Draft Report

Non-Aqueous Phase Liquid Focused Feasibility Study for the Soil and Groundwater Operable Units (OU2/OU4) Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

Prepared for

U.S. EPA, Region 10

September 2014

CH2MHILL®

1100 112th Avenue NE
Suite 500
Bellevue, WA 98004

Contents

Appendixes

Tables

Figures

Acronyms and Abbreviations

2000 ROD	*Record of Decision: Wyckoff Co./Eagle Harbor Superfund Site, Soils and Groundwater Operable Units, Bainbridge Island, Washington*
ACP	asphalt concrete pavement
ARAR	applicable or relevant an appropriate requirements
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
°C	degrees Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLA RI/FS Guidance	*Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*
COC	contaminant of concern
CY	cubic yard
DNAPL	dense non-aqueous-phase liquid
EAB	enhanced anaerobic biodegradation
EC	engineering control
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
FFS	focused feasibility study
FPA	Former Process Area
FRTR	Federal Remediation Technologies Roundtable
FS	feasibility study
GAC	granular activated carbon
gpm	gallons per minute
GRA	general response action
GWTP	groundwater treatment plant
HPAH	high-molecular weight PAH
IC	institutional control
ISCO	in situ chemical oxidation
ISS	in situ solidification/stabilization
ITRC	Interstate Technology and Regulatory Council
LNAPL	light non-aqueous phase liquid
LPAH	low-molecular weight PAH
MCL	maximum contaminant level
mg/L	milligrams per liter
MLLW	mean lower low water
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
MTTD	medium temperature thermal desorption
MVS	Mining Visualization Software

NAPL	non-aqueous-phase liquid
NCY	NAPL cubic yard
O&M	operations and maintenance
OU	operable unit
PAH	polycyclic aromatic hydrocarbons
PCP	pentachlorophenol
PGTS	passive groundwater treatment system
PO	performance objective
PRG	preliminary remediation goal
%RE	percentage of the reference emitter
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	Record of Decision
scfm	standard cubic feet per minute
Site	Wyckoff/Eagle Harbor Superfund Site
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TarGOST	Tar-specific Green Optical Scanning Tool
TMV	toxicity, mobility, or volume
TPH	total petroleum hydrocarbons
TPH-Dx	TPH-diesel
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
WAC	Washington Administrative Code
Wyckoff Site	Wyckoff/Eagle Harbor Superfund Site

Executive Summary

This report presents a non-aqueous-phase liquid (NAPL) focused feasibility study (FFS) conducted for the Wyckoff/Eagle Harbor Superfund Site (Wyckoff Site, or Site) Soil and Groundwater Operable Units (OUs). As described in the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (U.S. Environmental Protection Agency [EPA], 1988a), the feasibility study (FS) consists of three phases: screening remedial technologies, developing remedial action alternatives, and conducting a detailed analysis of the alternatives. The scope of the FFS is similar to the FS, however, the FFS addresses a specific problem or portion of a contaminated site. For the Wyckoff Soil and Groundwater OUs, this FFS specifically addresses NAPL present in soil and groundwater underlying the Former Process Area (FPA). Contaminated soil and groundwater that lies outside the NAPL footprint are not addressed.

Focused Feasibility Study Approach

Remedial action alternatives were developed for detailed evaluation in this FFS by combining various technologies, and the media to which they are applied, into alternatives that address NAPL source material. The overall FFS approach included the following steps:

- Step 1—Develop remedial action objectives (RAO) specifying the contaminants of concern (COCs) and their corresponding clean-up levels, the environmental media, and the exposure pathways to be addressed. Most information associated with this step, which is discussed in Chapter 2 of this FFS, was obtained from *Wyckoff Eagle Harbor Superfund Site – OUs 2 and 4 Draft Remedial Action Objective Meeting Minutes* (Snider, 2013) and the *Draft Wyckoff Soil and Groundwater OUs RAOs* (EPA, Revised May 18, 2014).

- Step 2—Identify the areas and volumes (e.g., remedial action target area or target zones) of contaminated media to be addressed. This is a key element that is summarized in Chapter 2 of this FFS. The remedial action target area was identified as described in the *Groundwater Conceptual Site Model Update Report for the Former Process Area, Wyckoff/Eagle Harbor Superfund Site, Soil and Groundwater Operable Units* (CH2M HILL, 2013a).

- Step 3—Identify general response actions (GRAs) for environmental media to be addressed, individually or in combination, which may be taken to achieve the RAOs. GRA categories applicable to NAPL present in the FPA include: no action, access controls, containment, removal and disposal, ex situ treatment, and in situ treatment.

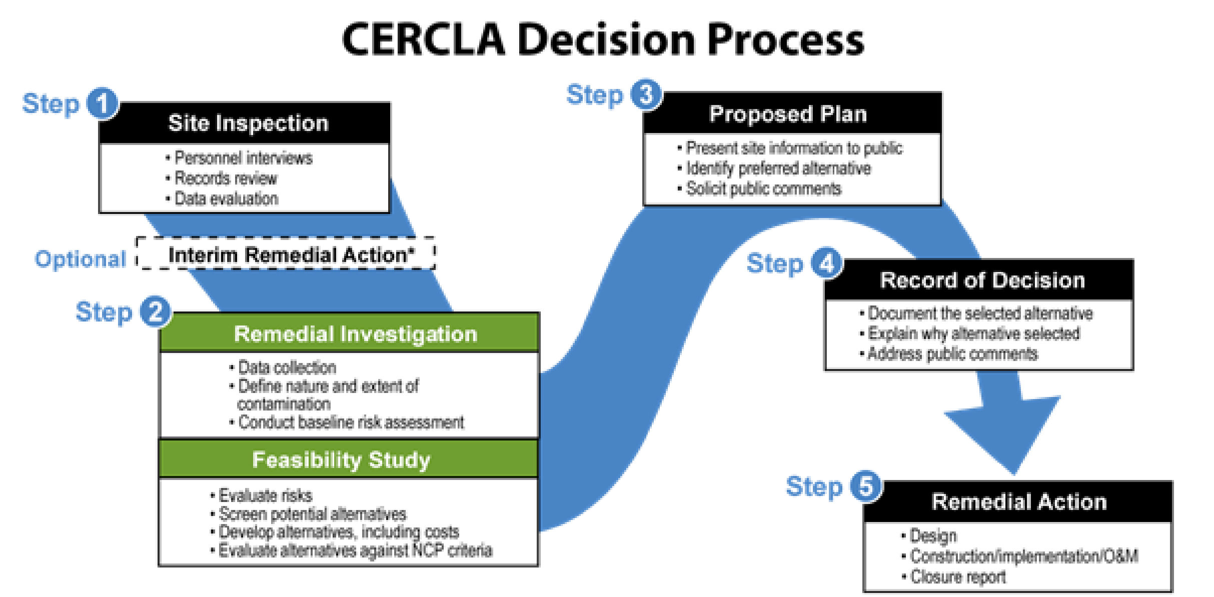
- Step 4—Identify and screen the technologies and their associated process options applicable to each GRA to eliminate those that are not viable for NAPL and the subsurface conditions present in the FPA. The screening process includes an evaluation of each technology based on considerations of effectiveness, implementability, and relative cost. The technology screening, which is presented in Chapter 2 of this FFS, was performed as generally described in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988a).

- Step 5—Assemble the retained technologies into a range of source control alternatives in accordance with the National Contingency Plan (NCP; Code of Federal Regulations [CFR], Title 40, Section 300.430(e)(3). When assembling alternatives containing multiple technologies, consideration was given to those that are compatible and complementary. The results from this step are presented in Chapter 3 of this FFS.

- Step 6—Conduct a detailed and comparative analysis of the alternatives individually, and relative to one another, against the evaluation criteria specified in the NCP, 40 CFR 300.430(e)(9). The detailed evaluation of the alternatives against the criteria of state acceptance and community acceptance was not performed in this FFS but will be conducted as described in the NCP, 40 CFR 300.430(e)(9)(iii)(H) and (I). The results from this step are presented in Chapter 4 of this FFS.

- Step 7—Identify a recommended alternative. Based on the results of the detailed and comparative evaluation and discussions between EPA, Washington State Department of Ecology (Ecology) and community representatives, a recommended alternative was identified as summarized in Chapter 5 of this FFS. The recommended alternative will be identified as the Preferred Alternative in the Proposed Plan.

As shown on Exhibit ES-1, The FFS/FS represents Step 2 of the decision process that leads to selecting a remedy for a Superfund site. Following EPA and Ecology review of this draft FFS, EPA, as the lead regulatory agency, will prepare and issue a Proposed Plan that will undergo public review and participation in accordance with 40 CFR 300.430(f). Following receipt of public comments and preparation of a Responsiveness Summary that address public comments, EPA will issue a Comprehensive Environmental Response Compensation and Liability Act (CERCLA) decision document that selects a remedial action alternative to address NAPL source material present in the Wyckoff Soil and Groundwater OUs.



Step 1. Site Inspection—Includes interviewing site personnel regarding the history of the site, reviewing waste disposal records, and evaluating existing data.

Step 2. Remedial Investigation/Feasibility Study—Topics of the combined segments are:

- **Remedial Investigation**—Consists of an environmental study to identify the nature and extent of contamination and a preliminary evaluation of the risk posed to human health and the environment.
- **Feasibility Study**—Includes the details of a remedial alternatives evaluation: a complete risk assessment of current conditions and an evaluation of the potential risk reduction presented for each of the remedial alternatives that are considered.

Step 3. Proposed Plan—Based on previous field investigations and reports that are completed in the first three steps of the CERCLA process described above. The Proposed Plan summarizes the remedial alternative evaluations and presents the preferred alternative recommended in the FS to the public for comments.

Step 4. Record of Decision—Formally documents the cleanup alternative that was selected after the Tri-Parties reviewed and responded to public comments on the Proposed Plan.

Step 5. Remedial Action—Consists of the actual cleanup activities being performed. When cleanup is completed, a final report is written that describes the remedial actions implemented, the result of the actions, and the conclusion of the CERCLA process.

CHPUBS1107_2010-96_DD_1-2

EXHIBIT ES-1
Comprehensive Environmental Response Compensation and Liability Act Decision Process

Remedial Action Target Area

The area and volume of NAPL-contaminated source material to be addressed in the FFS was defined using information obtained from a Tar-Specific Green Optical Scanning Tool (TarGOST) field investigation conducted in 2013. The objective for the TarGOST investigation was to define the distribution of NAPL within the Upper Aquifer underlying the FPA. Based on evaluation of the field investigation results (*2014 Conceptual Site Model Update for the OU2 and OU4 Former Process Area*, CH2M HILL, 2014b) a TarGOST response of 10 percent reference emitter (%RE) was identified as signifying the presence of NAPL. Because the TarGOST measurements do not specifically indicate the presence of mobile or immobile (residual) NAPL, all locations and depths with a TarGOST response of 10 %RE or greater were identified as NAPL source material. The TarGOST results were used to define the following five remedial action target zones that are described in this FFS: (1) Core Area, (2) North Shallow (Light NAPL [LNAPL]), (3) East Shallow (LNAPL), (4) North Deep (Dense NAPL [DNAPL]), and (5) Other Periphery. Based on evaluation of the TarGOST data, 99 percent of the Upper Aquifer underlying the FPA by soil volume was identified for remedial action.

Remedial Action Alternatives

The technologies retained from the screening were assembled into a range of source control alternatives in accordance with the NCP under 40 CFR 300.430(e)(3). Technology and technology combinations identified for each target zone included the following:

- **Core Area:** Containment, In Situ Solidification/Stabilization (ISS), Excavation and Thermal Desorption, Thermal Enhanced Extraction, Enhanced Recovery, and Enhanced Aerobic Biodegradation (EAB)
- **North Shallow (LNAPL):** Containment, ISS, Excavation and Thermal Desorption, Thermal Enhanced Extraction, Enhanced Recovery, and EAB
- **East Shallow (LNAPL):** Containment, ISS, Excavation and Thermal Desorption, Thermal Enhanced Extraction, Enhanced Recovery, and EAB
- **North Deep (DNAPL):** Containment, ISS, Thermal Enhanced Extraction, Enhanced Recovery, and EAB
- **Other Periphery:** Containment, ISS, Thermal Enhanced Extraction, and EAB

Enhanced Recovery was paired with Thermal Enhanced Extraction because it can increase the effectiveness and shorten the treatment timeframe. EAB is used as a “polishing” technology for deployment in areas with sparse NAPL occurrences and/or for implementation in target zones following completion of more aggressive remedial action.

Based on CERCLA program expectations, a range of seven source control alternatives were assembled. In addition to the technologies named in each alternative title, an array of common elements are also required to fully implement each alternative. The seven alternatives include the following:

- **Alternative 1: No Action—**The No Action Alternative was developed per NCP requirements.
- **Alternative 2: Containment—**This is the current remedy implemented under the existing Soil and Groundwater OUs Record of Decision (EPA, 2000a).
- **Alternative 3: Excavation, Thermal Desorption, and ISS—**The excavation and thermal desorption components of this alternative would be implemented in the Core Area, North Shallow (LNAPL), East Shallow (LNAPL), and Other Periphery target zones, and ISS in the North Deep (DNAPL) target zone.
- **Alternative 4: ISS—**This technology would be implemented in each target zone.
- **Alternative 5: Thermal Enhanced Extraction and ISS—**Thermal enhanced extraction would be implemented in the Core Area, North Shallow (LNAPL), East Shallow (LNAPL), and Other Periphery target zones and ISS in the North Deep (DNAPL) target zone.

- **Alternative 6: Excavation, Thermal Desorption, and Thermal Enhanced Extraction—**The excavation and thermal desorption components of this alternative would be implemented in the Upper Core Area and thermal enhanced extraction in the Lower Core Area, North Shallow (LNAPL), East Shallow (LNAPL), and Other Periphery target zones.
- **Alternative 7: ISS and Thermal Enhanced Recovery—**ISS would be implemented in the Core Area and around the perimeter of the NAPL source zone and thermal enhanced recovery in the remaining target zones.

Following development, the seven alternatives identified above were screened against the NCP criteria of effectiveness, implementability, and cost as described in 40 CFR 300.430(e)(7). Based on the results of this screening, Alternative 3 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction was eliminated based on implementability considerations. The shoring and dewatering necessary to implement the deep excavation technology at the Site was determined to pose significant geotechnical risk.

Detailed Evaluation of Alternatives

The six remedial action alternative retained following the initial screening were carried forward for more detailed engineering development and evaluation against the CERCLA threshold and balancing criteria described in the NCP under 40 CFR 300.430(e)(9). The alternatives will be evaluated against the modifying criteria during the CERCLA public participation process that occurs following issuance of the Proposed Plan.

In addition to the individual evaluation of each alternative against the CERCLA criteria, which is presented in Chapter 4 of this FFS, the alternatives were evaluated relative to one another to identify key trades-offs. The comparative evaluation (see **Table ES-1**) was used to facilitate a ranking of the alternatives. Based on the results of the detailed and comparative evaluation, Alternative 4—In Situ Stabilization/Solidification, and Alternative 5—Thermal Enhanced Extraction and ISS, were ranked comparably.

Recommended Alternative

Due to a shorter estimated timeframe to achieve RAOs (see Exhibit ES-2), and a lower level of long-term Site management, Alternative 4 was initially identified during stakeholder discussions as the recommended alternative. The estimated timeframe to achieve RAOs shown on Exhibit ES-2 assumes an aggressive – continuous implementation schedule with no technical, regulatory, or financial uncertainties.

Further, EPA and Ecology discussions are planned, and a presentation to the National Remedy Review Board may result in a different recommended alternative or identification of new technology combinations and new alternatives. Selection of the final alternative will occur in a CERCLA decision document following completion of the public participation process.

TABLE ES-1
Comparative Evaluation of Alternatives
Soil and Groundwater OUs – Former Process Area
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Alternative 1 – No Action	Alternative 2 - Containment	Alternative 4 - ISS	Alternative 5 – Thermal Enhanced Extraction and ISS	Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction	Alternative 7 – ISS of Core Area and Thermal Enhanced Recovery
Key Treatment Technologies						
- Core Area	Natural attenuation	Soil cap, hydraulic containment, and ICs	ISS, soil cap	Enhanced NAPL recovery, thermal enhanced extraction, EAB	Upper Core - Excavation, thermal desorption Lower Core – Enhanced NAPL recovery, thermal enhanced extraction, EAB	ISS
- East Shallow (LNAPL)					Enhanced NAPL recovery, thermal enhanced extraction, EAB	Enhanced NAPL recovery, thermal enhanced extraction, EAB
- North Shallow (LNAPL)						
- North Deep (DNAPL)				ISS		
- Other Periphery				EAB	EAB	EAB
Percent of NAPL Treated using Key Technologies						
– Hydraulic Containment	--	7	--	--	--	--
– NAPL Recovery	--	34	--	--	--	--
– ISS	--	--	95	12	--	37
– Enhanced NAPL Recovery/Thermal/EAB	--	--	--	26/52/8 (86 total)	21/43/18 (82 total)	26/31/6 (63 total)
– Excavation	--	--	--	--	14	--
– Passive Groundwater Treatment	--	--	1	1	1	1
– Natural Attenuation	100	12	4	1	3	--
Threshold Criteria						
Protects HHE	No	Yes	Yes	Yes	Yes	Yes
Complies with ARARs	No	Yes	Yes	Yes	Yes	Yes
Balancing Criteria						
Long-term Effectiveness and Permanence	Not evaluated	★☆☆	★★★	★★★	★★☆	★★★
Reduction of TMV through Treatment	Not evaluated	★☆☆	★★☆	★★★	★★☆	★★★
Short-term Effectiveness		★★☆ O&M limited to 100 years	★★★	★★☆	★★☆	★★☆
Implementability		★★☆	★★☆	★★☆	★★☆	★★☆
Cost – Total Present Worth Cost (millions) – Total Non-discounted Cost (millions)	 $0 $0	 $70.6 $109.8	 $86.3 $91.8	 $134.1 $149.1	 $185.7 $208.8	 $85.2 $95.9

TABLE ES-1
Comparative Evaluation of Alternatives
Soil and Groundwater OUs – Former Process Area
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Alternative 1 – No Action	Alternative 2 - Containment	Alternative 4 - ISS	Alternative 5 – Thermal Enhanced Extraction and ISS	Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction	Alternative 7 – ISS of Core Area and Thermal Enhanced Recovery
Modifying Criteria						
State Acceptance	Not evaluated in this FFS					
Community Acceptance						

★★★ = The alternative performs very well against the CERCLA balancing criterion with minimal disadvantages or uncertainties

★★☆ = The alternative performs moderately well against the CERCLA balancing criterion but with some disadvantages or uncertainties

★☆☆ = The alternative performs less well against the CERCLA balancing criterion with more disadvantages or uncertainty

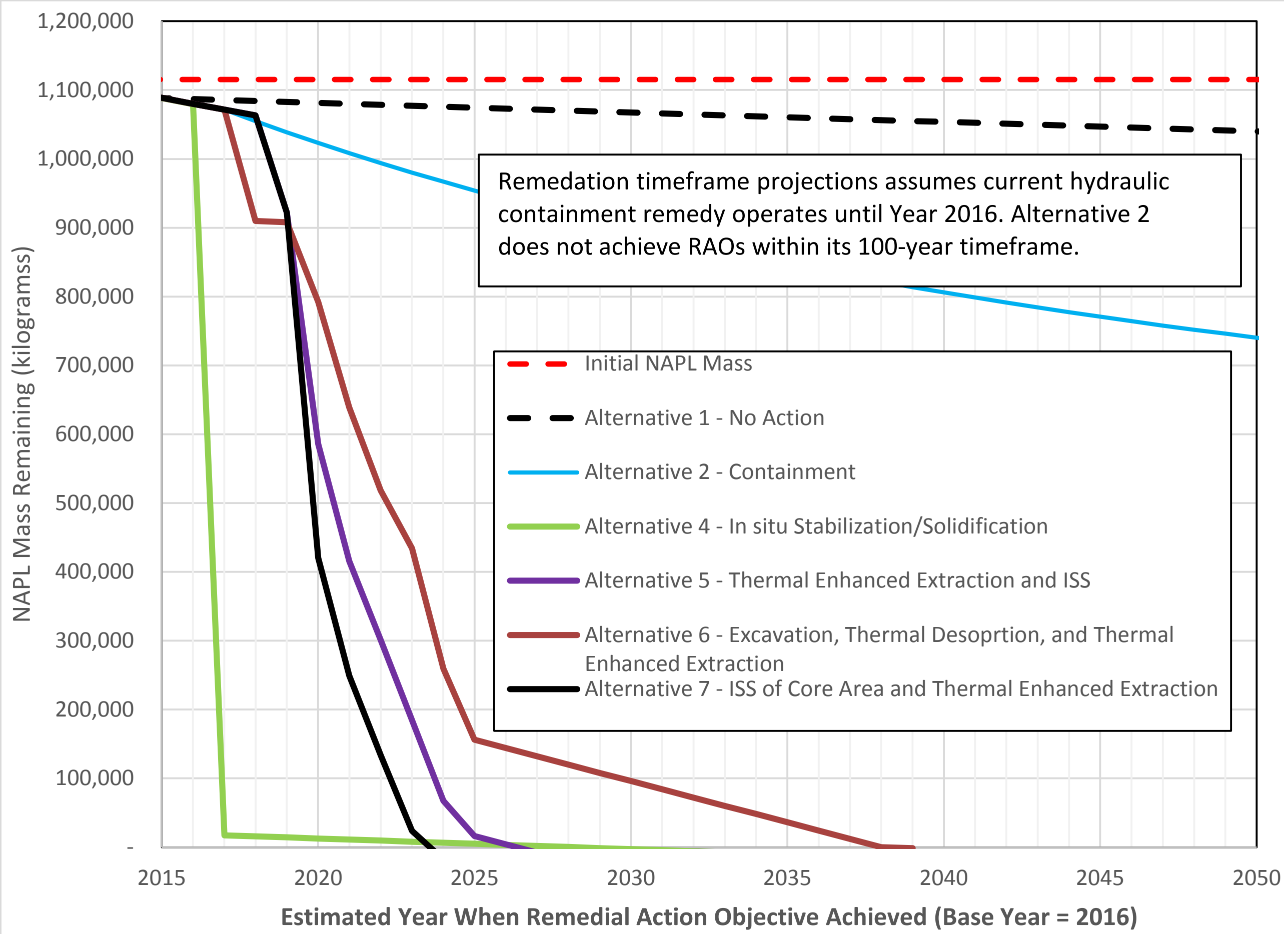


EXHIBIT ES-2
Estimated Timeframe to Achieve Remedial Action Objectives

SECTION 1

Introduction

This report presents the draft Focused Feasibility Study (FFS) conducted for the Wyckoff/Eagle Harbor Superfund Site (Wyckoff Site, or Site) Soil and Groundwater Operable Unit (OU) located on Bainbridge Island, Washington. The FFS describes the process by which remedial action alternatives were developed and evaluated to assist in identifying a recommended alternative to address non-aqueous-phase liquid (NAPL) source material underlying the Site's Former Process Area (FPA). This FFS was prepared as one of the work scope items included under Task Order 079-RI-FS-10S1 of the U.S. Environmental Protection Agency (EPA) Region 10 and CH2M HILL Architecture and Engineering Services Contract No. 68-S7-04-01.

