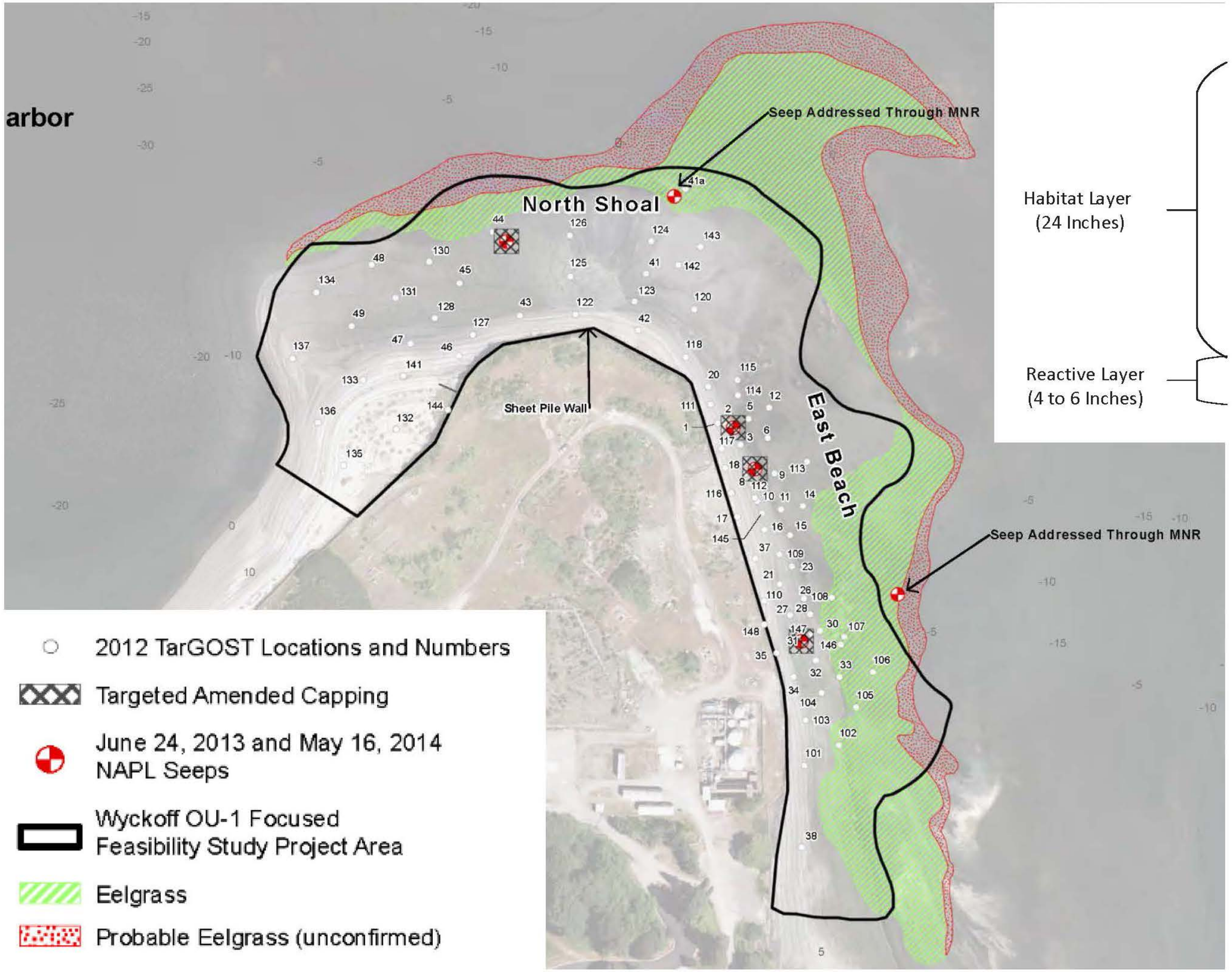


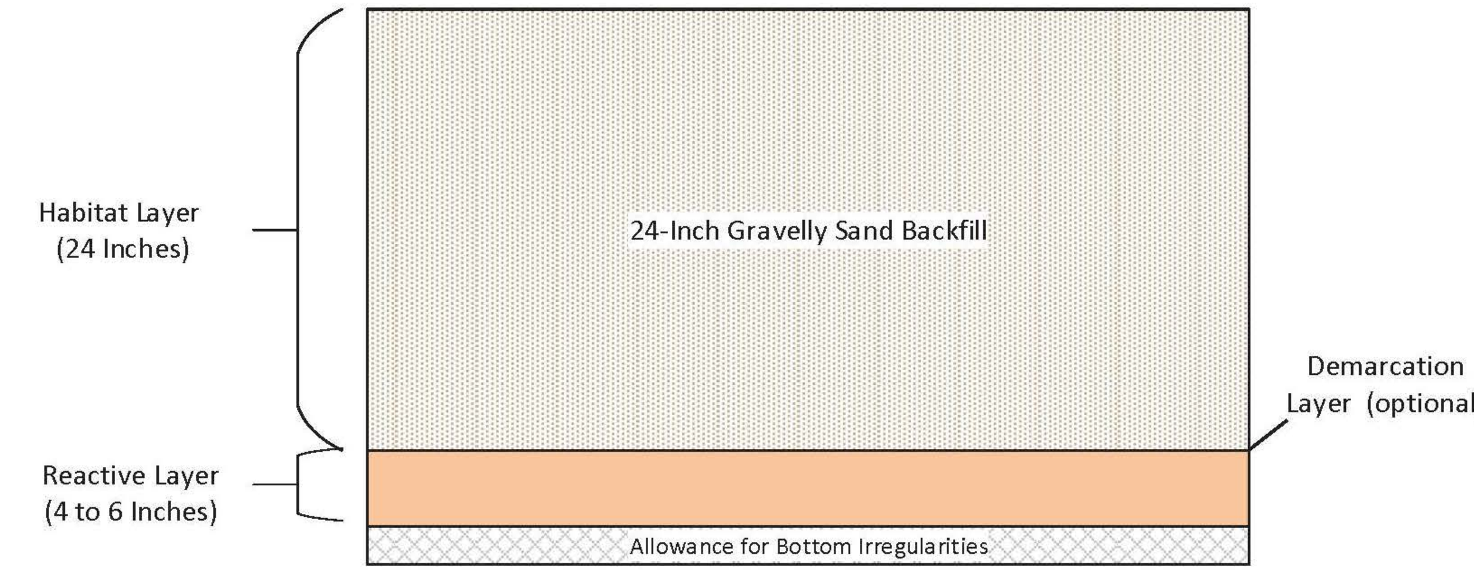
Figure 8-5

Upland Alternative 7 – In-situ Solidification/Stabilization of Expanded Core Area and Thermal-Enhanced Recovery

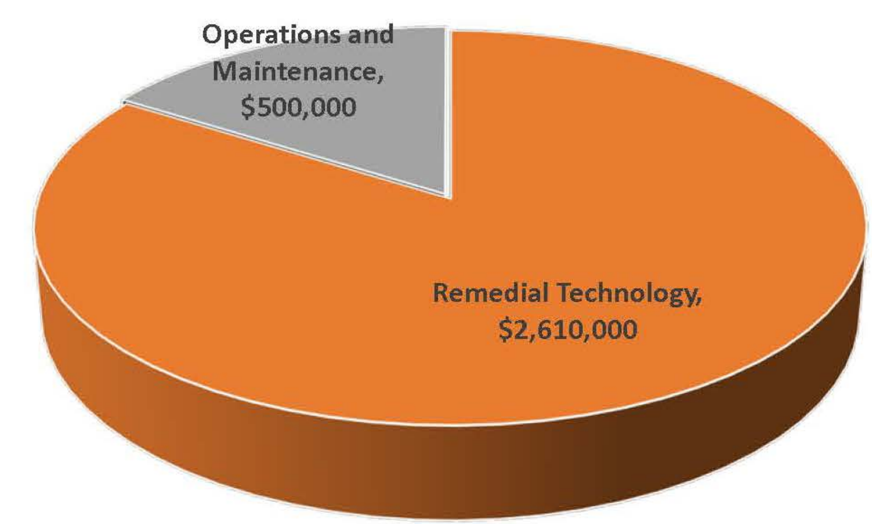
EPA



Conceptual Reactive Cap Construction Detail



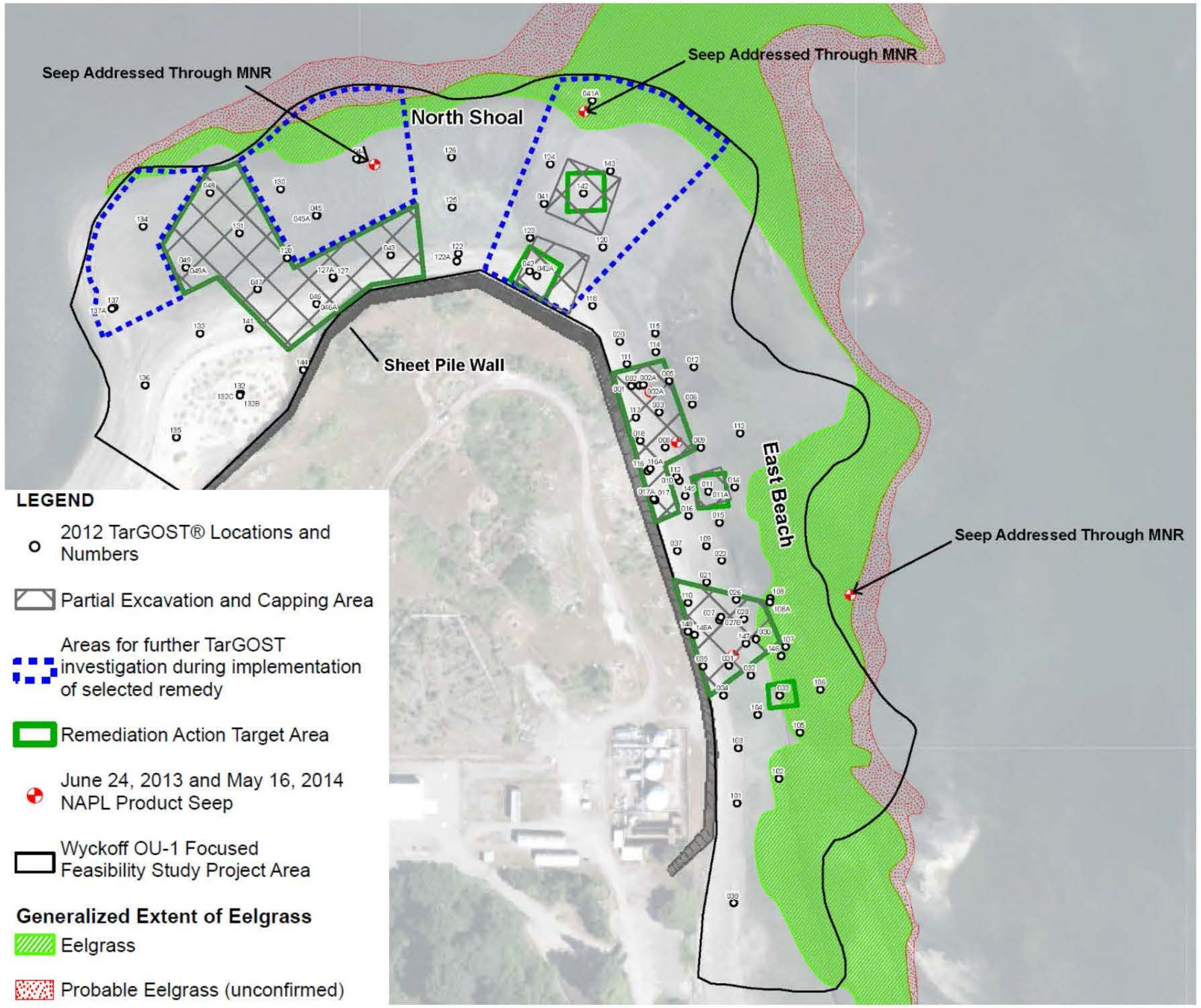
Nearshore Alternative 2: $3,110,000