1.1 Purpose and Report Organization

A feasibility study (FS) ensures that appropriate remedial action alternatives are developed and evaluated so that relevant information concerning the remedial action options can be presented and an appropriate remedy selected. This document is referred to as an FFS, rather than an FS, because it addresses a specific problem within the Soil and Groundwater OUs; that is NAPL source material.

As described in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (CERCLA RI/FS Guidance; EPA, 1988a), the FFS/FS consists of three phases:

- Screening remedial technologies
- Developing remedial action alternatives
- Conducting a detailed analysis of the alternatives

The results of the first two phases were presented in the *Wyckoff/Eagle Harbor Soil and Groundwater Operable Units Focused Feasibility Study - Remedial Technology Screening and Preliminary Remedial Action Alternatives* (CH2M HILL, 2014a). Much of the information presented in the February 2014 Technical Memorandum is included herein for completeness to support the identification of a recommended alternative in this draft FFS report.

The content and format of this document is based on the suggested FS report format described in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988a) as follows:

- Chapter 1 – Introduction
- Chapter 2 – Identification and Screening of Technologies
- Chapter 3 – Development and Screening of Alternatives
- Chapter 4 – Detailed Analysis of Alternatives
- Chapter 5 – Recommended Alternative
- Chapter 6 - References

The tables and figures called out in this document are presented in separate sections that follow Chapter 6. This FFS report also contains several key appendices that provide important contributing information as follows:

- **Appendix A, Soil and Groundwater Operable Unit Applicable or Relevant and Appropriate Requirements,** contains an evaluation of applicable or relevant an appropriate requirements (ARARs) that specify federal and state of Washington regulations that govern the soil and groundwater clean-up levels that need to be achieved by the NAPL source area remedial action, and the manner in which the remedial action alternatives are to be implemented.

- **Appendix B, Remedial Action Alternative Drawings,** contains the engineering drawings that illustrate conceptual level design information for the common elements and remedial action alternatives described in Chapter 3.
- **Appendix C, Common Element and Remedial Action Alternative Cost Estimate,** contains a -30/+50 percent cost estimate for each remedial action alternative carried forward for the detailed analysis of alternatives presented in Chapter 4.
- **Appendix D, Remedial Action Alternative Timeframe Projections,** summarizes the assumptions and methods that were used to estimate the time required to achieve remedial action objectives (RAOs) for each of the remedial action alternatives carried forward for the detailed analysis of alternatives presented in Chapter 4. *(Note: This appendix is still being prepared and will be included with the next submittal.)*
- **Appendix E, Wyckoff NAPL Composition**, presents laboratory analysis results from testing of NAPL samples collected at the Site.

1.2 Background Information

This section summarizes background information for the Wyckoff/Eagle Harbor Superfund Site Soil and Groundwater OUs, including the Site description, Site history investigation chronology, nature and extent of NAPL contamination, baseline risk, and status of the ongoing containment remedy. Most information was adapted from the following:

- *Record of Decision: Wyckoff Co./Eagle Harbor Superfund Site, Soils and Groundwater Operable Units, Bainbridge Island, Washington* (2000 ROD; EPA, 2000a)
- *Groundwater Conceptual Site Model Update Report for the Former Process Area, Wyckoff/Eagle Harbor Superfund Site, Soil and Groundwater Operable Units* (CH2M HILL, 2013a)

1.2.1 Site Description

The Wyckoff/Eagle Harbor Superfund Site is located on the east side of Bainbridge Island, Kitsap County, Washington (**Figure 1-1**[1]). The Site was divided into the following four OUs based on environmental media, contaminant sources, and environmental risks:

- **OU1** or the **East Harbor OU** (subtidal/intertidal sediments in Eagle Harbor contaminated by polycyclic aromatic hydrocarbons [PAHs])
- **OU2** or the **Wyckoff Soil OU** (unsaturated soil contaminated with PAHs and pentachlorophenol [PCP])
- **OU3** or the **West Harbor OU** (subtidal/intertidal sediments in Eagle Harbor contaminated by metals, primarily mercury, and upland sources)
- **OU4** or the **Wyckoff Groundwater OU** (the saturated soil and groundwater beneath OU2)

The Wyckoff Site spans approximately 57 acres of which OU2 and OU4 occupy about 18 acres. OU2/OU4 comprises the following three geographic areas: FPA, Former Log Storage/Peeler Area, and the Well CW01 Area. This FFS only addresses those portions of OU2/OU4 lying beneath the approximate 8-acre FPA, where most NAPL occurs. The Log Storage/Peeler Area and the Well CW01 Area are not discussed is this FFS report; additionally, OU1 and OU3 are also not discussed. OU1 is addressed in a separate FFS, while OU3 was addressed in a previous Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) decision document, *EPA Superfund Record of Decision Amendment: Wyckoff Co./Eagle Harbor EPA ID: WAD009248295 OU 03 Bainbridge Island, WA, EPA/AMD/R10-96/131* (EPA, 1996a).

[1] Figures are provided at the end of the report.

1.2.1.1 Hydrogeology

This section summarizes the hydrogeology underlying the FPA. This includes information on the key hydrostratigraphic units, groundwater flow patterns, and groundwater/surface water interaction. This hydrogeologic understanding is based on the cumulative findings of numerous investigations (**Table 1-1**[2]) that included drilling soil borings (geotechnical, direct push, probes, and/or cone penetrometer) and installing monitoring wells, piezometers, and/or extraction wells. Currently, there are 77 wells present in the FPA (**Figure 1-2**).

Based on geologic logging of the soil and well boreholes, the deepest of which is 127 feet below ground surface (bgs), there are four primary hydrostratigraphic units: Vadose Zone, Upper Aquifer, Aquitard, and the Lower Aquifer. A geologic cross-section showing the key hydrostratigraphic units is shown on **Figures 1-2** and **1-3.**

Vadose Zone

The vadose zone, or unsaturated zone above the water table, generally consists of fill material that extends from ground surface to depths ranging from 6 feet in the west portion of the FPA to 13 feet in the northeast portion. The vadose zone thickness varies with seasonal and tidally influenced groundwater elevations. Within the vadose zone, buried infrastructure, debris, and building foundations occurs within the footprint of the FPA (**Figure 1-4**). Some of these features are exposed at the ground surface, whereas others have been covered during filling and regrading activities. Buried debris is an important consideration for the FFS, because unless removed, it may affect NAPL source area remedy implementation.

Direct contact with the NAPL-contaminated soil present in the vadose zone, and associated with buried debris, represents the primary human health exposure pathway in the Soil and Groundwater OUs. Leaching of contaminants from NAPL present in vadose zone soil or associated with buried debris also represents a groundwater contaminant source.

Upper Aquifer

The Upper Aquifer consists primarily of sand and gravel with groundwater occurring under unconfined or water table conditions. Groundwater elevations range from about 7.5 to 10 feet mean lower low water (MLLW) under nonpumping, seasonal low conditions (based on September 2012 data). Daily tidal fluctuations have significantly influenced Upper Aquifer groundwater elevations, especially along the shoreline. These variations can result in water table fluctuations ranging from 1 to 10 feet. After the perimeter sheet pile wall was installed in 2001, tidal influence has diminished, and most wells now show a tidal influence ranging from 0.1 to 4 feet.

The perimeter or outer sheet pile wall bounding the north and east ends of the FPA is an important feature, because it represents an Upper Aquifer groundwater flow barrier. The integrity of the sheet pile wall influences the Upper Aquifer's hydraulic response to seasonal water level changes and daily Puget Sound-Eagle Harbor tidal cycles. Sheet pile wall integrity also affects NAPL and dissolved-phase contaminant transport from the Soil and Groundwater OUs to the East Harbor (OU1) and West Harbor (OU3) OUs.

The sheet pile wall integrity evaluation presented in the *Wyckoff Sheet Pile Wall – Non-Aqueous Phase Liquid and Plume Migration Barrier Effectiveness Evaluation* (CH2M HILL, 2013b) concluded that, while there is some hydraulic seepage though the sheet pile wall via the individual pile joints, comparing current to historical Upper Aquifer tidal efficiency factors, combined with the understanding of sheet pile wall schematics, indicates that the total groundwater flux through the sheet pile wall is significantly less than prewall conditions. Field observations made at the five channels welded to the sheet pile wall seams suggest that NAPL migration through the seams is possible; however, if it is occurring, the flux would be significantly less than prewall conditions.

[2] Tables are provided at the end of this report.

As shown on **Figure 1-3**, groundwater flow in the Upper Aquifer before the sheet pile wall was installed (original conditions) was from the inland area towards Eagle Harbor and Puget Sound, where it discharged to the intertidal and subtidal zones. Groundwater flow patterns in the Upper Aquifer are currently influenced by the perimeter sheet pile wall and hydraulic containment pumping, which generally promote an inward groundwater flow pattern.

Per the 2000 ROD (EPA, 2000a), due to elevated salinity, Upper Aquifer groundwater beneath the FPA is not currently extracted, nor is it expected to be extracted in the future, for potable, agricultural, or industrial purposes. Elevated salinity is a natural condition that results from saltwater intrusion attributed to tidal cycles and the Site's proximity to Puget Sound/Eagle Harbor. The EPA and Washington State Department of Ecology (Ecology) have determined that Upper Aquifer groundwater in the FPA is nonpotable because it is affected by salinity. The assignment of a nonpotable, Class III groundwater beneficial use designation (total dissolved solids greater than 10,000 milligrams per liter [mg/L]) to Upper Aquifer groundwater present beneath the FPA is consistent with EPA's *Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy* (EPA, 1986) and Washington Administrative Code (WAC) 173-340-720(2)(a)(ii).

Aquitard

The Aquitard is a dense layer of marine silt, glacial deposits, and nonmarine clay material that separates the Upper Aquifer from the Lower Aquifer. The top of the Aquitard, which dips northeast, extends from near ground surface in the south-central portion of the Wyckoff Site to approximately 90 feet bgs along the northern portion. Based on numerous field explorations conducted during the Soil and Groundwater OUs remedial investigation (RI; CH2M HILL, 1997), and various United States Army Corps of Engineers (USACE) exploratory drilling events (USACE, January 1998, April 1998, May 2000, October 2006), the Aquitard appears continuous throughout most of the FPA.

The Aquitard's thickness ranges from 10 to 40 feet, with the thinnest areas located near the northeast corner and central portion of the FPA. Borings drilled along the south hillside in 2004 to characterize the area for an upgradient cutoff wall (CH2M HILL, 2004) identified localized areas where the Aquitard was not visibly evident in the far southwest and southeast corners of the Site.

Lower Aquifer

The Lower Aquifer consists primarily of sand, with small amounts of silt, clay, and gravel. While the thickness and depth to the bottom of the Lower Aquifer have not been determined at the Site, it is believed that it extends to a depth of approximately 200 or 250 feet bgs. This estimate is based on the regional work of Frans et al. (2011) and the logs recorded for two deep, on-Site water supply wells that were decommissioned in 1997 and for a new water supply well that was completed in January 2002.

The direction of groundwater flow in the Lower Aquifer is also from the inland area towards Eagle Harbor and Puget Sound, which is a regional groundwater discharge zone, a condition that promotes an upward vertical hydraulic gradient from the Lower Aquifer to the Upper Aquifer. The sheet pile wall and Upper Aquifer hydraulic containment pumping do not influence horizontal groundwater flow patterns in the Lower Aquifer.

Per the 2000 ROD, groundwater in the Lower Aquifer (approximately 80 to 200 feet bgs) is considered potable (Class II B, Groundwater Not a Current Source but Potential Future Source), although this aquifer has never been used for drinking water at the Site. Routine groundwater monitoring performed in the Lower Aquifer has measured salinity levels that exceed the upper-bound potable water total dissolved solids concentration of 10,000 mg/L (EPA, 1986; WAC 173-340-720[2]) at locations up to 200 feet inland of the outer sheet pile wall (**Figure 1-5**). If a water supply well were installed in the Lower Aquifer within the FPA and routinely pumped, then the saltwater-freshwater interface would shift further inland. Rising sea levels would also push the freshwater-saltwater interface further inland. Therefore, for this FFS, all Lower Aquifer groundwater within 200 feet of the outer sheet pile wall is deemed Class III due to existing or future levels of elevated salinity.

1.2.2 Site History

From the early 1900s through 1988, a succession of companies treated wood at the Wyckoff property for use as railroad ties and trestles, telephone poles, pilings, docks, and piers. The wood-preserving plant was one of largest in the United States, and its products were sold throughout the nation and the rest of the world. Wood-preserving operations included the following activities: (1) using and storing creosote, PCP, solvents, gasoline, antifreeze, fuel and waste oil, and lubricants; (2) managing process wastes; (3) treating and discharging wastewater; and (4) storing treated wood and wood products.

The main features of the wood-treating operation included a process area that included numerous storage tanks and process vessels such as retorts; a log storage and log peeler area; and a treated log storage area.

There is little historical information about the waste management practices at the Wyckoff facility. Before the Wyckoff facility was reconstructed in the 1920s, logs were reportedly floated in and out of a lagoon that once existed at the Site; the lagoon has since been filled. Treated logs were also transported to and from the facility at the former West Dock via a transfer table pit, and the chemical solution that drained from the retorts after a treating cycle went directly on the ground and seeped into the soil and groundwater below the surface. This practice began around the mid-1940s until operations ceased in 1988. Wastewater was also discharged into Eagle Harbor for many years, and the practice of storing treated pilings and timber in the water continued until the late 1940s. The log storage area was primarily used to store untreated wood. **Table 1-1** summarizes a chronology of key investigation, enforcement, and clean-up activities conducted for the Soil and Groundwater OUs.

1.2.3 Nature and Extent of Contamination

This section summarizes NAPL distribution in the Soil and Groundwater OUs underlying the FPA. The three-dimensional NAPL contamination footprint defines the area where remedial action is proposed in this FFS.

1.2.3.1 Upper Aquifer

The distribution of NAPL in the Upper Aquifer was defined using the results of Tar-Specific Green Optical Scanning Technology (TarGOST) investigations conducted in 2012 and 2013 as described in the *2013 Wyckoff Upland NAPL Field Investigation Technical Memorandum Field Summary Report* (CH2M HILL, 2013c). During the 2013 upland NAPL field investigation, 141 primary and 7 replicate TarGOST borings (**Figure 1-6**) and 20 confirmation direct-push technology soil borings were advanced to characterize the horizontal and vertical distribution of NAPL in the Upper Aquifer.

The TarGOST technology does not explicitly measure an absolute NAPL saturation; instead, it measures the "optically available" NAPL that passes against the small window in the probe as it advances in the subsurface. A laser is emitted through the window, and the florescent response of the NAPL is captured and transmitted by fiber optics to a detector on the surface. A standard "reference emitter" (e.g., an oil with a known florescent response) is used to calibrate the instrument daily, and the individual readings are given as a percentage of the reference emitter (%RE).

The results were interpreted to select a TarGOST response factor that marks the transition from NAPL absent to NAPL present. Based on evaluation of the TarGOST data (CH2M HILL, 2013c) a TarGOST response factor of between 5%RE and 10%RE was selected as signifying NAPL presence. Therefore, for this FFS, a TarGOST response of 10%RE and greater was inferred to indicate that NAPL is present. The area enclosed by the 10% RE is shown on **Figure 1-6**.

The findings of the TarGOST investigation revealed the following:

- In general, the aggregate thickness of NAPL (e.g., the total thickness of all discrete NAPL layers) is greatest in the center core of the FPA where the highest TarGOST responses were observed. Extending outward from this core area, the aggregate NAPL thickness and inferred NAPL saturations decrease.

- Outside of the core area, discrete NAPL lenses are vertically distributed but not in an obvious pattern. This distribution likely results from multiple sources, preferential NAPL transport pathways associated with interbedded geologic materials, interaction with variable fluid densities resulting from the Upper Aquifer's transition from freshwater to saltwater, and operation of the Upper Aquifer containment remedy.
- TarGOST responses greater than 10%RE appear to terminate at or above the boring refusal depth, which generally occurs at the top of the Aquitard. In general, where colocated geologic information is available, the TarGOST boring refusal depth is coincident with or slightly below the transition from the Upper Aquifer to the Aquitard's glacial till layer. This indicates that the glacial till is restricting, but not necessarily preventing, NAPL migration to lower depths.
- Along the FPA's east and north sides, elevated TarGOST readings were observed next to the outer sheet pile wall at depths above the Aquitard's glacial till layer. In these areas, the sheet pile wall driven depths are greater than the deepest elevated TarGOST responses.

Because the TarGOST technology provides a relative indicator of NAPL saturation, confirmation soil borings were drilled and visually logged for soil type and NAPL absence and/or presence. The resulting field logs were compiled to evaluate NAPL association with soil type (**Figure 1-7**). Of the nearly 600 feet of soil core recovered, NAPL was observed in 119 feet, or 20 percent of the sampled material. When comparing NAPL occurrences by geologic material, NAPL tends to preferentially inhabit coarser-grained soil. Eighty-two percent of the NAPL present in the soil cores was detected in coarser-grained material consisting of marine sand or marine sand and gravel, and 15.5 percent of NAPL was observed in finer-grained material consisting of marine silt or marine sediment.

To estimate the total volume of NAPL-contaminated material underlying the FPA, TarGOST response data were coupled with a Thiessen polygon analysis where each boring was assigned a representative area based on proximity to adjacent borings and Site boundaries. Detailed information on the overall approach used to estimate the volume of NAPL-contaminated material is presented in *Groundwater Conceptual Site Model Update Report for the Former Process Area, Wyckoff/Eagle Harbor Superfund Site, Soil and Groundwater Operable Units* (CH2M HILL, 2013a). The layout of Theissen polygons and division of the Upper Aquifer into three compartments is shown on **Figure 1-8**.

Based on the observed geographic distribution of NAPL, the Upper Aquifer remedial action target area was partitioned into a Core Area, where thick sequences of NAPL occur, and a Periphery Area, where thinner lenses of NAPL are present. While evaluating TarGOST information for the Periphery Area, it became apparent that NAPL occurrences in the Periphery Area warranted further subdivision based on considerations of NAPL architecture, geology, depth, and potential remedial technology application. Therefore, the Periphery Area was partitioned into the following four different target zones: East Shallow (Light NAPL [LNAPL]), North Deep (Dense NAPL [DNAPL]), North Shallow (LNAPL), and Other Periphery. The locations of the five NAPL remedial action target zones are shown on **Figure 1-9,** and the volume of NAPL-contaminated material and estimated volume of NAPL present shown in **Table 1-2**. The total volume of NAPL-contaminated material present in the Soil and Groundwater OUs is estimated at 109,000 cubic yards (CY), or 15 percent of the total soil volume; this translates into a NAPL volume of 679,000 gallons and total naphthalene mass of 1.12 million kilograms. Naphthalene is one of the primary chemicals present in the wood-treating NAPL used at the Site and is expected to account for most of the NAPL mass.

The five remedial action target zones are described as follows:

- The **Core Area** is characterized by thick lenses of NAPL that in aggregate account for most of the NAPL mass present in the FPA. The volume of NAPL-contaminated soil is estimated at 38,700 NAPL CY (NCY), and this volume is estimated to contain 302,000 gallons of creosote, or 7.8 gallons per NCY.
- The **East Shallow (LNAPL) Periphery** target zone is located along the east side of the FPA and is characterized by LNAPL present in Compartment 1 and sporadic NAPL present in Compartment 2. The

volume of NAPL-contaminated soil is estimated at 43,200 CY and this volume is estimated to contain 208,000 gallons of NAPL or 4.8 gallons per CY of NAPL-contaminated soil.

- The **North Deep (DNAPL) Periphery** target zone is located on the north end of the FPA. This zone is characterized by DNAPL present in Compartment 3 (Upper Aquifer-Aquitard interface). The volume of NAPL-contaminated soil is estimated at 14,300 CY and this volume is estimated to contain 87,000 gallons of NAPL or 6.1 gallons per CY of NAPL-contaminated soil.
- The **North Shallow (LNAPL) Periphery** target zone is located on the north end of the FPA and is characterized by LNAPL present in Compartment 1 (capillary fringe). The volume of NAPL-contaminated soil is estimated at 4,700 CY and this volume is estimated to contain 29,700 gallons of NAPL or 6.3 gallons per CY of NAPL-contaminated soil.
- The **Other Periphery** target zone represents areas with discontinuous NAPL that are located near the south and southwest portions of the FPA. This target zone is characterized by NAPL present in isolated pockets. The volume of NAPL-contaminated soil is estimated at 4,300 CY, and this volume is estimated to contain 33,100 gallons of NAPL or 7.7 gallons per CY of NAPL-contaminated soil.

The target zones also include **North Shallow and Deep Periphery,** which is an overlap of the North Shallow (LNAPL) Periphery and North Deep (DNAPL) Periphery target zones located on the north end of the FPA. This zone is characterized by NAPL present in Compartment 2. The volume of NAPL-contaminated soil in this target zone is estimated at 3,400 CY and this volume is estimated to contain 18,400 gallons of NAPL or 5.4 gallons per CY of NAPL-contaminated soil.