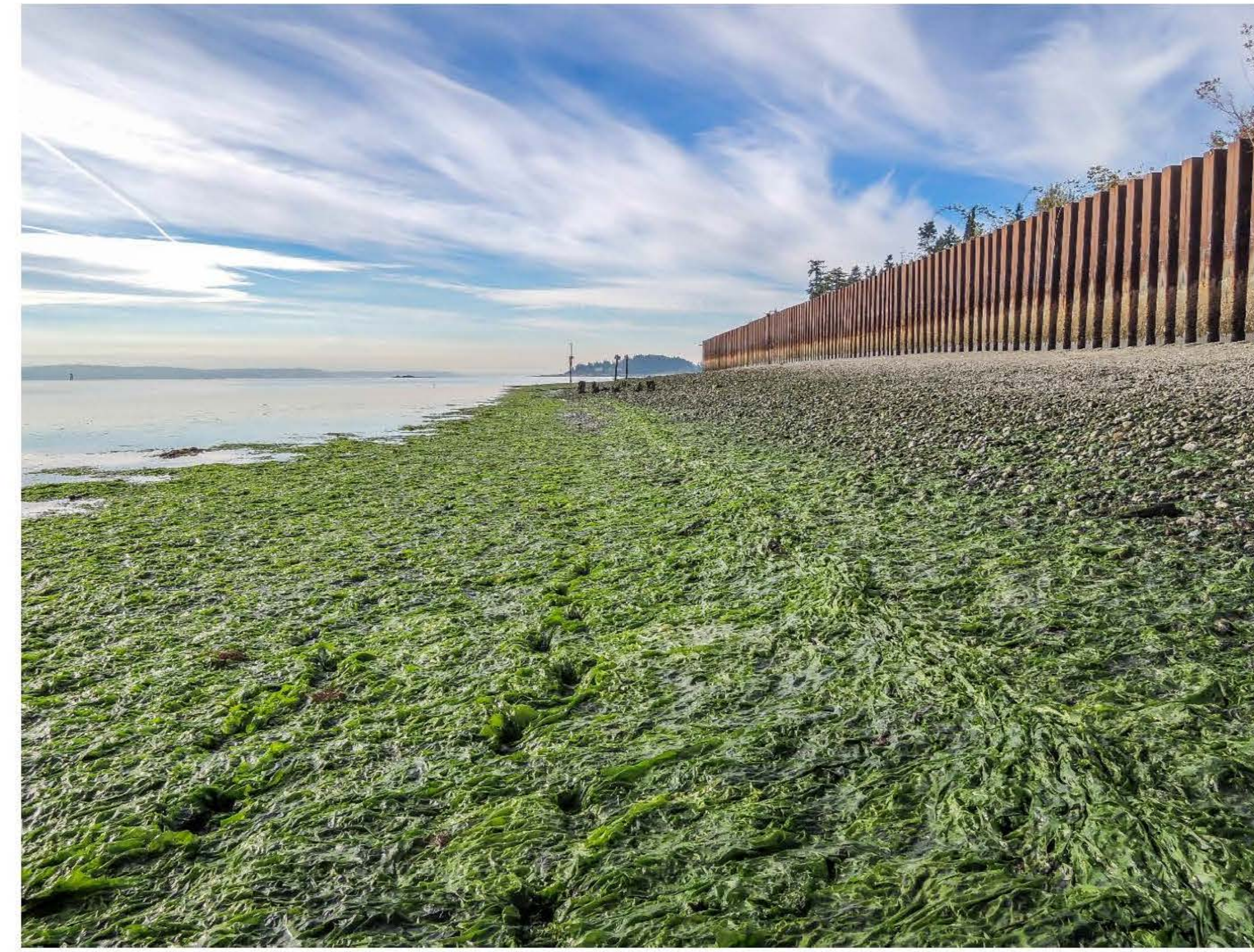


Active Remediation Area (Acres)	MNR Area (Acres)	Removal Volume (CY)	Construction Duration (Months)
0.3	10.5	900	1