1.2.3.2 Aquitard

There are no monitoring wells or piezometers within the Aquitard, and only limited borings have been advanced through it. Consequently, creosote as NAPL or as dissolved constituents in Aquitard pore water cannot be directly measured. Instead, indirect observations and estimates must be relied on to evaluate the extent of NAPL contamination in the Aquitard. The following observations are informative in evaluating NAPL extent in the Aquitard:

- NAPL is present at the base of the Upper Aquifer at varying thicknesses and volumes in certain areas of the FPA. This indicates there is potential for downward NAPL migration into the Aquitard. However, penetrating the Aquitard is likely limited due to the heights (e.g., thickness) that NAPL must pool to overcome the entry pressures present in the Aquitard. The critical pool height for NAPL to penetrate the Aquitard is estimated at 9.4 feet.[3] Once exceeded, the NAPL head increases with penetration into the Aquitard, and unless the pool height decreases, NAPL migration will continue through the Aquitard.
- NAPL is present in the Lower Aquifer in an area to the north of Lower Aquifer wells (VG-2L, P-3L, and CW15). NAPL has migrated to this area from the Upper Aquifer, but the migration pathway is unclear.
- Lower Aquifer groundwater quality monitoring has identified two areas with PAH constituent concentrations greater than clean-up levels specified in the 2000 ROD: one to the north encompassing monitoring wells CW05, CW15, P-3L, and VG-2L and the other to the southwest surrounding piezometer PZ-11.
- The Aquitard is thin to absent near PZ-11. Consequently, the potential migration of dissolved-phase constituents from surface contamination to the Lower Aquifer is not inhibited in this area. It is unclear whether NAPL is present in the Lower Aquifer in this area.

[3] The critical NAPL pool height was estimated as described in **Appendix A** of the *Groundwater Conceptual Site Model Update Report for the OU2 and OU4 Former Process Area* (CH2M HILL, 2013a).

- The Aquitard thickness varies over portions of the Site where NAPL is present at the base of the Upper Aquifer. The Aquitard's slope and thickness, capillary forces, and NAPL pool height control the potential for NAPL penetration and migration through the Aquitard to the Lower Aquifer.

Interpreting these lines of evidence on **Figure 1-10** suggests that the presence of NAPL and dissolved constituents in the Aquitard is likely in the northern portion of the FPA and possible in the center of the FPA. At the north end of the Site, Lower Aquifer water quality effects align with NAPL thicknesses observed in the Upper Aquifer that exceed the required height for NAPL entry into the Aquitard (as observed at TarGOST location 2013T-043). Furthermore, the Aquitard thickness is estimated to be thinner in this vicinity at approximately 8 to 25 feet, and the Aquitard surface itself is thought to have several depressions where NAPL could pool.

1.2.3.3 Lower Aquifer

The distribution of NAPL in the Lower Aquifer was estimated from NAPL thickness measurements made at Lower Aquifer monitoring wells during the June 2012 groundwater sampling event (CH2MHILL, 2013d). These measurements indicate the presence of NAPL in three Lower Aquifer wells (CW15, P-3L, and VG-2L) in the northern portion of the FPA. This corresponds with an area where acenaphthene and other PAH constituents (**Figure 1-11**) are consistently detected near or above the 2000 ROD groundwater clean-up levels.

1.2.4 Contaminant Fate and Transport

The coal-tar creosote used at the Wyckoff Site was a complex mixture of chemicals, containing many different compounds. Approximately 85 percent of these compounds are classified as PAHs and 2 to 17 percent as phenols (Bedient et al., 1984). Historical laboratory analysis of creosote samples collected from the Site shows that naphthalene accounts for most of the overall PAH composition (**Figure 1-12**). To improve penetration during the wood-treatment process, creosote and PCP were mixed with a carrier oil, which is presumed to have been diesel. The carrier oil is often indicated by the presence of benzene, toluene, ethylbenzene, and xylenes (BTEX) and total petroleum hydrocarbon (TPH)-diesel (TPH-Dx) concentrations in NAPL samples.

Wood-treating NAPL is subject to naturally occurring physical-chemical processes that, over time, result in transfer of contaminant mass from the NAPL to the vapor, aqueous, and solid-sorbed phases. Collectively, these processes reduce the mass of the NAPL source. Contaminants that partition from the NAPL to the vapor phase, and from the NAPL to the aqueous phase, may undergo further degradation and nondegradation reactions that reduce their concentrations in environmental media.

Volatilization is a process by which chemical compounds partition from the NAPL to a vapor and, hence, is an important process for NAPL present above the water table. The compounds present in NAPL at the Wyckoff Site that likely exhibit some volatilization behavior include naphthalene and benzene. Volatilization depends on soil temperatures with higher temperatures promoting higher rates of volatilization. The composition of NAPL present above the water table at the Site is expected to have been significantly affected by the loss of benzene and naphthalene.

Solubilization, or dissolution, is a process by which chemical compounds partition from the NAPL present above the water table to infiltrating rainfall or to groundwater for NAPL present below the water table. For multicomponent NAPLs, the solubilization process is governed by the compound's mole fraction in the NAPL and the water flux that moves across the NAPL zone. The chemical compounds present in NAPL at the Site have a wide range of aqueous solubilities with BTEX and low-molecular weight PAHs (LPAHs), such as naphthalene, acenaphthylene, and acenaphthane, most likely to be removed from the NAPL through solubilization.

Chemical compounds removed from the NAPL through solubilization can undergo abiotic and biotic degradation in groundwater under aerobic and anaerobic conditions. Biodegradation is expected to be an important process at the Site for many of the BTEX compounds and for the LPAHs, such as naphthalene. To assess potential rates of NAPL depletion resulting from dissolution and biodegradation, the mass of naphthalene present in the 679,000 gallons of NAPL and Upper Aquifer dissolved-phase plume were calculated. Naphthalene was used as an indicator because it accounts for most of the NAPL mass per **Figure 1-12**. The amount of naphthalene present in the NAPL was estimated at 1.15 million kilograms, and the mass of naphthalene present in Upper Aquifer groundwater estimated at 1,400 kilograms. The mass of naphthalene mass initially present presumes that 85 percent of the NAPL mixture comprises LPAH compounds, and of this fraction, naphthalene accounts for one-half of the LPAH mass.

A biodegradation half-life of 258 days, obtained from the literature (EPA, 1999a), was then applied to the dissolved-phase naphthalene plume and an annual removal rate of 1,381 kilograms estimated. This removal rate was then applied to the total mass of naphthalene present in the NAPL to create a decline curve (**Figure 1-13**). Assuming that the naphthalene dissolution is not rate controlled, and there are no other biodegradation rate limitations (e.g., nutrients, salinity or microorganism availability), it takes approximately 800 years for all naphthalene present in the NAPL to partition and biodegrade. This estimate assumes ideal conditions. In reality, as the NAPL composition changes with time, some other form of rate controls will begin to influence the rate of naphthalene dissolution resulting in a much longer timeframe.

Other key NAPL fate and transport behavior at the Site includes the following:

- As the spills and leaks occurred, the contaminants moved as mobile NAPL into the vadose zone, adsorbing onto soil, volatilizing into soil gas, and dissolving into pore water.
- Mobile NAPL migrated downward through the vadose zone until it reached the water table and separated into light and dense phases:
  - The LNAPL spread out along the water table surface and migrated laterally with the groundwater.
  - Downward migration of DNAPL was slowed or halted as it encountered higher-density saline groundwater and lower-permeability zones within the Upper Aquifer. Some DNAPL continued migrating downward until it reached the Aquitard.
  - Lateral movement of DNAPL has occurred through high-permeability gravel and cobble zones or through spreading when the DNAPL reached low-permeability zones within the Upper Aquifer or at the top of the Aquitard.
  - NAPL undergoes dissolution as it encountered groundwater in the Upper Aquifer, resulting in formation of a multicomponent dissolved-phase plume characterized primarily by the presence of LPAH compounds. The aqueous-phase contaminants were then transported with the groundwater flow, laterally toward Eagle Harbor and Puget Sound.

Following are potential mechanisms for transport of contaminants to the Lower Aquifer:

- Leakage of DNAPL or dissolved contaminants through “holes” and sand zones in the Aquitard. Downward advective transport of dissolved contaminants through the Aquitard is considered unlikely under natural conditions or containment pumping, because the hydraulic head is higher in the Lower Aquifer than in the Upper Aquifer creating a net upward flow potential.
- Transport of DNAPL across the Aquitard by water displacement or ”wicking” mechanisms.
- Leakage of DNAPL or dissolved contamination as a result of early drilling activities on the Site, which may have provided conduits through the Aquitard. In 1995, EPA decommissioned 12 old wells. These were industrial water supply wells, monitoring wells, groundwater/contaminant extraction wells, and two deep drinking water supply wells.
- Transport of dissolved contaminants by molecular diffusion across the Aquitard from DNAPL on top of the Aquitard.

Any dissolved contaminants reaching the Lower Aquifer would be carried by regional groundwater flow toward discharge areas deep in Eagle Harbor and Puget Sound. However, due to the long transport distances involved, any contaminants reaching the Lower Aquifer would likely be removed by sorption and decay before discharge to the surface waters.

1.2.5 Baseline Risk Assessment

No new Soil and Groundwater OUs risk assessment evaluation has been performed since the 2000 ROD was issued (EPA, 2000a). Therefore, risks posed to human health and the environment (HHE) by current conditions are expected to be comparable with those described in Section 7 of the 2000 ROD. Risk assessment to specifically characterize the threat to HHE by NAPL has not been performed, but direct exposure to NAPL is generally recognized to likely pose human health risk exceeding the upper bound of the CERCLA 1 x10^{-4} to 1 x 10^{-6} excess lifetime cancer risk range.

1.2.6 Status of Current Containment Remedy

In February 2000, EPA issued the 2000 ROD for the upland portion of the Wyckoff Site addressing contaminated soil (OU2) and groundwater (OU4). The selected remedy, thermal remediation, included a number of components designed to achieve substantial risk reduction by cutting off subsurface contaminant migration pathways with a sheet pile wall and treating the principal threat at the Site using thermal technology. The 2000 ROD also identified a contingent remedy to be implemented should the thermal remediation pilot test did not achieve its performance objectives.

A substantial amount of work has been completed since issuance of the 2000 ROD, including the following major activities:

- Installation of a 1,870-foot-long sheet pile wall around the north and east perimeter of the FPA. A shoreline protection system to protect the wall has not been constructed.
- Construction of a new 80-gallons per minute (gpm) groundwater treatment plant (GWTP) and demolition of the old GWTP.
- Upgrades to the existing groundwater extraction and water level monitoring systems.

The groundwater extraction system consists of groundwater and NAPL pumping from nine Upper Aquifer extraction wells (**Figure 1-14**), routine water level measurements to assess hydraulic containment, and periodic groundwater sampling to assess contaminant concentration trends in the Lower Aquifer.

Based on recent performance, about 22 million gallons were extracted from April 2012 through March 2013. The monthly groundwater extraction rate for all nine extraction wells during this period varied from 0 gallons per month in August 2012 to 3,381,757 gallons per month (77.2 gpm) in December 2012. Groundwater pumping rates generally follow a seasonal pattern that correlates with monthly rainfall. Average pumping rates were 1.6 gpm to 9.5 gpm at individual wells. Approximately 72 percent of the groundwater extracted from April 2012 through March 2013 was supplied by four wells (RPW2, RPW4, RPW5, and RPW7).

From March 2012 through March 2013, approximately 1,300 gallons of NAPL (120 gallons LNAPL and 1,180 gallons DNAPL) were removed from seven recovery wells (RPW1, RPW2, RPW4, RPW5, RPW6, RPW8, and RPW9). Approximately 90 percent of the NAPL recovered during this period was from four wells (RPW1, RPW2, RPW5, and RPW8). In addition to the NAPL pumped directly from the extraction wells, an estimated 2,900 gallons of NAPL was removed from the GWTP tanks during the same time period for a total of 4,200 gallons of NAPL recovered between March 2012 and March 2013.

The hydraulic containment system also removes dissolved-phase contaminant mass through the GWTP. Based on the average influent flow rate and average influent total PAH concentration, about 3,600 pounds of dissolved-phase contaminant mass was removed between March 2012 and March 2013.

The containment remedy is effective at maintaining an inward horizontal groundwater flow gradient in the Upper Aquifer and maintaining an upward vertical gradient from the Lower Aquifer to Upper Aquifer. When operating, it protects marine water quality by reducing or eliminating the discharge of dissolved-phase contaminants to Eagle Harbor and Puget Sound.

SECTION 2

Identification and Screening of Technologies

As described in Section 1.1, the FFS consists of three phases:

- Screening remedial technologies
- Developing remedial action alternatives
- Conducting a detailed analysis of the alternatives

This chapter presents the approach and results of the remedial technology screening phase. The technologies retained from the screening described in this chapter are assembled into a range of source area remedial action alternatives that are detailed in Chapter 3 and evaluated in Chapter 4 to assist in identifying a recommended alternative that is presented in Chapter 5. The remedial technology screening phase is preceded by the development of RAOs and preliminary remediation goals (PRGs) that define the clean-up levels that need to be achieved in soil and groundwater to protect HHE.

2.1 Remedial Action Objectives

RAOs are narrative statements that describe what the remedial action is intended to accomplish. The RAOs may identify the contaminants of concern (COCs) and environmental media of concern, the exposure pathways to be protected, and the levels of clean-up that need to be achieved.

The RAOs developed by EPA and Ecology for the Wyckoff Soil and Groundwater OUs are provided in **Table 2-1** and are described as follows:

- **RAO #1—**Prevent human health risks associated with direct contact, ingestion, or inhalation of shallow soil contaminated above levels for unrestricted outdoor recreational use.

  The designated future use of the Site is a public park. By cleaning up contaminated soil to a depth of 15 feet, the designated point of compliance under WAC 173-340-740(6), future recreational users will be protected from exposure to contaminants present at concentrations above the clean-up levels presented in Section 2.2.

- **RAO #2—**Prevent use of Upper Aquifer groundwater for drinking water, irrigation, or industrial purposes which would result in unacceptable risks to human health.

  Due to elevated salinity, Upper Aquifer groundwater is designated as Class III, which makes it nonpotable and most likely unusable for most industrial or irrigation uses. However, the concentration of COCs present in Upper Aquifer groundwater would pose a threat to human health should long-term exposure occur. Therefore, this RAO was established to prevent the withdrawal of Upper Aquifer groundwater for drinking, irrigation, or industrial purposes. Groundwater withdrawal for monitoring and remediation is allowable and noncontact industrial uses may also be allowable as approved by EPA and Ecology on a case-by-case basis.

- **RAO #3—**Prevent discharge of contaminated Upper Aquifer groundwater to Eagle Harbor and Puget Sound resulting in surface water contaminant concentrations exceeding the levels protective of beach play, aquatic life, and human consumption of resident fish and shellfish.

  Under natural groundwater flow conditions, Upper Aquifer groundwater flows toward Eagle Harbor and Puget Sound upwelling into the water column through seeps and diffuse flow across the intertidal and subtidal sediments. After the outer sheet pile wall was installed in February 2001, the groundwater flow path was altered reducing the natural flux to Eagle Harbor and Puget Sound. However, small amounts of leakage through the sheet pile wall joints do occur. This RAO was established to prevent contaminated Upper Aquifer groundwater from discharging to surface water at concentrations that would result in unacceptable risks to recreational users (fishers, shellfish gathers, or beach play), consumers of resident fish and shellfish, and Eagle Harbor or Puget Sound aquatic life.

- **RAO #4—**Restore the Lower Aquifer to beneficial use within a reasonable timeframe. Prevent use of Lower Aquifer groundwater, which would result in unacceptable risk to human health until restoration goals are met.

  As described in Section 1.2, Lower Aquifer groundwater is designated as Class IIB (future drinking water source) except for those portions lying within 200 feet of the outer sheet pile wall where elevated salinity would likely preclude most uses. This RAO was established to restore the portions of the Lower Aquifer that have been impacted by historical wood-treating activities and lie more than 200 feet inland of the outer sheet pile wall to a drinking water beneficial use as defined by maximum contaminant levels (MCLs). For those portions of the Lower Aquifer subject to saltwater intrusion (e.g., areas lying within 200 feet of the outer sheet pile wall), the groundwater would be restored to levels protective of aquatic life at the point of discharge to surface water.

2.1.1 Performance Objectives

In addition to the four RAOs described above, the following two performance objectives were also established by EPA and Ecology:

- **Performance Objective #1—**Remove or treat mobile NAPL in the Upper Aquifer to the maximum extent practicable such that migration and leaching of contaminants is significantly reduced. This will remove principal threat materials, which allows for considering monitored natural attenuation (MNA) as a remedial action technology for residual concentrations, and allows for implementing Performance Objective #2.
- **Performance Objective #2—**Implement a remedial action that does not require active hydraulic control as a long-term component of operations and maintenance (O&M) following completion of source removal action.

These objectives were used to guide the development of the remedial action alternatives presented in Chapter 3 of this FFS. Relative to Performance Objective #2, hydraulic control may be used during the active remediation phase, but not for the long term. A 10-year period of hydraulic control following completion of all source removal activities is assumed as the maximum allowable duration for active hydraulic control in this FFS.

2.1.2 Contaminants of Concern

Following are the soil and groundwater COCs identified in the 2000 ROD:

- PAHs also present in the NAPL
- PCP also present in the NAPL
- Dioxins/furans (soil only) are typically associated with PCP and, therefore, are inferred to be present in NAPL

Each of the above represent a specific contaminant or group of contaminants that are known through laboratory analysis or process knowledge to be associated with historical wood-treating activities conducted in the FPA. No additional NAPL related COCs have been identified.

For this FFS, other contaminants—such as BTEX, which is associated with the carrier oil that is blended with creosote and PCP-based wood-treating oils, and heterocyclic aromatic compounds (e.g., 2-methylnaphthelene, carbazole, and dibenzofuran)—are assumed to be colocated with the PAHs and PCPs and will be remediated along with these primary COCs.

2.1.3 Preliminary Remediation Goals

PRGs represent the allowable concentration of COCs in environmental media that are protective of HHE. Therefore, they define the level of clean-up that must be achieved at the completion of a remedial action. PRGs are defined based on expectations for land, groundwater, and interconnected surface water beneficial uses. PRGs are also used to identify the area and/or volume of contaminated media to be addressed by a soil and/or groundwater remedial action. However, this FFS develops and evaluates remedial action alternatives designed to address NAPL source material. Therefore, the area/volume of contaminated material is not defined by a soil or groundwater PRG but by areas where NAPL occurs. EPA and Ecology agreed to use a TarGOST 10%RE measurement value as an indication of NAPL presence. Areas with a TarGOST response of 10%RE or greater are presumed to contain NAPL and areas with a TarGOST response of less than 10%RE are presumed to not contain NAPL.

The RAOs presented in Section 2.1 are expected to require a level of NAPL remediation that accomplish the following:

- Protects human health from NAPL-contaminated material present within the ground surface to a 15-foot depth. Future Site use may expose individuals to NAPL-contaminated material present in this depth interval that is brought and spread at the surface during development activities.
- Restores Upper Aquifer groundwater quality to a level that protects marine surface water quality and aquatic receptors.
- Restores Lower Aquifer groundwater quality to a level that allows for future drinking water use in the portion of the FPA not affected by saltwater intrusion.

Owing to the technical challenge associated with remediating sites with large areas/volumes of NAPL contamination, it is not known what fraction of the NAPL present within the area enclosed by the TarGOST 10% RE isopach must be remediated to achieve the RAOs. Absent this information, and for this FFS and remedial action alternative development, it is presumed that a high level (e.g., greater than 90 percent) of NAPL source material will have to be treated.

The following subsections summarize the regulatory and technical approach used to develop soil and groundwater PRGs. These PRGs are preliminary and will be finalized in the CERCLA decision document.

2.1.3.1 Preliminary Remediation Goals Development Approach

PRGs for contaminants present in soil and groundwater are generally defined by state and federal regulations. These regulations are identified through a comprehensive review of ARARs. The Soil and Groundwater OUs ARARs review (**Appendix A**) was conducted in accordance with “Cleanup Standards” in “Degree of Cleanup” (CERCLA [Section 121(d)]) and *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988a); *CERCLA Compliance with Other Laws Manual: Interim Final* (EPA, 1988b]; and *CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes and State Requirements* (EPA, 1989a). Section 121(d) of the CERCLA statute, requires, with exceptions, that any promulgated substantive ARAR standard, requirement, criterion, or limitation under any federal environmental law, or any more stringent state requirement pursuant to a state environmental statute, or facility siting law be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain on Site after the remedial action has concluded. The National Contingency Plan (NCP; “Remedial Design/Remedial Action, Operation and Maintenance,” Code of Federal Regulations (CFR) Title 40, Section 300.435[b][2]) requires that ARARs be attained (unless waived) during the remedial action.

Potential ARARs for the Soil and Groundwater OUs were identified and reviewed to group them into one of three categories as follows:

- **Chemical-specific ARARs—**These include health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, establish public and worker clean-up levels (e.g., PRGs).

- **Location-specific ARARs—**These include restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas.

- **Action-specific ARARs—**These are technology- or activity-based requirements or limitations triggered by remedial actions performed at a site.

The chemical-specific ARARs applicable to the Wyckoff Soil and Groundwater OUs remedial actions are the elements of the WAC that implement the Model Toxics Control Action (MTCA) regulations. Within WAC 173-340, Cleanup, there are detailed regulations specifying soil ("Unrestricted Land Use Soil Cleanup Standards," WAC 173-340-740) and groundwater ("Groundwater Cleanup Standards," WAC 173-340-720) clean-up standards. These standards are in the form of risk-based concentrations that define soil, groundwater, and air clean-up standards for chemical contaminants. Following is a list of other chemical-specific ARARs:

- Substantive portions of MTCA, including "Selection of Cleanup Actions" (WAC 173-340-360) and "Overview of Cleanup Standards" (WAC 173-340-700) through "Priority Contaminants of Ecological Concern" (WAC 173-340-7494) that also includes "Cleanup Standards to Protect Air Quality" (WAC 173-340-750), "Sediment Cleanup Standards" (WAC 173-340-760), and "Sediment Management Standards" (WAC 173-204)

- Nonzero MCL goals and MCLs promulgated under the Safe Drinking Water Act, "National Primary Drinking Water Regulations" (40 CFR 141) and/or by the State of Washington ("Group A Public Water Supplies" [WAC 246-290]) as they apply to primary MCL constituents

- Ambient water quality criteria and state water quality standards at the groundwater/surface water interface developed under the CWA (Section 304) and/or promulgated by the state of Washington ("Water Quality Standards for Groundwaters of the State of Washington" [WAC 173-200] and "Water Quality Standards for Surface Waters of the State of Washington" [WAC 173-201A]), "National Pollutant Discharge Elimination System Permit Program" (WAC 173-220), and "Wastewater Discharge Standards and Effluent Limitations" (WAC 173-221A).