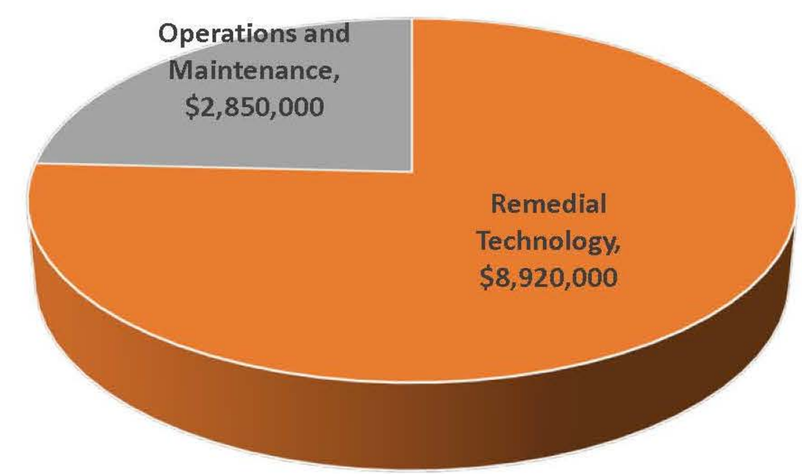
Figure 8-6

Nearshore Alternative 2 – Seep Capping





Nearshore Alternative 3: $11,770,000



Active Remediation Area (Acres)	MNR Area (Acres)	Removal Volume (CY)	Construction Duration (Months)
1.6	9.2	6,600	4

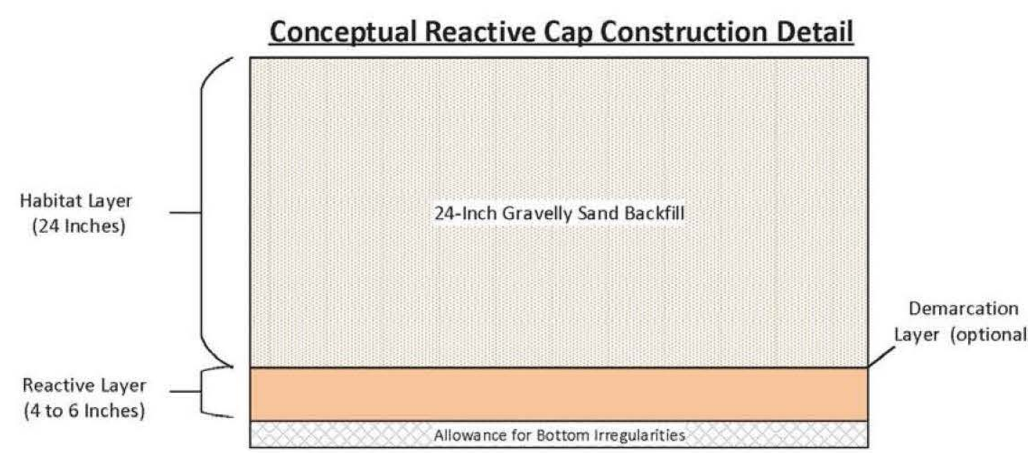
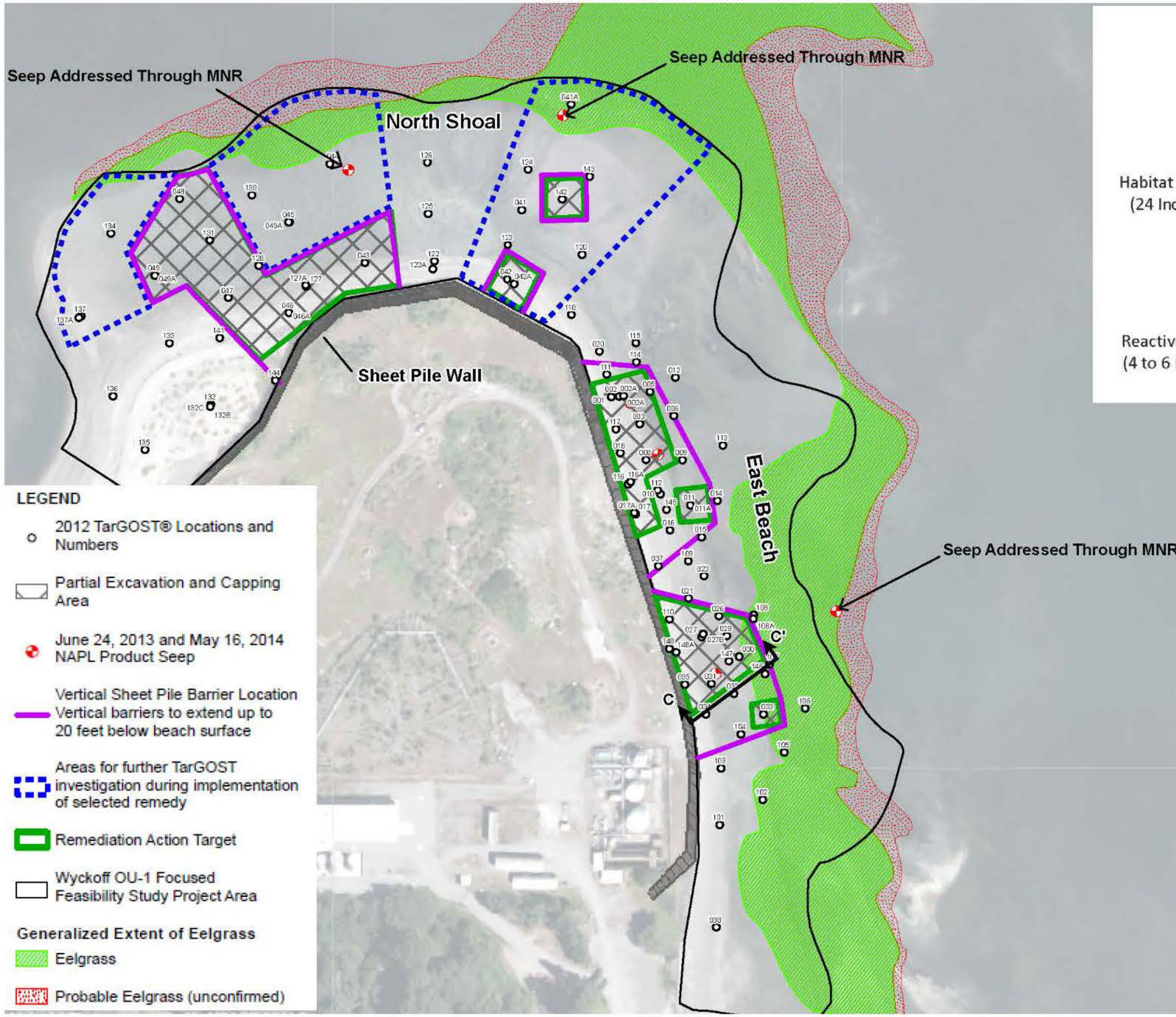