2.1.3.2 Soil

The State of Washington MTCA regulation is the principal ARAR governing the development of PRGs for environmental clean-up actions. As set forth in WAC 173-340-700(2), remedial actions shall attain the following:

- Numeric clean-up levels for all COCs
- Clean-up levels at defined locations termed the points of compliance

Numeric clean-up goals that define human health protectiveness for soil are presented in **Table 2-2**. These levels are based on MTCA, Method B (WAC 173-340-740) unrestricted use, which potentially represents a level of clean-up that is more conservative than necessary based a future recreational site use. During development of the final remedial goals for inclusion in the CERCLA decision document, if allowed by Ecology, these PRGs may be adjusted upward to reflect the lower exposure frequency associated with a recreational land use. The clean-up levels presented in **Table 2-2** are based on an excess lifetime cancer risk of 1×10^{-6}. Because NAPL-contaminated soil and groundwater contain multiple carcinogenic COCs, the 1×10^{-6}-based clean-up levels presented in **Table 2-2** will need to be adjusted downward when developing final remedial goals to satisfy the 1×10^{-5} MTCA requirement. A similar adjustment will also be required for the noncarcinogenic COC to satisfy WAC 173-340-708(5)(c).

The point of compliance for the soil PRGs that protect human health extends from the ground surface to a depth of 15 feet bgs. This represents a reasonable estimate of the depth where soil could be excavated and distributed at the surface as a result of unrestricted development activities. If future development of the

Site for recreational purposes does not include intrusive subsurface activities, then an alternate point of compliance could be established in the CERCLA decision document.

In addition to protecting human health, soil-based PRGs must also be protective of Upper Aquifer groundwater quality through the leaching pathway. As described in Section 1.2, the beneficial use of Upper Aquifer groundwater is marine surface water recharge. Per WAC 173-340-747, Deriving Soil Concentrations for Groundwater Protection, a four-phase partitioning model employing site-specific data is required at sites contaminated with NAPL. The information necessary to support developing NAPL-contaminated soil PRGs that reflect current conditions is being obtained as part of the May 2014 Upper Aquifer groundwater sampling effort. These PRG calculations are recommended to be performed as part of the Upper Aquifer groundwater quality data evaluation and the results incorporated into the next version of this FFS report. Based on experience at other wood-treating sites, soil PRGs protective of groundwater and/or surface water quality are expected to be lower than the values presented in **Table 2-2**.

2.1.3.3 Upper Aquifer Groundwater

Upper Aquifer groundwater PRGs must protect marine surface water quality. The overall approach used to develop PRGs for each COC consisted of multiplying the lowest applicable marine ambient water quality criteria by a dilution factor. The dilution-attenuation factor reflects the concentration reduction that occurs during COC transport along a flow path that extends from the Upper Aquifer, through or beneath the sheet pile wall, through the soil-sediment horizon, and terminating in the intertidal and subtidal sediments. As shown on **Figure 2-1**, the length of this flow path varies. Dissolved-phase COCs will experience different degrees of concentration reduction depending on the flow path length.

Once dissolved-phase COCs move through the sheet pile wall their concentrations will decrease as a result of two occurrences: (1) dilution due to tidal fluctuation and mixing and (2) biodegradation during groundwater transport.

Historical contaminant fate and transport modeling (CH2M HILL, 2004) estimated that COC concentrations would be reduced by a factor of 20 due to tidal dilution. Biodegradation and retardation processes will further reduce COC concentrations. For this FFS, only dilution was considered owing to uncertainty on biodegradation rates within the intertidal area where groundwater salinity levels increase.

As shown on **Table 2-3**, for many of the COCs, the lowest marine ambient water quality criteria multiple by a dilution-attenuation factor of 20 yields a concentration greater than its freshwater-single component aqueous solubility. Where this occurred, the Upper Aquifer groundwater PRG was set equal to one-half of the aqueous solubility. Due to the presence of NAPL outside the sheet pile wall, the Upper Aquifer groundwater point of compliance would occur just inside the sheet pile wall.

2.1.3.4 Lower Aquifer Groundwater

With respect to Lower Aquifer groundwater, the approach consisted of reviewing federal and state ARARs and selecting the most conservative drinking water standard for each COC (**Table 2-4**). The point of compliance for the Lower Aquifer is the south and west boundaries of the FPA.

2.2 General Response Actions

General response actions (GRAs) are typically media-specific actions that are appropriate for the site conditions, COCs, and RAOs. GRAs may include either individual or combinations of the following:

- No action
- Access restrictions, including institutional controls (ICs) and engineering controls (ECs)
- Containment
- Removal and disposal (on-site and off-site)
- Ex situ treatment (on-site and off-site)
- In situ treatment

Because this FFS focuses on NAPL source material, the GRAs were not segregated by soil and groundwater. Sections 2.2.1 through 2.2.5 provide a general description of each GRA.

2.2.1 No Action

This GRA is required as a baseline for comparison against other technologies as specified under the NCP (40 CFR 300.430[e][6]). Under this GRA, no further action is taken at a site. If interim or final actions have been completed or are underway at the time of remedy selection, they are terminated following ROD or ROD amendment signature.

2.2.2 Access Restrictions

This GRA includes ICs and ECs. ICs are administrative controls or legal restrictions placed on land and groundwater use to protect the public against inadvertent exposure to hazardous constituents and/or to protect the integrity of a functioning or completed remedy. ICs may include land use restrictions, natural resource use restrictions, groundwater use restrictions or management areas, property deed notices, declaration of environmental restrictions, access controls (digging and/or drilling permits), surveillance, information posting or distribution, restrictive covenants, and federal, state, county, and/or local registries.

ECs generally include fences or manned security to protect against trespasser exposure to contaminated soils or groundwater (seeps and/or springs) until RAOs are achieved. For groundwater, ECs may include providing an alternate water supply for current or future users when contaminated groundwater is identified as a current drinking water source.

The existing containment remedy for the Site uses access restrictions to reduce the potential for human exposure to contaminated media present in the Former Process Area.

2.2.3 Removal and Disposal

These GRAs include excavation to remove contaminated media with long-term containment and management provided by disposing of the material at a secure on-site or a permitted off-site Resource Conservation and Recovery Act (RCRA) Subtitle D or Subtitle C facility. Depending on the concentration of contaminants present, disposal may be combined with ex situ treatment to comply with RCRA land disposal restrictions.

2.2.4 Ex Situ Treatment

This GRA includes technologies employed at an on-site or off-site treatment facility that treat contaminated media in aboveground treatment units. The current containment remedy uses ex situ physical treatment technologies (NAPL separation and granular activated carbon filtration) to treat NAPL, PAH, and PCP contamination in groundwater.

2.2.5 In Situ Treatment

This GRA includes various technologies (biological, chemical, thermal, physical) to treat contaminated media below the ground surface or in situ. MNA is also included within the scope of this GRA.

2.2.6 Area and Volume of NAPL Source Material Addressed

As described previously, EPA and Ecology agreed to use the TarGOST 10%RE measurement value as an indicator of NAPL presence. Additional information on the rationale used for selecting the 10%RE value is presented in the *Wyckoff Upland NAPL Field Investigation Technical Memorandum Field Summary Report* (CH2M HILL, 2013c). The area enclosed by the 10%RE TarGOST response was subdivided into five different geographic areas based on differences in NAPL volumes and NAPL architecture (e.g., LNAPL versus DNAPL). The location of these areas was described previously in Section 1.2.3 and shown on **Figure 1-7**.

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP CFR 300.430[a][l][iii][A]). Identifying principal threat wastes combines concepts of both hazard and risk. The manner in which principal threats are addressed generally determines whether the statutory preference for treatment as a principal element of the remedial alternative is satisfied in a CERCLA decision document.

Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to public health or the environment should exposure occur. The decision to treat these wastes is made on a site-specific basis through a detailed analysis of remedial alternatives, using the remedy selection criteria specified in the NCP. This analysis provides the basis for making a statutory finding that the selected remedy uses a proven treatment technology as a principal element. For this Wyckoff Soil and Groundwater OUs FFS, NAPL source material meets the definition of a principal threat waste. Contaminated groundwater is not considered a principal threat or low-level threat waste because it is not source material (EPA, 1991).

2.3 Identification and Screening Technologies and Process Options

This section identifies remedial technologies, and their associated process options, that are applicable to NAPL source material present in the Soil and Groundwater OUs. The remedial technologies were screened for their ability to achieve the RAOs and Performance Objectives described in Section 2.1 based on the CERCLA criteria of effectiveness; implementability; and relative cost. The technologies retained from the screening are combined into a range of remedial action alternatives in Chapter 3 of this FFS report.

The technology screening step included a broad range of technologies applicable to wood-treating sites with an emphasis on treatment technologies that address NAPL source material. Additionally, because the remedial action timeframe is expected to span several to tens of years, technologies that protect HHE during the remedial action were also emphasized. Factors considered in this evaluation include the state of technology development, site conditions, NAPL characteristics and distribution, and specific COCs that could limit a technology's effectiveness or implementability.

Sources of information considered for the technology screening included the following:

- P*resumptive Remedies for Soils, Sediment, and Sludges at Wood Treater Sites* (EPA, 1995)
- 1997 OU2/OU4 FS Report (CH2M HILL, 1997)
- Previous bench-scale and field-scale pilot studies
- CH2M HILL project experience on other wood-treating sites
- Federal Remediation Technologies Roundtable (FRTR, 2010)
- Interstate Technology and Regulatory Council (ITRC, 2009)
- Vendor information, case studies, and technical journal articles
- Information presented in the *Wyckoff Generational Remedy Evaluation Report* (Ecology, 2010)

The technology screening includes many of the technologies retained in the OU2/OU4 FS Report (CH2M HILL, 1997) and technologies used under the current containment remedy.

2.3.1 Technology Screening Criteria and Methodology

The technology screening qualitatively assesses each technology's ability to achieve the RAOs and performance objectives using the CERCLA criteria of effectiveness, implementability, and relative cost as defined in the NCP (40 CFR 300.430[e][7]). Technologies that are not viable based on these considerations were eliminated from further consideration.

2.3.1.1 Effectiveness

Effectiveness refers to a technology's its associated process option(s) ability and to perform as a stand-alone or component of a broader alternative to meet RAOs under the conditions and limitations present at a site. Additionally, the NCP (40 CFR 300) defines effectiveness as follows: "…degree to which an alternative reduces toxicity, mobility, or volume through treatment; minimizes residual risk; affords long-term protection; complies with Applicable or Relevant and Appropriate Requirements (ARARs); minimizes short-term effects; and how quickly it achieves protection." Section 4.2.5 of CERCLA RI/FS Guidance (EPA, 1988a) states that the evaluation of remedial technologies and process options with respect to effectiveness should focus on the following: "(1) the potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the RAOs; (2) the potential impacts to HHE during the construction and implementation phase; and (3) how proven and reliable the process is with respect to the contaminants and conditions at the site."

2.3.1.2 Implementability

Implementability refers to the relative degree of difficulty anticipated in implementing a particular remedial technology and process option under technical, regulatory, and schedule (administrative) constraints posed by a site. As suggested by CERCLA RI/FS Guidance (EPA, 1988a), process options and entire technology types can be eliminated from further consideration if a technology or process option cannot be effectively implemented at a site. As discussed in Section 4.2.5 of CERCLA RI/FS Guidance, "technical implementability is used as an initial screening of technology types and process options to eliminate those that are clearly ineffective or unworkable at a site." Administrative implementability, which includes "the ability to obtain necessary permits for off-site actions, the availability of treatment, storage, and disposal services (including capacity), and the availability of necessary equipment and skilled workers to implement the technology," is also considered in the initial screening.

2.3.1.3 Relative Cost

For the initial screening of technology types and process options, the cost criterion is relative, meaning quantitative cost estimates are not prepared. Rather it compares remedial technology and process option costs using narrative terms. Section 4.2.5 of CERCLA RI/FS Guidance (EPA, 1988a) states that "cost plays a limited role in the screening of process options. Relative capital and O&M costs are used rather than detailed estimates. At this stage in the process, the cost analysis is made on the basis of engineering judgment, and each process is evaluated as to whether costs are high, low, or medium relative to other process options in the same technology type." For this evaluation, relative cost is used to screen out process options that have a high capital cost if there are other choices that perform similar functions with similar effectiveness. Technology screening based on relative O&M costs was not specifically performed but was considered as part of the overall cost evaluation.

2.3.1.4 Assessment Methodology

The assessment of individual technologies and their associated process options was performed based on the criteria described above using a relative grading scale employing a "good," "moderate," or "poor" rating. To create greater separation, or where a technology's performance could vary within the different target zones at the Site, a blended rating such as poor to moderate or moderate to good was used. Once the assessment against each of the three criteria was completed, a "retained" or "not retained" determination was made.

2.3.2 Retained Technologies

Individual remedial technologies and their associated process options were screened based on considerations of effectiveness, implementability, and relative cost. The screening step is designed to narrow the list of remedial technologies to identify the most viable candidates for use in assembling remedial action alternatives. The technology screening and screening results are summarized in **Table 2-5**. Where appropriate, the technology screening also provides the justification for retaining or not retaining a technology for further consideration. The overall goal is to retain representative process options within the GRA's categories to form remedial alternatives. The remedial technologies and process options retained from the screening are summarized in **Table 2-6**. Individual technology and technology pairings assigned to each target zone are presented in **Table 2-7**.

SECTION 3

Development and Screening of Alternatives

This chapter assembles the technologies retained from the screening performed in Section 2.3 into an array of NAPL source remedial action alternatives, presents a conceptual design for each alternative based on the representative process options, and then screens the alternatives to determine which ones should be carried forward for detailed evaluation in Chapter 4.

3.1 Development of Alternatives

The NCP ("Remedial Investigation/Feasibility Study and Selection of Remedy," 40 CFR 300.430[e][3]) sets forth the following expectations for development of source control alternatives:

- *"A range of alternatives in which treatment that reduces the toxicity, mobility, or volume of the hazardous substances, pollutants, or contaminants is a principal element. As appropriate, this range shall include an alternative that removes or destroys hazardous substances, pollutants, or contaminants to the maximum extent feasible, eliminating or minimizing, to the degree possible, the need for long-term management.*
- *Alternatives, as appropriate, which, at a minimum, treat the principal threats posed by the site but vary in the degree of treatment employed and the quantities and characteristics of the treatment residuals and untreated waste that must be managed.*
- *One or more alternatives that involve little or no treatment, but provide protection of human health and the environment primarily by preventing or controlling exposure to hazardous substances, pollutants, or contaminants, through engineering controls, for example, containment, and, as necessary, institutional controls to protect human health and the environment and to assure continued effectiveness of the response action."*

In accordance with the above NCP expectations and the technologies retained from the screening performed in Section 2.3, a range of source control alternatives were assembled. While other technology and process option combinations are possible, technology combinations that are most viable based on the RAOs, performance objectives, and subsurface conditions present in each of the target zones were considered.

The proposed alternatives include the following (**Table 3-1**):

- Alternative 1—No Action (required per the NCP)
- Alternative 2—Containment (the current remedy)
- Alternative 3—Excavation, Thermal Desorption, and In Situ Chemical Oxidation (ISCO)
- Alternative 4—In Situ Solidification/Stabilization (ISS)
- Alternative 5—Thermal Enhanced Extraction and ISS
- Alternative 6—Excavation, Thermal Desorption, and Thermal Enhanced Extraction
- Alternative 7—ISS of Core Area and Thermal Enhanced Extraction

The alternatives listed above are identified by their primary technologies. However, exclusive of Alternative 1—No Action, each alternative requires supporting technologies to allow for full and successful implementation. Section 3.2 describes these supporting technologies, which are identified as common elements, and Section 3.3 describes in detail the remedial action alternatives.

3.1.1 Preliminary Screening

After the technologies were assembled into a range of alternatives, preliminary engineering was performed to develop a design concept to identify technical and overall implementation considerations. Following this step, the alternatives were screened (see Section 2.3.1 for the definition of the screening criteria) per *The Feasibility Study: Development and Screening of Remedial Action Alternatives* (EPA, 1989b). The purpose of the screening step is to determine whether any alternatives should be eliminated from further consideration based on effectiveness, implementability, or relative cost considerations. The alternatives retained from the screening step were carried forward for more detailed engineering and cost estimate development.

3.1.2 Conceptual Design

The level of engineering performed for the alternatives presented in Section 3.3 varies and is expected to range from 3 to 15 percent of that required to prepare a fully biddable and constructible remedial design.

3.1.3 Cost Estimating

The cost estimates prepared for each retained remedial action alternative were developed per *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study* (EPA, 2000b). The cost estimates are intended for comparison purposes and were prepared to meet the -30 to +50 percent range of accuracy recommended in the CERCLA RI/FS Guidance (EPA, 1988a). Actual costs will depend on the final scope and design of the selected remedial action alternative, implementation schedule, competitive market conditions, and other variables. However, these factors are applicable to all alternatives and not expected to affect the relative cost differences between them. The cost estimates include allowances for the following items:

- Remedial design costs, including preparation of design drawings and specifications and construction bid documents, which were calculated as a percentage of the construction cost
- Remedial alternative construction costs, including construction management, capital equipment, general and administrative costs, and construction subcontract costs and fees, which are based on engineering judgment, cost estimating references, actual costs for similar work performed at other sites, and vendor quotes
- Annual O&M and remedy performance monitoring and reporting costs for the duration of the remedial action
- Equipment or remedy component replacement costs
- Project management, oversight costs, and preparation of CERCLA five-year reviews until RAOs are achieved

The total remedial action alternative life-cycle costs (see **Appendix C**) are presented as non-discounted (base year of 2014) and present worth values. The present worth cost-estimating method establishes a common baseline for evaluating costs that occur during different periods, thus allowing for direct cost comparisons between different alternatives. The present worth cost represents the dollars that would need to be set aside during the base year, which for this FFS is assumed to occur in 2016, at the defined interest rate, to ensure that funds would be available in the future, as they are needed to implement the remedial action alternative. Present worth costs were estimated using the real discount rate published in Appendix C, Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analyses, of *Guidelines and Discount Rates for Benefit Cost Analysis of Federal Programs* (OMB Circular A-94), effective June 2014 (White House, 1992).

3.2 Common Elements

The following subsections briefly summarize each common element. **Table 3-2** shows which common elements are associated with each alternative, while **Figure 3-1** show the total common element cost for each alternative. Several common element descriptions include a reference to engineering drawings, which are provided in **Appendix B**.

3.2.1 Pre-Construction Activities

This common element is associated with Alternatives 2 through 7 and includes the following activities:

- Obtaining local and State permits as applicable
- Preparing subcontractor work plans, health and safety plans, activity hazard analysis, and project schedule
- Mobilizing/demobilizing subcontractor general equipment
- Conducting community relations
- Preparing the Site and conducting a property survey
- Developing prorated remedial design, construction management, and project management costs.

The total estimated cost for this common element is $869,000.

3.2.2 Access Road

Most equipment needed to implement the remedial action alternatives is large and will require delivery to the Site via trailer. The existing road has curves that are too sharp for large semitrailer trucks to navigate, and the 15 percent grade is too steep for trucks to maintain traction. This common element, which is required for Alternatives 2 through 7, includes realigning, regrading, and resurfacing the existing asphalt road (1,500 lineal feet) at an estimated cost of $288,000 as shown on **Appendix B**, **Drawings 101-CE-100 and 101-CE-101**.

3.2.3 Concrete Demolition, Decontamination, and Reuse

Previous demolition conducted at the Wyckoff Site has primarily included aboveground equipment and facilities. Most of the equipment and building foundations, and other below ground concrete structures (primarily sumps), have not been removed. This common element removes buried concrete (**Appendix B**, **Drawing 101-CE-102**) that could prevent or significantly impede implementation of the subsurface components of Alternatives 3 through 7. The estimated cost for this common element is $2.2 million.

The work associated with this element would occur before the remedial action alternative is implemented. All concrete would be removed and/or demolished, pressure-washed to capture creosote for off-Site disposal, and then crushed to segregate rebar and size the material for subsequent on-Site reuse. Recycling the rebar provides an estimated credit of $189,000. The area of concrete foundations and structures requiring demolition is estimated at 1.5 acres (7,200 square yards). The thickness of each foundation was conservatively estimated to be 2 to 3 feet based on the known previous use of the foundations. The total estimated volume of concrete is 8,000 CY.

3.2.4 Sitewide Debris Removal

Other buried utilities and debris (e.g., process pipes, storm drains, electrical conduit, and the wing wall) are also known to exist given the Site's long history. Under this common element, Sitewide subsurface debris would be removed (**Appendix B**, **Drawing 101-CE-102**) to allow the subsurface work required in Alternatives 3 through 7 to be implemented. The estimated cost for this common element in Alternatives 3 through 6 is $3.2 million, and $1.1 million for Alternative 7. This work would include excavating an estimated 66,600 CY (22,200 CY for Alternative 7) of material and disposing of 670 CY (300 tons) of hazardous debris at an off-Site RCRA Subtitle C facility.

3.2.5 Bulkhead Removal

The area between the original Site bulkhead and the current outer sheet pile wall was filled with rock and concrete debris that must be removed (**Appendix B Drawing 101-CE-102**) to permit access for remediation of subsurface material up to the edge of the sheet pile wall under Alternatives 3 through 7. Under this common element, an estimated 17,000 CY of rock, 30,000 CY of other material, and 2,700 CY of bulkhead would be removed. Approximately 2,000 tons of this material would be transported and disposed at a RCRA Subtitle C facility and a similar amount disposed at a Subtitle D facility. The area would then be backfilled with 45,000 CY of clean soil and rock. The estimated cost for this common element is $8.8 million.

3.2.6 Other and Miscellaneous Demolition

This common element allows for decommissioning and disposing of the steam pilot plant area, equipment, and its associated infrastructure. Under Alternatives 3 through 7, all pilot plant components would be demolished and disposed at an estimated cost of $3.0 million. Under Alternative 2, all pilot plant components except the northwest beach sheet pile wall would be removed at an estimated cost of $1.3 million. It is assumed the equipment will be disposed at a Subtitle D landfill.

3.2.7 Stormwater Infiltration Trench

This common element involves installing a stormwater infiltration trench along the southern boundary of the FPA to intercept and divert run-off away from the Alternatives 4 through 7 work area during construction of the alternatives before the final cap is placed. The estimated cost for the trench is $214,000.