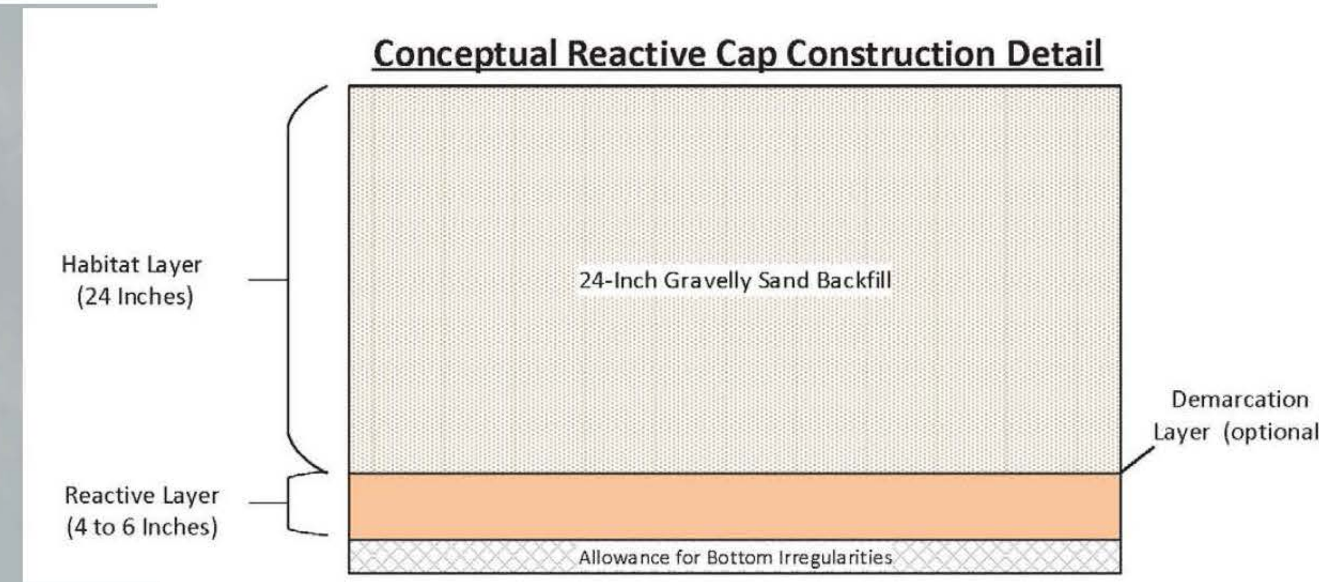