3.2.8 Replacement Sheet Pile Wall

This common element includes replacing the outer sheet pile wall, which due to corrosion at and above the mud line (approximate elevation 5 feet), could fail within 10 to 20 years. The replacement sheet pile is required for installing the concrete perimeter bulkhead wall described in Section 3.2.9. Replacement includes installing 1,900 lineal feet of wall to an average depth of 75 feet (142,200 square feet total). The sheet pile wall would be replaced under Alternatives 2, 5, and 6 at an estimated cost of $13.3 million.

3.2.9 Concrete Perimeter and Bulkhead Wall

Under this common element, a new reinforced concrete wall would be constructed on the inside of the existing outer sheet pile wall (see **Appendix B, Drawing 101-CE-300**). The purpose of the wall is to provide geotechnical support to accommodate additional soil loading associated with reuse of remediation material and to promote post-remediation stability of the shoreline.

There are three different designs for the wall (**Appendix B**, **Drawing 101-CE-300**). The design under Alternatives 2, 3, 5, and 6, which is estimated to cost $11.2 million, involves installing a 1,900-foot-long wall to a depth of 38 feet. The design for Alternatives 4 and 7 is estimated to cost $7.9 million and involves constructing a 1,900-foot-long wall to a depth of approximately 30 feet.

3.2.10 New Outfall

The existing GWTP outfall pipe is 8 inches in diameter and used only for effluent discharge. Once the final Site cap (a separate common element described further below) is constructed, stormwater that previously infiltrated into the ground will have to be collected and discharged. Based on a 100-year storm event, the peak stormwater discharge rate was estimated at 11 cubic feet per second or 4,900 gpm. Under this common element, a new 20-inch-diameter outfall (**Appendix B, Drawings 101-CE-103 and 101-CE-104**) would be installed under Alternatives 2 through 7 to provide for stormwater discharge to Eagle Harbor, using horizontal directional drilling methods at an estimated cost of $3.3 million.

3.2.11 Passive Groundwater (Drainage) Treatment

This common element provides technology for post-active remediation of low-level dissolved-phase Upper Aquifer groundwater contamination, if necessary, using a passive technology. This system includes three main components: a collection system, a treatment media such as granular-activated carbon (GAC) housed in a utility hole-accessible vessel to remove dissolved-phase COCs, and a pipe that conveys the treated water to the discharge location outside the sheet pile wall and the new concrete bulkhead (**Appendix B, Drawings 101-CE-105 and 101-CE-301**).

The design concept utilizes the hydraulic head difference present during the outgoing tide to move the water through the GAC to the discharge point. It is estimated each system would treat about 360,000 gallons of groundwater per year (3.6 million gallons total, assuming 10 systems) recovering 570 kilograms of dissolved-phase contaminant mass. The groundwater treatment volume was estimated from a tidal flux analysis described in **Appendix D**.

Ten independent systems would be installed using vertical wells under Alternative 4 at an estimated cost of $1.3 million. Under Alternatives 3, 5, 6, and 7, horizontal drains would be used instead of wells at an estimated costs of $1.1 million. Annual O&M costs under Alternative 4 are estimated at $333,000 and $284,000 for Alternatives, 3, 5, 6, and 7.

3.2.12 Final Site Cap

The planned final end use of the Wyckoff Site is a park with open areas. To reduce surface water infiltration at the Site and prevent exposure to potential, low-level residual contaminants, a permanent surface cap with a low-permeability geomembrane layer is included as a common element for all alternatives.

The conceptual design assumed for this FFS (**Appendix B, Drawings 200-CE-101 and 200-CE-301**) is based on a 60-mil high-density polyethylene geomembrane overlain by 12 inches of drainage material and 12 inches of topsoil. A 12-ounce-per-square-yard cushion geotextile would be placed over the geomembrane to provide drainage layer puncture protection. The total covered area is 8.1 acres. The drainage material and topsoil will be imported to the Site and will have a total volume of 13,050 CY each. During remedial design, the cap design could modified to support an alternate topographic profile if desired. The estimated cost for this common element is $4.1 million.

3.2.13 Monitored Natural Attenuation

MNA relies on natural degradation and nondegradation processes to decrease contaminant concentrations. When relying on MNA processes for site remediation, EPA prefers processes that degrade or destroy contaminants (EPA, 1999a). The key degradation processes for dissolved-phase creosote constituents at the Wyckoff Site include aerobic and anaerobic biodegradation. The key nondegradation processes include dispersion and groundwater-surface water mixing.

Under current Site conditions, anaerobic biodegradation is expected to be the most important MNA process for the LPAHs. Based on information provided in *Anaerobic Biodegradations for Organic Chemicals in Groundwater: A Summary of Field and Laboratory Studies* (EPA, 1999b), it is estimated that 1,381 kilograms per year of naphthalene are biodegraded based on a half-life of 258 days.

Under this common element, a network of monitoring wells would be sampled quarterly to track Upper Aquifer remediation accomplishments, while Lower Aquifer wells would be sampled annually to assess MNA rates. This common element is a recurring item at annual O&M cost under Alternatives 2 through 7 of approximately $90,000 per year.

3.2.14 Access Controls

For all remedial alternatives (except Alternative 1—No Action), Site fencing would remain until the Site could be converted to a public area. ICs to ensure that the Upper Aquifer groundwater within the FPA remains unused would be maintained. ICs restricting Site use to reduce direct exposure to soil would also be maintained. No capital or annual O&M cost has been assumed for this common element.

3.2.15 5-Year Reviews

The NCP, under 40 CFR 300.430(f)(4)(ii), requires that periodic reviews be conducted if a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the Site above levels that allow for unlimited use and unrestricted exposure. These reviews are conducted no less often than every 5 years after the selected remedial action is initiated. Three 5-year reviews have been performed to date, with the third 5-year review completed in 2012. This common element provides for continuing the 5-year reviews until the contaminants are no longer present at unrestricted use and/or unrestricted exposure levels. For this FFS, a $20,000 period cost was include under each alternative.

3.3 Description and Screening of Remedial Alternatives

This section describes the seven NAPL source area remedial action alternatives listed in Section 3.1. Each description includes a narrative summary of the key components, a table listing the primary components, and engineering drawings showing equipment layout, treatment diagrams, and implementation logic. All drawings referenced in this section are provided in **Appendix B** and the cost estimates presented in **Appendix C**.

3.3.1 Alternative 1—No Action

Section 300.430(e)(6) of the NCP requires that a No Action Alternative be included in the FFS to use as a baseline for comparison to other alternatives. Under Alternative 1—No Action, no additional actions would be taken for the Wyckoff Soil and Groundwater OUs. The existing groundwater extraction wells and GWTP would be shutdown (if operating), and this equipment would not be decommissioned. The outer sheet pile wall would be left in place, and over time, it would be expected to fail near the mudline due to corrosion. The sections of wall present below the mudline may still provide some partial containment of NAPL and dissolved-phase contaminants.

3.3.1.1 Screening Evaluation

Per the NCP (40 CFR 300.430) requirement to develop the No Action Alternative and carry it through the detailed analysis of alternatives, Alternative 1—No Action was not screened and will be retained.

3.3.1.2 Cost Estimate

Alternative 1 has no components, and therefore, the net present value cost is $0.

3.3.2 Alternative 2—Containment

Alternative 2 is the contingent remedy implemented under the 2000 ROD. Including this alternative in the FFS satisfies the NCP requirement to develop an alternative that involves little or no treatment and protects HHE by preventing or controlling exposure to contaminants through engineering controls and, as necessary, ICs.

Under this alternative, constructing the remaining containment components specified in the 2000 ROD would be completed, and the remedy operated for 100 years. The key components of Alternative 2 include the following (**Table 3-3**):

- The applicable common elements listed in **Table 3-2**.
- An outer sheet pile wall that is 1,870 feet long bounding the north and east sides of the FPA. This remedy component was installed in 2001. It is assumed that the wall would be replaced once during the 100-year O&M timeframe.
- Installation of four new recovery wells and rehabilitation of the nine existing recovery wells (**Appendix B, Drawing 200-C-100**). All wells would be completed with flush-mounted vaults and buried high-density polyethylene piping. The total system pumping rate with all 13 wells in operation would vary seasonally from 80 to 140 gpm. The wells would operate 24 hours a day, 7 days a week, except for maintenance and repair and during electrical service disruptions.
- Upgrades to the existing GWTP electrical and instrumentation and control systems to provide greater remote/off-Site wellfield and GWTP operations control and improved reliability.
- One hundred years of O&M. The recovery wells and some GWTP mechanical equipment are assumed to require replacement approximately every 30 years. GWTP tanks and piping constructed of fiberglass reinforced plastic would not need replacement due the integrity of this material.
- Periodic sampling and analysis to accomplish the following: 1) confirm GWTP treatment effectiveness, assess the need for treatment media changeout, and compliance with outfall discharge criteria, 2) assess COC concentration changes in Upper and Lower Aquifer groundwater, and 3) verify hydraulic containment of the dissolved-phase plume.

- Existing engineering controls (GWTP and recovery well fencing and signage) and ICs would be maintained to prevent unauthorized land and groundwater use and to protect the integrity of the soil cover.
- Documentation of remedy performance and protectiveness in 5-year reviews.

The location of the four new and nine existing recovery wells is shown on **Appendix B, Drawing 200-C-100**. A process flow diagram showing the various treatment steps in the existing GWTP is shown on **Appendix B, Drawing 200-CE-102**.

Under this alternative, hydraulic containment pumping would remove an estimated 737 kilograms of dissolved-phase COCs per year, while natural attenuation would biodegrade an estimated 1,381 kilograms[4] of dissolved-phase COCs per year. Pumping the hydraulic containment wells would also remove DNAPL with recovery rates steadily declining from 3,972 gallons per year in 2016 to 128 gallons per year in 2116. Based on the 100-year O&M timeframe established for this alternative, it is estimated that 53 percent of the NAPL present in the FPA would be removed.

Alternative 2 addresses RAO #1 by installing a final Site cap across the FPA to prevent direct contact with contaminated soil and maintaining ICs to protect cap integrity and to prevent inadvertent intrusion through the cap to the underlying contaminated soil. RAO #2 is addressed by implementing and maintaining ICs that prevent Upper Aquifer groundwater withdrawals except for remediation purposes. Engineering controls (fencing and signage) would also be maintained around the GWTP and extraction well vaults to prevent potential contact with contaminated groundwater pumping equipment. RAO #3 is addressed by operating the recovery wells to hydraulically contain the dissolved-phase plume, thereby preventing migration to Eagle Harbor and Puget Sound, and treating Upper Aquifer groundwater in the GWTP prior to Eagle Harbor outfall discharge. RAO #4 is addressed by operating the Upper Aquifer hydraulic containment system and MNA within the Lower Aquifer to reduce COC concentrations to the Lower Aquifer groundwater PRGs.

3.3.2.1 Screening Evaluation

Screening of Alternative 2—Containment against the criteria of effectiveness, implementability, and cost indicates that this alternative should be retained. This alternative would be effective because it reduces or eliminates contaminant migration through treatment and over the long term also reduces toxicity and volume. This alternative would be readily implemented because most components have already been constructed. Although long-term O&M costs are expected to be high, some of this cost would be offset by low capital costs.

3.3.2.2 Cost Estimate

The total present worth cost for Alternative 2 is $70.6 million with a -30/+50 percent cost range of $49.4 million to $105.9 million. A breakout of total life cycle costs is provided in **Table 3-3**.

3.3.3 Alternative 3—Excavation, Thermal Desorption, and In Situ Chemical Oxidation

Alternative 3 addresses the NCP requirement to develop an alternative that removes contaminants to the maximum extent practicable minimizing the need for long-term management. This alternative includes the following components:

- The applicable common elements listed in **Table 3-2**.
- Excavation and thermal desorption treatment of contaminated soil present in the Core Area, North Shallow (LNAPL), and East Shallow (LNAPL) target zones. The design basis for this alternative assumes a medium temperature thermal desorption (MTTD) unit operating at a rate of 20 tons per hour. Assuming

[4] This estimate may be revised following completion of Appendix D.

soil excavation is conducted 50 hours per week, and the MTTD unit operates 100 hours per week, 1,500 CY of contaminated soil would be treated per week.

- ISCO-permanganate treatment of NAPL-contaminated material present in the North Deep (DNAPL) target zone. Three separate injection events would be performed with groundwater monitoring conducted following each injection event. The monitoring results would be used to confirm treatment effectiveness and to optimize the scope of subsequent injection events.
- ISCO-hydrogen peroxide treatment of small amounts of NAPL-contaminated material present in the Other Periphery target zone. ISCO-hydrogen peroxide treatment would be applied in a manner similar to that described above for ISCO-permanganate treatment.
- Enhanced aerobic biodegradation (EAB) following completion of Core Area, North Shallow (LNAPL), and East Shallow (LNAPL) treatment using an array of biosparge wells that would inject air into the Upper Aquifer.

The excavation, MTTD, and ISCO treatment steps would be performed simultaneously. EAB would be implemented after the excavation, MTTD, and ISCO treatment steps. Additional information on the primary alternative components of excavation, MTTD, and ISCO is provided in the subsections below.

This alternative addresses RAOs #1 through #3 by excavating and thermally treating NAPL-contaminated soil to reduce COC concentrations to the defined PRGs. The ISCO treatment program, is designed to achieve a high level of treatment but it's uncertain that ISCO treatment alone would achieve the soil and Upper Aquifer groundwater PRGs; therefore, EAB would be implemented to complete any remaining treatment necessary to achieve Upper Aquifer groundwater PRGs. RAO #4 is addressed through treatment of Upper Aquifer NAPL source material and MNA within the Lower Aquifer to reduce COC concentrations to the Lower Aquifer groundwater PRGs.

3.3.3.1 Excavation Methods

In the Core Area, the target depth interval for excavation and thermal desorption would include the ground surface down to the top of the Aquitard (e.g., Compartments 1, 2, and 3). In the North Shallow (LNAPL) and East Shallow (LNAPL) target zones, excavation would extend to an estimated depth of 35 feet bgs. The footprint for each target zone would be subdivided into an array of excavation cells, and each cell geotechnically and hydraulically isolated by internal and external braced sheet pile walls. After the sheet pile walls are installed, the excavation cell would be dewatered using two dewatering wells and the water pumped to the existing GWTP for treatment. Excavation would proceed downward in vertical lifts until the target depth is reached. As each excavation cell is completed, treated soil would be returned to the excavation and used for backfilling. Once the Core Area excavation cells are completed, the work would proceed to the North Shallow (LNAPL) and East Shallow (LNAPL) target zones.

Excavation of the North Shallow (LNAPL) and East Shallow (LNAPL) target zones would be performed in a similar manner but would not requiring lowering of the water table to the same degree as the Core Area due to the shallower excavation depths.

3.3.3.2 Thermal Desorption Treatment

Excavated soil would be treated through a direct-fired thermal desorption unit that includes a rotary desorber for soil treatment, a baghouse for dust collection, and a thermal oxidizer to destroy organic vapors. Excavated material would be segregated in stockpiles for air drying and subsequent loading into the thermal desorber unit. A burner located at the discharge end of the desorber unit would provide the energy to heat the soil, causing organic compounds to volatilize into an air stream and be carried out of the unit. Material processing temperatures would be adjusted during the treatment process based upon COC concentrations present in the feed stockpile and soil PRGs. For this FFS, a soil temperature of 1,100 degrees Fahrenheit (°F) is assumed. Field-scale trials would be conducted to establish optimum treatment temperatures and contact times. After treatment, the soils would exit the kiln at temperatures of 400 to 900 °F and be staged for cooling and confirmation testing prior to placement as backfill in the excavation cells.

Air containing water, organic vapors, and particulate matter would exit the desorber unit to the baghouse, where particulates would be removed. The resulting air flow would be routed to the thermal oxidizer and heated to between 1,400 and 1,800 °F, at which point the organics would be combusted to carbon dioxide and water vapor. The creosote NAPL present at the Wyckoff Site contains PCP, which would generate hydrochloric acid in the thermal oxidizer unit. Therefore, the offgas would undergo additional treatment in an acid scrubber or thermal oxidizer unit operations limited per hydrochloric acid atmospheric discharge regulatory limits. Air monitoring of the thermal oxidation unit would be performed to confirm that the stack offgas complies with discharge limits.

3.3.3.3 In Situ Chemical Oxidation Treatment

The North Deep (DNAPL) target zone would be treated using ISCO-permanganate with treatment occurring in Compartment 3. Permanganate was selected because of the depth of DNAPL contamination lying below the water table, its effectiveness for PAH treatment, the persistence of its oxidizing power, and its relative ease of injection through temporary or fixed wells. The primary disadvantage of permanganate is its potential negative impact on groundwater quality (e.g., increased manganese concentrations and discoloration) and the conditions required to apply EAB polishing. A lag period would exist before suitable conditions for EAB are reestablished.

To reduce the overall oxidant demand and increase ISCO treatment effectiveness, a program of enhanced NAPL recovery from existing and newly installed recovery wells would precede ISCO injection. Once the enhanced NAPL recovery step is completed, oxidant injection would be performed through the same wells used for enhanced NAPL recovery. Following completion of the initial (Phase 1) permanganate injections, which are expected to require about 6 months, changes in PAH concentration, redox conditions, and other groundwater quality parameters would be monitored for 6 to 12 months. Reductions in hydraulic conductivity from precipitated manganese dioxide, which could decrease future injection rates, would also be assessed. Following the Phase 1 injection and monitoring period, Phase 2 injections would occur. The Phase 2 injections are assumed to require approximately 50 percent of the permanganate mass injected during Phase 1. After the Phase 2 monitoring period is completed, Phase 3 permanganate injection would occur. Phase 3 injections are assumed to require approximately 25 percent of the permanganate mass injected during Phase 1.

In the Other Periphery target zone, ISCO would be implemented with catalyzed hydrogen peroxide injected through direct-push technology to provide more focused treatment. Up to three ISCO injections, performed in a phased manner, are assumed to be required in a similar manner as described above for the permanganate injection in the North Deep (DNAPL) target zone.

For both oxidant types, Site-specific, bench-scale testing of oxidant dosage in both Upper Aquifer and Aquitard material would be performed along with field-scale pilot tests during remedial design to confirm treatment effectiveness prior to full-scale field deployment.

3.3.3.4 Screening Evaluation

Screening of Alternative 3—Excavation MTTD and ISCO against the criteria of effectiveness, implementability, and cost indicates that this alternative should be eliminated based on implementation considerations. During preliminary engineering, the degree of shoring and dewatering necessary to excavate Upper Aquifer soil to depths up to 55 feet bgs was determined to not be technically practicable without incurring significant geotechnical risk. Additionally, due to these considerations, it was apparent that the cost of this alternative would be grossly excessive relative to its effectiveness.

3.3.3.5 Cost Estimate

Because this alternative was eliminated at the screening step, a cost estimate was not prepared.

3.3.4 Alternative 4—In Situ Stabilization/Solidification

Alternative 4 addresses the NCP requirement to develop and alternative that treats the principal threat posed by the Site but varies in the degree of treatment and the characteristics of the treatment residuals. Under Alternative 4, all NAPL-contaminated material greater than the TarGOST 10%RE would be treated in situ by immobilizing the NAPL in a cement -type matrix. This approach is expected to greatly reduce the need for long-term management. Alternative 4 includes the following components (**Table 3-4**):

- Each of the applicable common elements listed in **Table 3-2**.
- ISS of NAPL-contaminated material using a combination of auger mixing and jet grout techniques in each of the five remedial action target zones as follows:
  - **Core Zone—**85,300 CY of contaminated material would be treated to a depth of about 50 feet.
  - **North Shallow (LNAPL)—**17,700 CY of contaminated material would be treated to a depths ranging from 25 to 45 feet
  - **North Deep (DNAPL)—**About 59,200 CY of contaminated material would be treated to depths up to 76 feet (treatment in this area includes auger mixing of more shallow impacts and jet grout mixing of discreet deeper zones of impacts)
  - **East Shallow (LNAPL)—**120,000 CY of contaminated material would be treated to depths ranging from 25 to 45 feet
  - **Other Periphery—**43,100 CY of contaminated material would be treated to a depth ranging from 10 to 45 feet
- The overall approach as presented in the following subsections assumes that ISS would be performed 10 hours per day, 7 days per week, requiring approximately 2 years. ISS is assumed to have a 100 percent treatment efficiency, because the technology promotes excellent contact between the reagent and the NAPL-contaminated material.
- An additional 2,700 CY of soil would receive ISS treatment along the bulkhead to solidify soil to a minimum elevation of -15 MLLW to facilitate repairs and new wall construction
- Excavating and removing 7 feet (86,000 CY) of overburden material to offset the swell that occurs during ISS treatment. Excavated material would be staged and treated in an aboveground treatment cell using ISS reagent and the material reused for final Site grading and contouring. Groundwater and stormwater that accumulates in the excavation would be pumped to the GWTP for treatment and outfall discharge. Berms and trenches would also be used to minimize stormwater entry into the excavation footprint.

Under Alternative 4, an estimated 95 percent of 678,000 gallons of the NAPL present in the FPA would be immobilized. The remaining 5 percent would be addressed through natural attenuation and passive groundwater treatment.

This alternative addresses RAOs #1 through #3 by altering NAPL characteristics to reduce toxicity, mobility, and leachability, thereby protecting human health from unacceptable risk due to direct contact and protecting the environment by eliminating a dissolved-phase contaminant source. RAO #4 is addressed through treatment of Upper Aquifer NAPL source material and MNA within the Lower Aquifer to reduce COC concentrations to the Lower Aquifer groundwater to PRGs.

3.3.4.1 In Situ Stabilization/Solidification Description

Auger mix ISS would be performed using a crane mounted auger or hydraulic drill rig. For deep soil application (60 to 75 feet bgs) in the North Deep (DNAPL) zone, small diameter, jet grout injection equipment would be used. Two ISS auger rigs would operate at the Site full-time. **Appendix B, Drawing 300-C-100** shows the ISS Site layout and **Drawings 300-C-101 and 300-C-102** show the footprint where auger ISS and jet grout ISS would be implemented, respectively.

In the Core Area, North Shallow (LNAPL), East Shallow (LNAPL), and Other Periphery target zones, the ISS auger rigs would mechanically mix reagent and NAPL-contaminated soil, creating an array of overlapping, cement-like columns extending from the surface to the bottom of the target zone. Reagent for the ISS would be delivered to the Site by truck and mixed on Site in a batch plant. In the North Deep (DNAPL) target zone, jet grouting equipment would be used to mix the reagent and NAPL-contaminated soil. Due to the high pressures employed for jet grouting, the reagent and NAPL-contaminated soil are fluidized rather than mechanically mixed. Jet grouting ISS also would create an array of overlapping, cement-like columns, but the columns would be generally smaller in diameter than those created with vertical augers. Areas of the Site would be treated with both auger-mix ISS and jet grouting, with untreated zones between as shown on **Appendix B, Drawing 300-C-300**. Along the perimeter of the ISS treatment zone, the mix design would be enriched to create a “rind” or ”crust” to form a contiguous ring of overlapping columns with increased durability resulting from a higher unconfined compressive strength. This crust is shown on **Appendix B, Drawing 300-C-300**.

Prior to commencing ISS, the treatment area would be excavated to a depth of 7 feet to create a sump to contain the swell volume that accompanies ISS. This volume expansion is estimated to range from 20 to 25 percent of the original treatment volume. The excavated material would be treated in an aboveground cell (**Appendix B, Drawing 300-C-100**) using the ISS reagent and stockpiled for future Site grading and contouring reuse.

3.3.4.2 Design Criteria and Basis for Approach

Following are the primary ISS design criteria:

- Identify the compressive strength for the stabilized material that supports future Site reuse.
- Determine the leaching reduction needed to achieve soil and Upper Aquifer groundwater PRGs.
- Develop mix design for inner and perimeter columns. The mix design for the perimeter columns is expected to contain a higher concentration of reagent relative to the inner columns to improve durability characteristics.
- Conduct Upper Aquifer groundwater flow modeling to evaluate new groundwater flow patterns around the ISS monolith, evaluate groundwater elevation mounding that could result in groundwater seeps, and to estimate post ISS groundwater quality conditions.

Bench-scale testing would be performed during remedial design to determine the optimum reagents, mix ratios, and reagent addition rates for the inner and perimeter columns. The mix design would be evaluated by measuring the maximum hydraulic conductivity, minimum unconfined compressive strength, and overall leaching reduction in a series tests prepared using NAPL-contaminated soil obtained from the Site. Optimization testing may also be performed to better refine the reagent mix design, establish ranges for reagent and water addition ratios, and evaluate reagent enhancements that can be added to improve performance (e.g., decrease leachability) or lower costs. Based on experience at other wood-treating Superfund sites (e.g., Mountain Pine, North Cavalcade, and Texarkana), the mix design for Alternative 4 includes up to 10 percent Portland cement and 1 percent bentonite. A typical compressive strength of 50 pounds per square inch with no single point less than 40 pounds per square inch is assumed for this FSS. Compressive strength is an indirect indicator of durability as materials with higher initial compressive strength are typically considered more resistant to aging (ITRC, 2011). For the perimeter crust, the target compressive strength would be double the requirement of the interior columns or a minimum of 100 pounds per square inch.

A field demonstration test would also be performed to verify the bench-scale results, evaluate full-scale equipment options, establish productivity rates, and identify Sitewide implementation considerations. Due to logistical limitations associated with mobilizing ISS equipment to the Site for a field scale pilot test, a demonstration test would occur at the start of full-scale remediation.

Leaching is reduced by either a reduction in hydraulic conductivity or by using amendments to absorb organic constituents. The lower hydraulic conductivity of the ISS monolith relative to the surrounding soils forces groundwater around it, thereby reducing the potential for groundwater to come into direct contact with entombed COCs. Absorbents (activated carbon or oleophilic clay) can reduce leaching by increasing the ability to absorb contaminants over native soils. However, based on testing conducted for other CERCLA sites the increased cost of absorbent does not warrant the nominal increase in leachability performance. For this FFS, an absorbent material is assumed to not be necessary.

Leaching reduction would be evaluated through treatability testing conducted during remedial design to aide in selecting the most effective reagent mix design. Leachability testing would be conducted on both the untreated NAPL-contaminated soil and the NAPL-contaminated soil treated with various mix designs after a 28-day cure period. The test would be conducted in accordance with the approaches presented in the *Development of Performance Specifications for Solidification/Stabilization* (ITRC, 2011) using EPA pre-methods known as Leaching Environmental Assessment Framework. The leaching characteristics of the untreated material would be evaluated using Pre-method 1314 or 1316, while the treated material would be evaluated using Pre-method 1315 to assess the reduction in leaching after treatment. These tests are not intended as a measure of performance during full-scale ISS, but rather as a tool to identify the most effective mix design and to provide data to model post-ISS groundwater quality conditions outside the target zones.

3.3.4.3 Implementation and Sequencing

Given the Site's size and volume of material to be treated, several operations would be performed concurrently. Field activities would be general be sequenced as shown on **Appendix B, Drawing 300-C-600,** as follows:

1. The ISS rig and reagent batch plant would first be mobilized and set up. Large items such as silos and the ISS rig would be transported to the Site via barge and crane and offloaded via the existing sheet pile wall. Smaller items that can be transported without oversize load restrictions would be delivered to the Site via truck. The batch plant would be set up in a central location to allow for delivery of reagent to the entire treatment area. In general, the batch plant must be located within 1,000 feet of the target zones. Additional grading surface stabilization may be required within the batch plant and bulk material storage area. The batch plant includes pumps, mixers, silos, mixed reagent storage, tool shed, and laydown areas. ISS operation likely would be performed year-round; as such, adequate winterizing of the batch plant would be required.

2. Site controls, erosion and sediment controls, stormwater controls and collection systems, odor and vapor controls systems, temporary facilities, and temporary utilities would be installed. Perimeter air monitoring systems would be set up prior to the start of subsurface intrusion activities.

3. As the swell sump excavation progresses from north to south across the Site, jet grouting would be initiated in the North Deep (DNAPL) target zone. Prior to full-scale jet grout treatment, a jet grout field demonstration test would be performed to evaluate jet grout characteristics and expected jet grout column size based on the Site-specific conditions. Several columns would be created using varying injection pressures, drill stem revolutions per minute, and drill stem withdrawal rate. The columns would be created at a depth that allows for excavation and observation after curing. Jet grouting would occur prior to auger mix ISS in areas that are treated using both techniques to avoid drilling through previously solidified soils.

4. As the swell sump excavation and jet grout ISS operations proceed south across the Site, ISS auger mixing would begin. Mixing would be accomplished with 6-foot- and 8-foot-diameter augers, depending on required depth of treatment and mixing difficulty. While auger diameter up to 10 or 12 feet are often used for large ISS projects, smaller diameter augers may be required to penetrate and mix "hard" soil layers. A review of the existing boring logs in the FPA indicates the presence of varying thickness of poorly and well-graded sand and gravel. Standard penetration test "blow counts" ranged from 35 to

55 blows per foot using a 300-pound hammer. This soil density would slow auger advancement requiring more mix time and potentially the addition of more reagent. Using smaller-diameter augers would improve mixing conditions and minimize auger refusal. ISS columns would be overlapped to treat 100 percent of the NAPL-contaminated soil within the target zone. The first several days would be used to demonstrate that the treatability results are verified and to establish the effectiveness of the selected equipment to mix sufficiently to the target depths. Visual observations, field tests, and quick turnaround laboratory testing would be used to demonstrate achievement of performance requirements.

5. Quality control during full-scale ISS includes the following:
   a. Verifying contractor calculations for reagent slurry mixture and for volume of reagents to be added for each ISS column.
   b. Requiring the contractor to complete at least three mixing strokes (a stroke is from top to bottom to top again).
   c. Discrete sampling at different depth intervals to check for consistency of mixing, using color charts, pH, and slump. No unmixed soil should be observed in the sample. This sampling would be done at no less than one time per shift.
   d. Collection of samples for laboratory testing at a frequency of once every 500 CY or once per shift, whichever is less. This frequency would be reduced once data shows that the contractor can consistently meet performance requirements after the completion of 10,000 CY or 20 days of mixing.
6. Stockpiled soil removed during the sump excavation step would be treated using ex situ solidification/stabilization. A treatment cell(s) would be created using a lined and bermed area. Measured quantities of soil would be transferred from the soil stockpile to the treatment cell and mixed with reagents. The same reagent mix design used for ISS is assumed to be appropriate to treat the preexcavation soils, although the water ratio may be adjusted for ex situ conditions. This would be evaluated during the initial demonstration period. The soil and reagent mixture would be mixed using a hydraulic excavator and/or excavator equipped with a horizontal blending attachment. When the soil is adequately mixed, it would then be transferred on Site and allowed to cure in place for final Site grading and contouring, consistent with planned future Site use, to create landscape features.
7. At completion of ISS, the contractor would decontaminate equipment, dismantle the ISS auger and jet grout rig and batch plant, and demobilize.
8. The passive groundwater treatment system and final soil cap would be installed after ISS demobilization.

Groundwater monitoring performed following completion of ISS treatment would be used to confirm groundwater flow patterns and assess the need for the passive groundwater treatment common element.

3.3.4.4 Screening Evaluation

Screening of Alternative 4—ISS against the criteria of effectiveness, implementability, and cost indicates that this alternative should be retained. This alternative would be effective because it would reduce toxicity and mobility through treatment, achieve protection in a relatively short timeframe, and minimize the need for long-term management. This alternative would be readily implemented using technology and equipment proven at other NAPL-contaminated sites, although some implementation elements would need to be refined during the field demonstration. While the cost would be high, due the volume and depth of NAPL-contaminated material requiring treatment, this cost is not disproportionate to overall effectiveness.

3.3.4.5 Cost Estimate

The total present worth cost for Alternative 4 is $86.3 million with a -30/+50 percent cost range of $60.4 million to $137.1 million. A breakout of total life cycle costs is provided in **Table 3-4**.

3.3.5 Alternative 5—Thermal Enhanced Extraction and In Situ Stabilization/Solidification

Alternative 5 addresses the NCP requirement to treat the principal threats posed by the Site using thermal enhanced extraction to draw NAPL from the subsurface in the Core, North Shallow (LNAPL), and East Shallow (LNAPL) zones and destroying the NAPL in an aboveground thermal oxidation unit. In the North Deep (DNAPL) zone, NAPL is immobilized using ISS. Alternative 5 includes the following components (**Table 3-5a**):

- Each of the applicable common elements listed in **Table 3-2**.
- Enhanced NAPL recovery using an array of multipurpose wells and the GWTP for approximately 3 years. Mobile NAPL removal prior would shorten the duration of the thermal treatment period thereby reducing cost.
- Thermal steam-enhanced extraction and thermal destruction of NAPL as follows:
  - **Core Zone—**186,000 CY of contaminated material would be treated to a depth of about 55 feet.
  - **North Shallow (LNAPL) zone—**18,600 CY of contaminated material would be treated to depths ranging from 25 to 45 feet.
  - **East Shallow (LNAPL) zone—**143,000 CY of contaminated material would be treated to depths ranging from 25 to 45 feet.
- ISS of the North Deep (DNAPL) zone. 29,400 CY of contaminated material would be treated to depths up to 76 feet using the jet-grout mixing as described for Alternative 4.
- EAB[5] of the Other Periphery zone. 327,000 CY of low-level NAPL-contaminated material present at depths from 10 to 45 feet would be treated.
- EAB polishing of thermally treated zones. After thermal treatment is completed, EAB would be implemented in each zone as a polishing step to promote aerobic biodegradation of residual NAPL and dissolved/sorbed-phase COCs. Residual heat from the thermal treatment step would accelerate aerobic biodegradation promoting a higher degree of treatment.

Under this alternative, the enhanced NAPL recovery (26 percent), thermal enhanced extraction (52 percent), and EAB (8 percent) technology pairing would remove and destroy an estimated 86 percent of the NAPL present in the FPA, while ISS would immobilize 12 percent. The remaining 2 percent would be treated through natural attenuation processes (1 percent) and passive groundwater treatment (1 percent).

This alternative addresses RAOs #1 through #3 using multiple technologies to extract, destroy, and immobilize NAPL source material thereby reducing COC concentrations in Upper Aquifer soil and groundwater to levels that would allow for further concentration reductions to PRGs through EAB treatment. RAO #4 is addressed through treatment of Upper Aquifer NAPL source material and MNA within the Lower Aquifer to reduce COC concentrations to PRGs in Lower Aquifer groundwater.

3.3.5.1 Enhanced NAPL Recovery Description

Thermal treatment would be preceded by a period of enhanced NAPL recovery from an array of 147 extraction wells (**Appendix B, Drawing 400 C-100**). NAPL and groundwater would be extracted using pneumatically driven pumps. The wells and pumps are both compatible with thermal-steam injection operations. Enhanced NAPL recovery reduces the duration and cost of the steam-injection phase. During the initial phases of recovery, NAPL and groundwater would be pumped directly from the wells. As NAPL recovery volumes diminish, NAPL recovery would be enhanced by increasing the gradient through injection

[5] EAB may also be referred to as biosparging in the text and Appendix B drawings.

of treated water from the GWTP. During the NAPL recovery phase, the Upper Aquifer recovery wells would continue to maintain hydraulic containment of the dissolved-phase plume.

Extracted NAPL and groundwater would be pumped to the GWTP where the NAPL would be separated in a newly installed oil-water separator and the groundwater treated in the existing GWTP. Recovered NAPL would be transported and disposed of (incinerated) off Site. The total volume of NAPL recovered during the 3-year enhanced recovery program is estimated at 134,000 gallons.

3.3.5.2 Thermal Treatment

Description

Thermal enhanced extraction would be performed using steam injected into an array of multipurpose wells. The Core Area (three cells identified as Core A, Core B, and Core C) and East Shallow (LNAPL) (two cells identified as North and South) target zones would be divided into smaller treatment cells using sheet pile walls that extend from the ground surface to the top of the Aquitard so that hydraulic containment can be maintained during the thermal treatment step. To maintain hydraulic containment, the steam injection rate must be offset by a groundwater extraction rate that is equal or greater. The sheet pile walls would reduce groundwater intrusion and allow the water table to be lowered close to the bottom of the NAPL treatment zone. The total volume of NAPL-contaminated material that is thermally treated would be larger than described for Alternatives 3 and 4 to allow for “squaring off” the individual treatment cells. For example, the Core Area was extended northward in “Core C” to capture additional highly NAPL-impacted soil.

After isolating each treatment cell with the vertical sheet pile walls, a vapor barrier would be constructed over the treatment area. The vapor barrier would span 6 acres extending approximately 20 feet beyond the edges of the thermal treatment footprint (**Appendix B, Drawing 400-C-101**).

After installing the vapor barrier, all remaining wells would be installed, including 27 dewatering wells, 172 multipurpose steam injection/EAB wells, 201 temperature monitoring wells, and 31 EAB wells. The 147 wells previously installed for NAPL recovery would be re-purposed as steam extraction wells. Installation of piping, fittings, instrumentation, and surface process systems would be performed sequentially and precede initiation of thermal operations in each treatment cell. After all the wells are installed, and during enhanced NAPL recovery operations, the surface process components necessary for vapor and liquid treatment would be constructed.

Core Area, East Shallow (LNAPL), and North Shallow (LNAPL)

Thermal enhanced extraction in these three areas utilizes the enhanced NAPL recovery wells for fluid/vapor extraction and injects steam through a network of injection wells installed in a repeated 7-spot configuration with a 30-foot spacing between injection and extraction wells. The layout of the 172 steam injection wells is shown on **Appendix B, Drawing 400-C-101**. The 7-spot well pattern was modified based on the placement of the sheet pile walls and identified areas of NAPL accumulation. **Appendix B, Drawing 400-C-101** also shows the approximate location of 201 temperature monitoring wells. The thermal treatment areas are overlain by a temporary vapor barrier to prevent steam and contaminant vapor escape and heat losses to the atmosphere during operations. This vapor barrier is augmented by active extraction of vapors through perforated piping installed under a geomembrane and/or injection of air through other piping installed under the geomembrane. Injected air is intended for extraction by the deeper, vertical steam extraction wells. The extent of the vapor barrier cap across the Core, East Shallow (LNAPL), and North Shallow (LNAPL) areas, and the placement of shallow, horizontal piping beneath the vapor barrier is shown on **Appendix Drawing 400-C-102**.

As NAPL recovery in the Core Area diminishes or ceases, sequential application of thermal enhanced extraction is initiated with Core A treated first, followed by Core B, and Core C. Upon completion of all thermal treatment in the Core Area, the process is moved to the East Shallow (LNAPL) South and then the East Shallow (LNAPL) North treatment cells. The North Shallow (LNAPL) target zone would be treated last.

3.3.5.3 EAB Description

After thermal operations are completed, EAB would be implemented across the thermally treated areas for approximately 1 year accompanied by hydraulic containment to promote mixing and oxygen distribution. **Appendix B, Drawing 400-C-103,** presents the biosparging well layout. EAB has synergy with the thermal treatment. Air injection for aerobic biodegradation promotes mixing dissolved contaminant mass with oxygen, while the residual heat from thermal operations promotes increased dissolution of residual NAPL and increased biological degradation rates. During EAB operations, the infrastructure for thermal operations is dismantled and removed from the Site.

The passive groundwater treatment system, as described in Section 3.2, Common Elements, and deemed necessary from performance monitoring, would be installed during the final stages of EAB. When EAB is terminated, hydraulic containment also would be terminated, and passive treatment operations begin. The passive treatment system would operate for approximately 20 years, after which all wells would be are abandoned, save a few monitoring wells, the GWTP is demolished, and the final Site cap is constructed, as described in Section 3.2, Common Elements.

In the Other Periphery target zone, EAB would be applied using an array of air and amendment injection points and wells. Supplemental biosparging points and wells for amendment injection and monitoring are installed as illustrated in **Appendix B, Drawing 400-C-103** to provide injection points for air and nutrients to enhance aerobic biodegradation of contaminants.

3.3.5.4 Design Criteria and Basis for Approach

The following subsections present the design criteria and design basis for the key Alternative 5 treatment technologies.

ISS -Jet Grouting

The design criteria and basis for ISS-jet grouting of the North Deep (DNAPL) target zone is the same as described for Alternative 4 in Section 3.3.4.2.

Enhanced NAPL Recovery

Enhanced NAPL recovery rates were estimated using a decline curve analysis (American Petroleum Institute Publication 4711, 2011) along with Site-specific parameters for the recovery well spacing (approximately 55 feet), fraction of NAPL volume characterized as mobile (0.34), and the NAPL and soil physical properties. Based on the analysis (**Appendix D**), 3 years of operation would recover approximately 60 percent of the mobile NAPL. The 55-foot spacing between recovery wells was optimized with the design basis for the steam injection well spacing.

Thermal Treatment

Thermal enhanced extraction utilizes the enhanced NAPL recovery wells and injects steam through a network of injection wells installed amongst the extraction wells in a repeated seven-spot configuration with a 30-foot spacing between steam injection and extraction wells. This pattern overlays with the 55-foot spacing between NAPL recovery (steam extraction) wells.

The primary design criteria for thermal enhanced extraction is the GWTP’s 80-gpm available hydraulic capacity, which controls dewatering and vapor/fluid extraction rates, and hence the size of each treatment cell. Per this criteria, the Core, East Shallow (LNAPL), and North Shallow (LNAPL) target zones were divided into six treatment volumes (cells) ranging in size from 31,000 CY to 78,000 CY. The cells would be segregated by internal sheet pile walls as shown on **Appendix B, Drawing 400-C-100**.

The design basis for Alternative 5 accounts for high naphthalene mass extraction rates. Naphthalene crystallization considerations start in the treatment train and within the extraction wells. Wellhead details are shown on **Appendix B, Drawing 400-C-500** and include multipurpose drop tubes that allow measurements of water level, soil temperature at the bottom of the well, and access for steam cleaning of the well screen should naphthalene fouling degrade recovery rates. Steam can also be supplied through this location to clean the vapor instrumentation and piping at the wellhead.

The conveyance piping includes heat tracing to maintain high temperatures that minimize crystallization while providing access ports for periodic steam cleaning as a routine maintenance procedure. As shown on **Appendix B, Drawing 400-C-600**, all extracted liquids and vapors are routed through a direct contact condenser specifically designed to remove NAPL sludge, solid-phase PAH, and any solids extracted from the subsurface. Steam condensation is expected to generate PAH solids that would be handled as shown on **Appendix B, Drawing 400-C-600**. This process flow diagram illustrates the primary treatment equipment required for the thermal component of Alternative 5 including vapor treatment in a thermal oxidizer.

The water from the thermal treatment is near ambient temperature, has a low NAPL content, and is routed to the GWTP for final treatment. The existing GWTP process flow diagram is shown on **Appendix B, Drawing 400-C-601** with the proposed upgrades to increase its capacity to 140 gpm and handle higher temperature water shown on **Appendix B, Drawing 400-C-602**. The thermal treatment system layout is shown on **Appendix B, Drawing 400-M-101**.

Dewatering and Soil Vapor Extraction

Each of the three Core Area treatment cells includes six dewatering wells with the objective of lowering the water table as close to the Aquitard as practical. The total pumping rate is estimated to range from 60 to 80 gpm. The East Shallow (LNAPL) South, East Shallow (LNAPL) North, and North Shallow (LNAPL) treatment cells each have three dewatering wells. The objective for pumping in these cells is to lower the average water table elevation by 10 to 15 feet to expose the majority of the NAPL. The total pumping rate is estimated to range from 30 to 45 gpm. After lowering the water table, soil vapor extraction (SVE) is initiated using the NAPL extraction wells at a total rate up to 600 standard cubic feet per minute (scfm).

Soil Heating and Mobile NAPL Recovery during Steam Injection

Once most of the mobile NAPL is recovered, thermal treatment would be used to recover additional NAPL through the steam enhanced recovery and distillation recovery steps (**Table 3-5b**). Steam injection is not expected to result in complete recovery of all NAPL due to subsurface heterogeneities. Under Alternative 5, the design assumption is for 35 percent recovery achieved through a longer period of enhanced NAPL recovery preceding steam injection and more uniform heating during steam operations in each treatment cell. The estimated NAPL volumes characterized as residual, that require recovery or treatment through the distillation, dissolution, and EAB steps account for about 65 percent of the original NAPL volume present in each treatment cell.

Of the 582,000 gallons of NAPL initially present in the “squared off” treatment cells, it is estimated that 208,000 gallons are recovered using enhanced pumping and steam enhanced recovery methods. The remaining 374,000 gallons of immobile NAPL re thermally recovered through volatilization into the extracted vapor phase, dissolution into extracted water, or EAB. Some COC mass is adsorbed by aquifer solids. Desorption of this mass is enhanced by steam injection, but this fraction is not considered further because the mass is very small relative to the total NAPL mass.