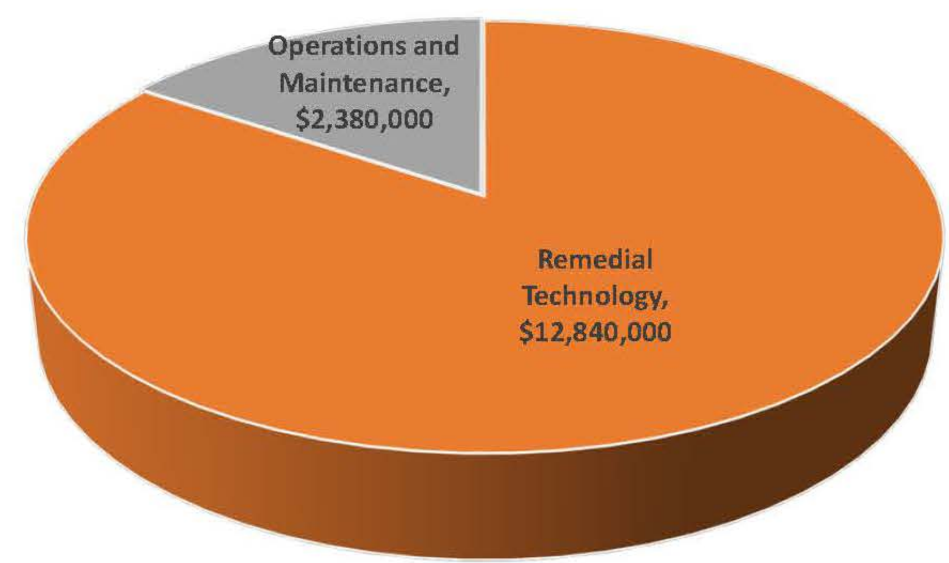
Figure 8-7

Nearshore Alternative 3 – Partial Excavation and Capping





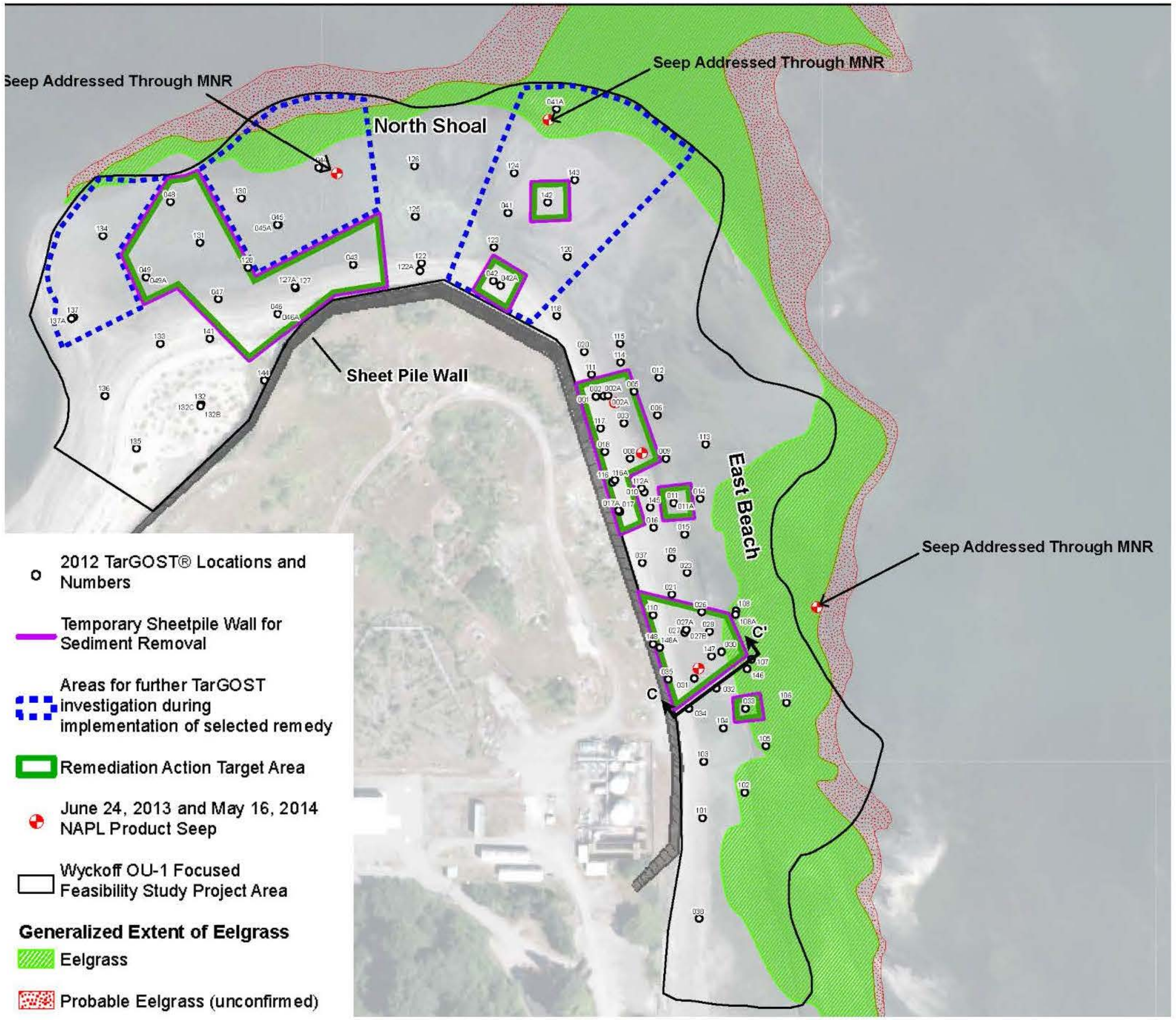
Nearshore Alternative 4: $15,220,000



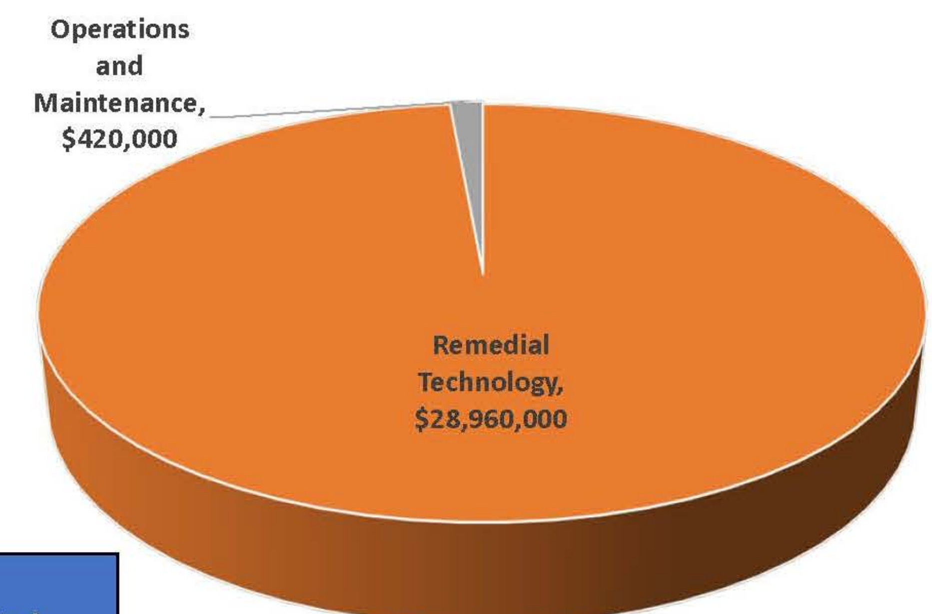
Active Remediation Area (Acres)	MNR Area (Acres)	Removal Volume (CY)	Construction Duration (Months)
1.6	9.2	6,600	4

Figure 8-8

Nearshore Alternative 4 – Vertical Containment with Partial Excavation and Capping



Nearshore Alternative 5: $29,380,000



Active Remediation Area (Acres)	MNR Area (Acres)	Removal Volume (CY)	Construction Duration (Months)
1.6	9.2	26,000	8

Figure 8-9
Nearshore Alternative 5 – Dredging