Residual NAPL Distillation during Steam Injection

The duration of steam distillation to achieve the NAPL mass reduction is calculated from the rate of steam injection and the total mass of steam required. A practical steam injection rate during NAPL distillation was determined from the surface treatment capacity for condensing extracted steam and for handling PAH solids. Based on practical mass and energy balances, the assumed steam injection rate during distillation is 6,500 pph. For this steam injection rate, initial production of solid PAHs in the treatment system for the Core treatment cells is on the order of 6,000 pounds per day. The total mass of steam required for the NAPL mass reduction would be more than the mass calculated from the ideal distillation model. Overall, the steam requirement averaged 1,000 pounds per CY and required a total injection of about 277 million pounds of steam. The thermal component in the six treatment cells requires about 5 years to complete based on the proposed approach.

EAB following Steam Injection

Soil temperatures remain elevated for a long period following the end of steam injection and afford the opportunity for continued volatilization and recovery of NAPL components. When steam injection is terminated, air injection is continued through the same system of wells. The vapor and groundwater extraction systems continue operating to maintain a depressed water table and recover the injected air. For design, the air injection rate is assumed to sweep the vapor pore volume within the treatment target once per day. A daily pore volume sweep corresponds to an air injection rate of 200 scfm. Air injection and extraction operates for 30 days following the end of steam injection while the water table is lowered in the next treatment target.

As subsurface temperatures decay further and after 30 days of operation, liquid and vapor extraction cease in the extraction wells allowing the water table to rise. Biosparging is then initiated into the warm saturated zone to enhance the aerobic degradation of remaining dissolved-phase and desorbing contaminants. Biosparging is implemented by pulsing air injection into rotating sets of wells at an average rate of 100 scfm and extracting from the vapor barrier at a similar rate. Biological degradation parameters (e.g., dissolved oxygen and oxidation-reduction potential in groundwater and carbon dioxide in vapor barrier extraction) and groundwater PAH concentrations are monitored. This operation continues for six to nine months during steam injection in the next treatment volume.

The design basis for EAB is described further in the following subsection.

EAB of Other Periphery Target Zone

The Other Periphery target zone lies outside and partially within the footprint of the thermal enhanced extraction and the ISS treatment zones. The design basis for implementing EAB in this target zone and as a thermal treatment polishing step varies and depends on the following Site-specific factors:

- Oxygen requirement for aerobic biodegradation based on contaminant mass estimates (assume 1,000 standard cubic feet of air per kilogram of contaminant mass degraded)
- Air injection well radius of influence (assume 25 feet)
- Anticipated average air injection rate for soil properties, air distribution patterns, NAPL dissolution rates, and aerobic biodegradation rates of individual creosote components (assume 8 scfm per well).

NAPL dissolution, oxygen distribution and diffusion, and reaction rates combine to slow the process and reduce the efficiency of oxygen utilization, thereby requiring the injection of an excess of oxygen into the subsurface. The air injection rate in the EAB system would be estimated from the anticipated half-lives of contaminants in the groundwater at the Wyckoff Site and the partitioning of oxygen from air into groundwater during design. For naphthalene in groundwater, typical half-lives under ambient anaerobic conditions have been observed from 110 to 462 days with a recommended value of 258 days (HydroGeoLogic, 1999). For aerobic conditions, such as those created during EAB, the half-life of naphthalene in groundwater at ambient temperatures is typically about 30 days (Aronson et al., 1999).

3.3.5.5 Implementation and Sequencing

The implementation of thermal treatment under this alternative[6] would typically consist of the following steps:

1. Install all process piping, including heat tracing or equivalent, to maintain vapors at an elevated temperature up to the point of ex situ treatment.

[6] The steps described are based on conditions present in Core A and would likely vary for other treatment cells.

2. Initiate dewatering from the six dewatering wells and pump water to the GWTP.
3. Reroute groundwater extraction piping from the enhanced NAPL recovery wells to the thermal pretreatment system, and increase the extraction rate to recover as much remaining mobile NAPL as practical.
4. Initiate SVE in the extraction wells and beneath the vapor barrier.
5. Initiate steam injection and use performance observations to optimize flow and withdrawal rates.
6. Cease steam injection after 270 days, and continue liquid and vapor extraction at decreased rates.
7. With elevated soil temperatures still present, initiate EAB through multipurpose wells.
8. As subsurface temperatures decrease, cease liquid and SVE allowing the water table to rise. Continue SVE beneath vapor barrier at a rate matching the EAB injection rate. Continue EAB and monitor biological degradation parameters and COC concentrations for six months. Introduce amendments, as necessary, to optimize aerobic biodegradation of residual COCs by adjusting redox conditions and adding electron donors, acceptors, and nutrients as needed.
9. Remove and inspect extraction wellhead assemblies and downhole pumps, remove steam injection wellhead assemblies, disassemble piping (excluding air lines to injection wells) and manifolds, and refurbish all for reuse in subsequent treatment cells. Move to the next treatment cell in the sequence and proceed with constructing the piping system for injection and extraction.
10. The leapfrogging construction and operations sequence continues across the FPA proceeding from Core A to Core B, Core C, East Shallow (LNAPL) South, East Shallow (LNAPL) North, and last the North Shallow (LNAPL) target zone.

Implementing Alternative 5 would span approximately 9 years of sustained Site activity from initial design to the initiation of the passive groundwater treatment (if necessary). Assuming 2016 as the base year, the implementation sequence, which does not show the remedial design, bid evaluation and award steps, would consist of the following activities:

2016	2017	2018	2019	2020-2024	2025	2026	2027-2043	2031
• Common elements • ISS North Deep (DNAPL) • GWTP O&M	• Common elements • GWTP O&M	• Thermal construction • GWTP O&M	• Enhanced NAPL recovery • GWTP O&M	• Thermal operations • GWTP O&M • EAB	• Well abandon • EAB • Passive groundwater treatment	• Summary of EAB • Passive groundwater treatment	• Passive groundwater treatment	GWTP demolition

3.3.5.6 Screening Evaluation

Screening of Alternative 5 – Thermal Enhanced Extraction and ISS against the criteria of effectiveness, implementability, and cost indicates that this alternative should be retained. This alternative would be effective because it would reduce toxicity, mobility, and volume through treatment, achieve protection in a reasonable timeframe, and reduce the need for long-term management. This alternative would use advanced treatment technology that requires an extensive network of injection and recovery wells that utilize the GTWP to recover NAPL and thermal oxidation to destroy vapor-phase contaminants. Thermal enhanced extraction has been deployed successfully at other sites. While the cost is high, due the volume of NAPL-contaminated material requiring treatment, this cost is not disproportionate to overall effectiveness.

3.3.5.7 Cost Estimate

The total present worth cost for Alternative 5 is $134.1 million with a -30/+50 percent cost range of $93.9 million to $201 million. A breakout of total life cycle costs is provided in **Table 3-5a**.

3.3.6 Alternative 6—Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Alternative 6 combines the excavation and MTTD technologies to treat NAPL source material present in the upper portion of the Core Area to a depth of 20 feet. Alternative 6, like Alternative 5, addresses the NCP requirement to develop an alternative that removes or destroys contaminants to the maximum extent feasible, eliminating or minimizing, to the degree possible, the need for long-term management.

This alternative includes the following components (**Table 3-6**):

- The applicable common elements listed in **Table 3-2**.
- Excavation and MTTD treatment of an estimated 81,300 CY of NAPL source material present within the top 20 feet of the Core Area. Before backfilling treated soil, a geosynthetic clay liner would be placed on the bottom of the excavation to create a vapor barrier to support subsequent thermal treatment operations.
- Thermal enhanced extraction in the Lower Core Area, between depths of 20 feet and the top of the Aquitard, and the East Shallow (LNAPL), North Shallow (LNAPL), and North Deep (DNAPL) target zones. Following completion of thermal treatment, EAB would be implemented as a polishing step to promote aerobic biodegradation of residual NAPL and dissolved/sorbed-phase COCs. Residual heat from the thermal treatment step would accelerate aerobic biodegradation promoting a higher degree of treatment.
- EAB in the Other Periphery target zone.

Under this alternative, excavation and thermal desorption would treat an estimated 14 percent of the NAPL present in the FPA, while enhanced NAPL recovery and thermal enhanced extraction would remove an estimated 21 percent and 43 percent, respectively. Passive groundwater treatment (1 percent) and natural attenuation (3 percent) would address the remaining 4 percent of the NAPL.

This alternative addresses RAOs #1 through #3 by excavating and/or thermally treating NAPL-contaminated soil to reduce COC concentrations to the defined PRGs. EAB would be implemented to complete any remaining treatment necessary to achieve Upper Aquifer soil and groundwater PRGs. RAO #4 is addressed through treatment of Upper Aquifer NAPL source material and MNA within the Lower Aquifer to reduce COC concentrations to the Lower Aquifer groundwater PRGs.

3.3.6.1 Excavation Methods Description

To facilitate dewatering and soil excavations, the Core Area would be divided into nine sheet pile cells (**Drawing 500-C-100**) with surface areas ranging from 10,000 to 16,000 square feet. The sheet pile walls extend from the ground surface to the Aquitard. Sheet pile wall bracing would be accomplished using welded whalers and struts, which would be left in place for backfilling. Within each of the cells, two dewatering wells would be installed to lower the water table below a depth of 20 feet. Each dewatering well is estimated to yield 10 to 20 gpm. The dewatering wells would be left in place to assist with the thermal treatment portion of the remedy or used as monitoring wells.

3.3.6.2 Thermal Desorption Treatment Description

MTTD would generally be performed as described for Alternative 3.

Additional infrastructure to support MTTD operations includes the following:

- **Sheet Pile Cells and Dewatering Wells** – would be installed to form the nine cells in the Core Area and would be installed into the top of the Aquitard.
- **Soil Blending and Handling Building** – this is a metal building or fabric structure used for staging the soil in order to improve its uniformity prior to feeding into the MTTD. The building is constructed on an asphalt concrete pavement (ACP) pad with a concrete berm. The building atmosphere is ventilated

through a vapor-phase GAC system to control odor and emissions. Trucks would dump over a ramp near the eastern building entrance. The feeder to the MTTD system would be placed in the building thus allowing for interior loading to reduce noise during night and weekend periods.

- **MTTD Pad** – an ACP lined pad for the MTTD equipment as well as the genset and fractionation tanks for quenching of treated soils. The pad is sloped for stormwater collection and to support treatment.
- **Soils Awaiting Analysis Pad** – ACP-lined holding area divided into cells to stage soil while it is tested to support blending, re-treatment, and backfill determinations. The cells are constructed of ecology blocks stacked three high. A turn-around-time for PAH and PCP soil analysis of 3 days is planned.
- **Treated Soils Stockpile Area**- ACP-lined pad holding up to 16,000 CY of soil awaiting confirmation that soil PRGs have been achieved prior to backfill placement.
- **Propane Storage Tank** – a 30,000 gallon storage tank placed on a concrete pad with cradles enclosed by ecology blocks. The tank also includes a vaporizer.
- **MTTD Genset** – a containment pad for the genset as well as fuel cell. The fuel cell would have a capacity of about 16,000 gallons and provide for an estimated 12 days of operation.
- **Existing GWTP** – the water from the dewatering wells would be treated through the GWTP.
- **Storm Water Infiltration Trench** – would handle stormwater from the Site as well as the Treated Soil Stockpile Area if it is contaminated and can’t be direct discharged. Prior to construction of the trench, the soils in this area would be excavated to a depth of 7 feet and treated via MTTD.
- **Decontamination Pad** – including a fractionation tank, genset, and a powered wheel wash. The fractionation tank would also support dust control. This pad would be located along the main access road between the Treated Soils Stockpile and the Soil Blending and Handling Building. The road would be constructed with 12-inches of crushed rock over a geotextile fabric.
- **Existing Well** – the well would be used for process and dust control water supply.
- **Underground Piping and Cables**. The following would be run underground; dewatering well pipe to GWTP; propane service to the primary and secondary chambers; stormwater conveyance to the infiltration trench; power to MTTD control trailer and the Soils Blending and Handling Building. The dewatering well piping would be buried high-density polyethylene with stub ups at each of the cells. The discharge header from the dewatering wells would be connected to the transfer piping using fire hoses. The wells would be powered by genset.

3.3.6.3 Thermal Enhanced Extraction and EAB

The thermal enhanced extraction and EAB components of Alternative 6 are similar to that described for Alternative 5. The layout of these components is shown on **Drawing 500-C-101** (Enhanced NAPL Recovery Wells and Thermal Wells), **Drawing 500-C-102** (Vapor Cover), **Drawing 500-C-102** and **500-C-103** (Piping), and **Drawing 500-C-104** (EAB Wells).

3.3.6.4 Design Criteria and Design Basis

Propane consumption for the MTTD unit is estimated at 23 gallons per ton of soil treated or 3 million gallons total. Electrical power would also be required and would be obtained from a 750-kilowatt TIER IV genset (480-volt three-phase) with an estimated fuel consumption at 100 percent operations of 55 gallons per hour or 450,120 gallons of diesel total.

The treatment rate through the MTTD system is estimated at 20 tons per hour with an estimated maximum treatment rate of 480 tons per day. The system would operate 24 hours per day for 7 days per week, and with an 80 percent availability, the daily treatment rate is about 16 tons per hour or 380 tons per day for 11 months.

The design criteria and design basis for the thermal enhanced extraction and EAB components are the same as described for Alternative 5.

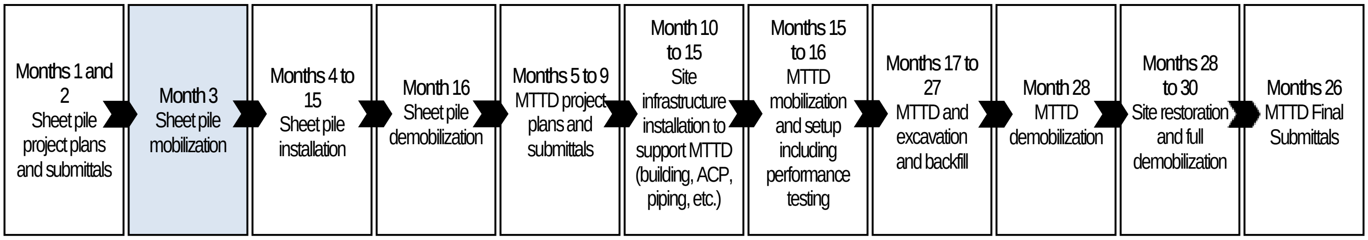
3.3.6.5 Implementation and Sequencing Schedule

The general sequence of events for excavation and MTTD operations in each treatment cell would include the following steps:

1. During week days, excavation would be conducted in parallel with MTTD treatment.
2. During the week day night shift, and on weekends, soil would not be excavated but MTTD treatment would continue using stockpiled material loaded from the Soil Blending and Handling Building interior into the MTTD feeder to minimize noise levels. For extended weekends, excavation may be required or additional soil may need to be staged within the cells.
3. Excavation would begin in the first cell using a combination of long reach excavator and a drag line. Foam would be used to control odors during excavation. Soils with excess moisture may be staged in an adjoining contaminated cell for drying prior to transport to the Soils Blending and Handling Building.
4. As the excavation within a cell proceeds to the design depth, the whalers and struts would be installed using a crane and man lift to provide lateral support for the sheet pile walls.
5. As the excavation progresses a track mounted dozer would be lowered into the cell to support the staging of soils for removal by long reach excavator or clam shell.
6. Excavated soil would be transported in 20 ton off-road trucks to the Soil Blending and Handling Building where it would be staged for further dewatering (using a tiller) as well as blending and/or addition of admixtures. Soils would be end dumped over a dump ramp.
7. Soils in the Soil Blending and Handling Building would be windrowed for tilling or mixing to support dewatering and homogenization as well as adding reagents (such as lime) to support dewatering. The building would be designed to hold a 3 to 4 day supply of soil for MTTD treatment.
8. Soils within the Soil Blending and Handling Building would be loaded into the feeder of the MTTD unit, which is located within the building. This approach minimizes odors and dust, as well as reducing noise levels during nighttime and weekend operations.
9. Treated soil is staged by conveyor in day piles on the MTTD pad, where it is subsequently hauled to the Soils Awaiting Analysis pad where it is held in cells (one day's treatment per cell) until it has been demonstrated, through analytical testing, that the soil meets the treatment objectives.
10. Soil that doesn't meet the treatment objectives would be staged for re-treatment. Soil meeting the treatment objectives would be staged in the Treated Soils Stockpile area and/or staged for direct backfill adjacent to an excavation.
11. Prior to backfilling, sump pumps would be used for any further dewatering prior to the placement of the geosynthetic clay liner vapor barrier.
12. When two cells are open the backfilling operation would be conducted. Backfill would be placed in lifts and compacted. A crane would be used to lower equipment into each cell as required to support geosynthetic clay liner placement, spreading of backfill, and compaction. As indicated above the whalers would be left in place. As conditions dictate, the struts may be removed to support backfilling.

Once MTTD is completed the unit would be decontaminated and removed along with other surface and below ground (piling) features. ACP would be removed and recycled to the degree feasible. Subgrade gravel for base material would be removed from the Treated Soil Stockpile area and used along with other base materials for backfill within the cell or general Site.

The general duration of key excavation and MTTD treatment activities would include the following:



Following completed of excavation and MTTD treatment, thermal enhanced extraction and EAB would be implemented as described for Alternative 5.

3.3.6.6 Screening Evaluation

Screening of Alternative 6 – Excavation, MTTD and Thermal Enhanced Extraction against the criteria of effectiveness, implementability, and cost indicates that this alternative should be retained.

Alternative 6 is effective because it utilizes multiple treatment technologies, employing excavation and MTTD to address high concentration NAPL source material and thermal enhanced extraction to address areas where lower concentrations of NAPL source material occur. Although this alternative faces some implementation challenges, the design concept has developed approaches to address each condition. As described in the following subsection, the estimated cost for this alternative is higher relative to the other alternatives but provides important information that shows what is required to implement this technology combination at the Site.

3.3.6.7 Cost Estimate

The total present worth cost for Alternative 6 is $186 million with a -30/+50 percent cost range of $130 million to $279 million. A breakout of total life cycle costs is provided in **Table 3-6**.

3.3.7 Alternative 7—ISS of Core Area and Thermal Enhanced Recovery

This alternative was not identified during the scoping phase of this FFS but was developed later on by merging key elements of Alternative 4 and Alternative 5 to provide an adaptive management approach that is amenable to a performance based phasing approach that allows for optimizing subsequent treatment phases. Consequently, the level of design development and quantity estimation is not as detailed as the other alternatives.

The primary components of this alternative (**Table 3-7a**) include:

- ISS of the Core Area around the perimeter of the FPA to create an ISS shell around the 10% RE border.
- NAPL recovery with thermal enhancement, and EAB polishing in the remaining target areas. This alternative uses the existing GWTP, with some modifications, for treatment and eliminates the system described for Alternatives 5 and 6.

Under this alternative, ISS of the Core Area and FPA periphery would immobilize 37 percent of the NAPL present in the FPA while enhanced NAPL and thermal enhanced recovery would remove 26 percent and 31 percent, respectively. EAB would treat 6 percent with the remaining 1 percent addressed using passive groundwater treatment.

ISS treats the high concentration NAPL source material present within the Core Area with the added benefit of using ISS around the perimeter of the FPA to hydraulically isolate the NAPL source as shown on **Appendix B, Drawing 300-C-100** and **Drawing 300-C-101**. After stabilizing the majority of the NAPL and isolating the NAPL source zone, the East Shallow (LNAPL) and North Shallow (LNAPL) with lower NAPL concentrations are treated by targeted pumping of mobile NAPL and implementation of EAB, both enhanced with steam and/or air injection as field observations dictate. Steam injection has the benefit of increasing dissolution rates from immobile NAPL and increasing rates of aerobic biodegradation. As dissolved-phase concentrations decay towards Upper Aquifer groundwater PRGs, passive groundwater treatment would be implemented. The soil volumes and estimates of NAPL volume in each targeted zone are provided in **Table 3-7b**.

Concurrent with ISS, EAB is initiated as soon as practical to assess and optimize its effectiveness. In this manner the effectiveness of ISS on Upper Aquifer groundwater quality can also be assessed. NAPL recovery is phased in across the Site. As compared to Alternative 5, any steam injection in Alternative 7 is much less intense with the objective of simply increasing soil and groundwater temperatures without creating a defined steam zone where NAPL distillation occurs. As such, the steam injection is not accompanied by the extraction of hot vapors negating the need for a specialized aboveground process treatment system as described for Alternative 5.

3.3.7.1 Adaptive Management Approach

A guiding principle for the adaptive management approach is to treat the most contaminated areas first and expand treatment as determined by field observations to achieve the state RAOs and performance objectives (POs).[7] Initial ISS activities and NAPL recovery are expected to meet PO#1 leaving PO#2 as the focus for adaptive management. PO#2 is interpreted as transitioning Site remedial activities solely to operation of a passive groundwater treatment system (PGTS) that meets the RAO of protecting Eagle Harbor and Puget Sound. Potential management decision points for meeting PO#2 are outlined below followed by descriptions of each remedial component.

The primary element of this alternative is application of the ISS technology in the Core Area to treat NAPL down to the top of the Aquitard. This action would treat a large fraction of the NAPL present in the FPA. Concurrent, or preceding, this activity is the treatment of NAPL along the entire perimeter with a 10 foot wide ISS column (e.g., crust). The crust creates a perimeter wall that hydraulically isolates the upper portion of the internal soil volume and eliminates the need for a new perimeter sheet pile wall. In addition, ISS can be expanded beyond the Core Area, if deemed necessary, to selectively treat additional high-value NAPL zones identified during detailed design or field activities.

The GWTP is operated throughout the ISS activities for hydraulic control. GWTP influent monitoring following ISS treatment provides initial data for assessing treatment effectiveness and to estimate worst-case concentrations for early implementation of PGTS. Data also become available to assess changes in the subsurface hydraulics at the Site. Detailed design of the PGTS can proceed based on ISS-modified subsurface hydraulics and mass influent estimates. Design of the PGTS would better define performance requirements for NAPL recovery and EAB, and any enhancements to allow transition to the PGTS in a timely manner.

At the completion of the ISS (and any expanded ISS), the NAPL recovery and thermal enhancement components are constructed along with the EAB infrastructure. The GWTP continues to operate and measures of influent groundwater concentrations and extraction rate continue to provide data for assessing reductions in dissolved-phase concentrations and mass discharge rates and the potential for transitioning to the PGTS. If reductions in mass discharge rates meet specified design criteria for the PGTS, construction of the passive treatment system can proceed with limited NAPL recovery and EAB.

After construction and initial NAPL recovery and EAB (pulsed air sparging), remaining NAPL accumulations would likely become better defined. In high value areas, thermal enhanced NAPL recovery using low-quality (“wet”) steam injection would be implemented. The purpose of this injection is to heat and mobilize NAPL for recovery without creating a continuous steam zone. Extraction of vapors does not accompany the enhanced NAPL recovery because of the lesser increase in groundwater temperature associated with this process. Introduction of thermal enhancements would proceed across the Site with the low-quality steam injection in high value areas to mobilize and recover NAPL, increase dissolution rates from immobile NAPL,

[7] PO #1. Remove or treat mobile NAPL in the Upper Aquifer to the maximum extent practicable such that migration and leaching of contaminants is significantly reduced.

PO #2. Implement a remedial action that does not require active hydraulic control as a long-term component of O&M following completion of source removal action.

and increase biological degradation rates. The entire soil volume isolated by ISS can be moderately heated to optimal degradation temperatures in less than two years, if necessary, without specialized operators and maximizes the soil volume acting as a bioreactor. The GWTP operates throughout this period and if mass discharge rates decay sufficiently thermal enhancements can be terminated. Conversely, if performance is lacking, the thermal operations can be intensified.

After modestly heating the Site, NAPL recovery (if any), dissolved-phase extraction, and EAB continue as needed along with operation of the GWTP. Periodic addition of heat to maintain an optimal degradation temperature is anticipated for up to six years beyond the initial heating period. Annual evaluations of the mass discharge rates against design requirements for the PGTS would be performed and appropriate action taken: intensifying treatment or terminating the active extraction and transitioning to the passive treatment system.

When design requirements for the PGTS are attained, operations would transition away from active extraction to the passive system over several months to allow an evaluation of PGTS performance. Active systems would remain in place but dormant until the PGTS demonstrates meeting its performance requirements. When the PGTS is fully functional, the remaining Site activities would be completed (e.g., construct concrete perimeter wall, abandon wells, demolish GWTP, install Site cap).

3.3.7.2 ISS Description

Application of ISS in the Core Area and the 10% RE Perimeter is similar as described for Alternative 4 and would treat approximately 60 percent of the NAPL source material present in the FPA.

3.3.7.3 NAPL Recovery and EAB Description

For Alternative 7, the existing GWTP is upgraded to a capacity of 140 gpm with provisions for an increased influent temperature as high as 104 °F. These upgrades are described as part of Alternative 5. After initiation of ISS in the Core, wells for this alternative are installed across the Site including NAPL extraction, thermal injection, biosparging and monitoring wells. The well installations are similar to those in Alternative 5 although the number is decreased with the subtraction of the Core volume and the elimination of internal sheet pile walls. A summary of the estimated well installation is as follows: (1) NAPL Extraction Wells = 92; (2) Thermal/EAB Injection Wells = 66; (3) Temperature Monitoring Wells = 92; and (4) EAB Wells = 31.

Installation of piping, fittings, instrumentation, and surface process systems follows the well installation. New surface process components are limited to liquid treatment. The tasks include,

1. Place process equipment for pre-treatment of extracted liquids ahead of the existing GWTP (e.g., heat exchangers, NAPL separators, NAPL storage tank, accumulation tank, and connecting pipes).
2. Place a propane storage tank (30,000 gallons).
3. Place a propane-fired steam generator and connect to propane tank.

Installation of the surface components for the enhanced aerobic biological system consist of placing two air compressors, installing pipe and instrumentation between the compressors and biosparging wells, and a control system for the air injection.

NAPL Recovery with Thermal Enhancements in the East and North

Remediation of the subsurface is initiated with the recovery of NAPL across the Site through the system of 92 extraction wells. NAPL and groundwater are extracted from each of these 4-inch diameter wells using pneumatically driven pumps. The wells and pumps are both compatible with subsequent thermal operations using steam injection and/or hot water. This NAPL recovery reduces the duration of subsequent treatment that relies upon NAPL dissolution and biological degradation for the majority of treatment.

Thermal enhancements are applied across the LNAPL and DNAPL areas following the initiation of NAPL recovery and EAB over the entire Site. The thermal enhancements make use of the existing NAPL recovery wells for extraction and inject “wet” steam through a system of injection wells installed in a pattern roughly approximate to a repeated seven-spot configuration with a 30-foot spacing between injection and extraction wells. Temperature monitoring wells are located among the injection and extraction wells.

Enhanced Biological Degradation

Throughout the target zones, EAB is applied as soon as practical and precedes thermal enhancements to NAPL recovery. EAB is applied using an array of air and amendment injection points and wells. Supplemental biosparging points and wells for amendment injection and monitoring provide injection points for air and nutrients to enhance aerobic biodegradation of contaminants throughout the Other Periphery areas.

3.3.7.4 Design Criteria and Basis for Approach

The following subsections present the detail design criteria and design basis for each of the key Alternative 7 components.

3.3.7.5 ISS of the Core Area

The design criteria and basis for ISS of the Core Area is similar to that described for Alternative 4.

3.3.7.6 NAPL Recovery and EAB

The estimated NAPL recovery during this step is similar to that described for Alternative 5.

The estimates for NAPL recovery within each target treatment volume are listed in **Table 3-7c** and assumes 100 percent recovery of the mobile NAPL (34 percent of the total NAPL) over the full term of the pumping effort (up to 8 years).

To achieve 100 percent recovery of mobile NAPL, thermal enhancement is anticipated and this heating also accelerates the biological degradation of dissolved contaminants.

The duration of initial heating for each target soil volume is listed in the **Table 3-7d**. As shown the entire non-ISS soil volume can be heated in about 14 months of continuous operation.

3.3.7.7 EAB – Other Periphery

Throughout thermal injection, air injection is performed through the same system of wells to encourage aerobic biodegradation. The groundwater extraction system continues operating to enhance mixing and dissolution and contaminant extraction. Air injection also enhances mixing and dissolution over groundwater pumping alone.

The calculated NAPL volumes characterized as residual and requiring dissolution and degradation or extraction are summarized in **Table 3-7b** for each target volume. Aerobic biodegradation can be more effective in larger volumes since more volume is available for microbes to inhabit. The primary variables governing degradation, beyond oxygen availability, are temperature and dissolution rates from residual NAPL. In general, the higher the NAPL saturation, the higher the dissolution rate because of larger contact area between water and NAPL. Equilibrium between the groundwater and NAPL cannot be assumed if degradation is relatively rapid. A common assumption for the bulk mass transfer at hydrocarbon NAPL sites under ambient conditions is 0.05 day^{-1} (Mobile et al., 2012). With the agitation provided by pumping and air injection, this value is assumed double for the feasibility in the East and North targets. The Other Periphery is assumed to be 0.05 day^{-1} as the NAPL content is lower. With an initial mass of NAPL, a system temperature, and a method to determine dissolution rates, persistence of NAPL components in groundwater can be estimated from with specification of a component's half-life in the groundwater. Under ambient conditions and temperatures, if sufficient oxygen is provided, the half-life of naphthalene in groundwater is typically about 30 days (Aronson et al., 1999). This value is assumed for the Wyckoff Site at a system temperature of 12 degrees Celsius (°C). Heating the subsurface to 40 °C, an increase of nearly 30, is expected to reduce the half-life by a factor of 4 in the presence of abundant oxygen. For the heated East and North targets, an aerobic naphthalene half-life of 7.5 days is assumed. In the Other Periphery, heating is not expected to be as intensive with an increase in temperature of only 10 °C yielding an aerobic half-life of 15 days for naphthalene as indicated in **Table 3-7e**. For naphthalene in groundwater, typical half-lives under ambient anaerobic conditions have been observed from 110 to 462 days with a recommended default value of 258 days (HydroGeoLogic, 1999). In the soil volume with no treatment, the half-life is assumed infinite with little impact on estimates as concentrations are initially low. Using these NAPL estimates and Site parameters, calculations of naphthalene persistence were calculated as described below.

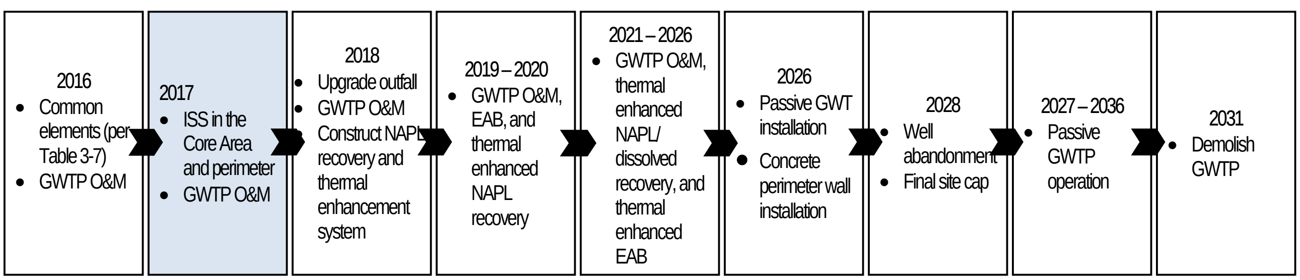
NAPL dissolution, oxygen distribution and diffusion, and reaction rates combine to determine the rate of aerobic degradation of dissolved contaminants. A simple, volume-averaged model was utilized to calculate the persistence of naphthalene in the Wyckoff target volumes listed in **Table 3-7e** using the parameters described above. The model is provided in **Appendix D** and combines the initial mass of NAPL, the NAPL composition, NAPL dissolution and component half lives in the groundwater at varying temperatures to estimate the reduction and persistence of naphthalene resulting from the active portion of Alternative 7.

The model calculations assume 8 years of groundwater extraction, biosparging and thermal enhancements concurrent with the NAPL recovery effort. The pertinent results are quantified in the last column of **Table 3-7e** by listing the estimated reduction in naphthalene loading to the passive groundwater treatment system resulting from the NAPL recovery and EAB effort following ISS in the Core. As indicated, all targets are expected to see reductions exceeding 90 percent except the East and North LNAPL targets where a larger initial mass of NAPL is estimated. However, combined with groundwater from other areas of the Site during entry to the PGTS, the overall reduction in naphthalene is approximated to be 96 percent. This reduction is expected to be sufficient to make operation of the PGTS viable. For a concentration reduction exceeding one order of magnitude, the usage of granular activated carbon in the PGTS is expected to be reduced by approximately one order of magnitude.

3.3.7.8 Implementation Sequence and Schedule

Implementing Alternative 7 would span approximately 9 years of sustained Site activity from initial design to the initiation of the passive groundwater treatment system.

The tentative sequence and duration of activities are summarized below:



3.3.7.9 Screening Evaluation

Screening of Alternative 7 – ISS of the Core Area and Thermal Enhanced Recovery against the criteria of effectiveness, implementability, and cost indicates that this alternative should be retained.

Alternative 7 is effective because it utilizes multiple treatment technologies, employing ISS and thermally enhanced NAPL recovery to address the highest concentration NAPL source material while using EAB to address areas where lower NAPL concentrations occur.

3.3.7.10 Cost Estimate

The total present worth cost for Alternative 7 is $85.2 million with a -30/+50 percent cost range of $59.6 million to $128 million. A breakout of total life cycle costs is provided in **Table 3-7a**.

SECTION 4

Detailed Analysis of Alternatives

This chapter presents the detailed analysis of remedial action alternatives described in Section 3.3 for the Wyckoff Soil and Groundwater OUs. The remedial action alternatives were evaluated against seven of the nine CERCLA criteria described in the NCP ("Remedial Investigation/Feasibility Study and Selection of Remedy," 40 CFR 300.430€[9]). The CERCLA evaluation criteria are described in **Table 4-1**, and each of the remedial action alternatives evaluated individually and comparatively against these criteria in Sections 4.2 and 4.3, respectively. The remaining two criteria, which are identified as modifying criteria, are formally assessed during preparation of the Proposed Plan (State Acceptance) and following review of public and stakeholder comments (Community Acceptance) on the Proposed Plan.

The detailed and comparative analysis of alternatives helps to develop the information necessary to recommend an alternative in this FFS and assist in identifying a preferred alternative in the Proposed Plan. Following public and stakeholder review of the Proposed Plan, EPA and Ecology would select a final remedial action alternative for the Soil and Groundwater OUs and identify the selected alternative in a CERCLA decision document.

4.1 Description of CERCLA Evaluation Criteria

The nine CERCLA evaluation criteria upon which the detailed and comparative evaluations are based are designed to enable the analysis of each alternative to address the statutory, technical, and policy considerations necessary for selecting a final remedial alternative. These evaluation criteria (**Table 4-1**) provide the framework for conducting the detailed analysis of alternatives and selecting an appropriate remedial action. The performance or acceptability of each alternative is first evaluated individually, so relative strengths and weaknesses may be identified (Section 4.2), and then comparatively (Section 4.3) to assess trade-offs and to aid in an alternative ranking.

The evaluation criteria are divided into three categories (threshold, balancing, and modifying) based on the function of each category in the remedy selection process. The NCP ("Remedial Investigation/ Feasibility Study and Selection of Remedy," 40 CFR 300.430[f]) states that the first two criteria—protection of HHE and compliance with ARARs—are "threshold criteria" that must be met by the selected remedial action unless a waiver can be granted under CERCLA ("Cleanup Standards," Section 121[d][4]).

The five "balancing criteria" represent technical considerations, upon which the detailed analysis is primarily based and include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume (TMV) through treatment; short-term effectiveness; implementability; and cost. The cost estimate details and supporting information are included in **Appendix C**. In assessing how well each alternative performs relative to the balancing criteria, the fraction of NAPL mass that is treated by each alternative is a key subfactor.

The final two criteria—State and Community Acceptance—are "modifying criteria." State Acceptance is formally assessed during preparation of the Proposed Plan, and Community Acceptance is formally assessed following review of Tribal Nations, public, and stakeholder comments on the Proposed Plan. Community and State Acceptance are not addressed in this FFS. Based on information from public participation, EPA and Ecology may modify some aspects of the preferred alternative or decide that another alternative is more appropriate.

4.2 Individual Analysis of Alternatives

This section evaluates each of the remedial action alternatives retained from the screening presented in Section 3.3 against the CERCLA threshold and balancing criteria described in **Table 4-1**. The evaluation results are presented in a narrative and tabular form. The tabular format also provides a pass (yes)/fail (no) determination for each threshold criteria and a rating for each of the balancing criteria. The rating is designed to assist with the comparative evaluation of alternates presented in Section 4.3 and identification of a recommended alternative in Chapter 5. The three rating factors used include the following:

★★★ = The alternative performs very well against the CERCLA balancing criterion with minimal disadvantages or uncertainties

★★☆ = The alternative performs moderately well against the CERCLA balancing criterion but with some disadvantages or uncertainties

★☆☆ = The alternative performs less well against the CERCLA balancing criterion with more disadvantages or uncertainty

4.2.1 Alternative 1—No Action

This alternative was developed per NCP requirements ("Remedial Investigation/Feasibility Study and Selection of Remedy," 40 CFR 300.430[e][6]) to provide a baseline for comparison to other alternatives. Alternative 1 – No Action represents a scenario where no access restrictions, ICs, or active remedial actions would be taken. Under this alternative, hydraulic containment pumping would cease in year 2015, and no further maintenance of access restrictions (fencing) or ICs would be performed. Absent hydraulic containment pumping, NAPL and dissolved-phase contaminants would migrate towards Eagle Harbor and Puget Sound resulting in potential for greater human and ecological receptor exposure to contaminants within the intertidal area.

Evaluation of Alternative 1 against the CERCLA threshold criteria (**Table 4-2**) indicates this alternative would not protect HHE nor would it comply with chemical-specific ARARS for protection of marine surface water quality. Because this alternative would not protect HHE nor comply with chemical-specific ARARS, it cannot be selected under CERCLA. Therefore, an evaluation against the CERCLA balancing criteria was not performed.

4.2.2 Alternative 2—Containment

Alternative 2 is the contingent remedy implemented under the 2000 ROD. This alternative is included in this FFS to satisfy the NCP requirement to develop a source control alternative that involves little or no treatment and protects HHE by preventing or controlling exposure to contaminants through engineering controls, and as necessary, ICs.

Evaluation of Alternative 2 against the CERCLA threshold criteria (**Table 4-3**) indicates this alternative would protect current and future human health by restricting land use and Upper Aquifer and Lower Aquifer groundwater use. Protection of HHE also would be achieved by operating the hydraulic containment system to reduce or prevent NAPL and dissolved-phase contaminant migration to Eagle Harbor and Puget Sound. Installing the soil cap and replacement sheet pile wall (common elements) would provide additional protection of HHE by placing barriers that protect against direct contact exposure and reduce contaminant flux to Eagle Harbor and Puget Sound. This alternative would comply with action and location-specific ARARs and is expected to comply with chemical-specific ARARs, defined by groundwater PRGs, at the point of compliance.

Relative to the CERCLA balancing criteria (**Table 4-3**), this alternative would perform less well for long-term effectiveness and permanence because 47 percent of the NAPL mass[8] is estimated to remain at the end of the 100-year O&M period. Additionally, while the adequacy and reliability of the containment measures would be good during the 100-year O&M period, this maintenance would be discontinued after 100 years; therefore, the reliability of these controls would decrease over time. Alternative 2 also would perform less

[8] All references to fraction of NAPL mass remaining or mass of NAPL treated are based on the use of naphthalene as a NAPL indicator.

well relative to the TMV reduction through treatment criteria due to the large mass of the NAPL source material that would remain at the end of the 100-year O&M period.

With respect to short-term effectiveness and implementability, Alternative 2 would perform moderately well because risks to the remedial action workers and community are low and the technologies associated with this alternative have been in use at the Site for 20 years. Because this alternative would maintain compliance with chemical-specific ARARs and RAOs only while the hydraulic containment system is in operation during the 100-year O&M timeframe it was rated lower for short-term effectiveness.

The total present worth cost of Alternative 2 is $70.6 million. Further cost information is shown in **Table 4-3**.

4.2.3 Alternative 3—Excavation, Thermal Desorption, and In Situ Chemical Oxidation

This alternative was screened out in Section 3.3 and not carried forward in the FFS. Therefore, a detailed evaluation of this alternative against the CERCLA criteria was not performed.

4.2.4 Alternative 4—In Situ Solidification/Stabilization

Alternative 4 addresses the NCP requirement to develop an alternative that treats the principal threat posed by the Site but varies in the degree of treatment and the characteristics of the treatment residuals. Under Alternative 4, NAPL present within all remedial action target zones (e.g., entire area enclosed by the TarGOST 10% RE) would be immobilized in situ within a cement – soil solid matrix. The cement concentration used to treat the perimeter of the NAPL source zone would be higher than used to treat the interior portion to create a hardened shell that would have a lower leachability and higher durability characteristic. Passive groundwater treatment is also a component of this alternative that may be implemented if post-ISS performance monitoring indicates it is necessary.

Evaluation of Alternative 4 against the CERCLA threshold criteria (**Table 4-4**) indicates this alternative would protect current human health by restricting land use and Upper Aquifer and Lower Aquifer groundwater use until RAOs are achieved. Protecting HHE in the future also would be achieved by immobilizing the NAPL, which reduces or eliminates its toxicity and mobility. The hardened shell would provide additional protection for the environment by entombing the NAPL in a leaching resistant matrix. Chemical-specific ARARs in marine surface water would be achieved by immobilizing the NAPL which reduces COC concentrations in FPA soil and groundwater to PRGs.

Relative to the CERCLA balancing criteria (**Table 4-4**), this alternative would perform very well for long-term effectiveness and permanence because 95 percent of the NAPL source material would be treated using the ISS technology. The NAPL-soil-cement monolith would have durability and low leachability, thus minimizing the need for long-term maintenance. The soil cap and bulkhead common elements would provide protection against erosion that could expose the ISS treated zone. Because RAOs would be achieved in a relatively short timeframe (estimated 12 years), with low risk to workers and the community, Alternative 4 would perform very well relative to the short-term effectiveness criteria. This alternative would perform moderately well for TMV reduction because the volume of NAPL source material would not be reduced but the mobility and leachability would be greatly reduced. This alternative also would perform moderately well for implementability due to size of the ISS treatment zone and geotechnical challenges associated with potential difficult drilling conditions that could slow remediation progress.

The total present worth cost of this alternative is $86.3 million. A detailed breakdown of costs is provided in **Table 4-4**.

4.2.5 Alternative 5—Thermal Enhanced Extraction and In Situ Solidification/Stabilization

This alternative addresses the NCP requirement to develop an alternative that removes or destroys contaminants to the maximum extent feasible, eliminating or minimizing, to the degree possible, the need for long-term management. Alternative 5 addresses the principal threat using thermal enhanced extraction to draw NAPL from the subsurface in the Core, North Shallow (LNAPL), and East Shallow (LNAPL) zones, and destroying the NAPL in an aboveground thermal oxidation unit. Thermal enhanced extraction would be preceded by up to 3 years of enhanced NAPL recovery to shorten the thermal treatment period. EAB would be used as a polishing technology in the thermally treated zones to biodegrade residual NAPL that may remain and in the Other Periphery target zone where NAPL is more disperse and present at lower concentrations. In the North Deep (DNAPL) zone, NAPL would be immobilized using ISS. Passive groundwater treatment also would be a component of this alternative that may be implemented if post-EAB performance monitoring indicates it is necessary.

Evaluating Alternative 5 against the CERCLA threshold criteria (**Table 4-5**) indicates that this alternative would protect current human health by restricting land use and Upper Aquifer and Lower Aquifer groundwater use. Protecting HHE in the future would be achieved by removing NAPL and treating the soil and groundwater to the PRGs that protect HHE. Chemical-specific ARARs in marine surface water would be achieved by reducing COC concentrations in FPA soil and groundwater to PRGs.

Relative to the CERCLA balancing criteria (**Table 4-5**), this alternative would perform very well for long-term effectiveness and permanence and TMV reduction through treatment because 86 percent of the NAPL source material would be treated using enhanced NAPL recovery/thermal enhanced extraction/EAB and 12 percent using ISS. By removing, immobilizing, and biodegrading NAPL, soil and groundwater PRGs would be achieved, eliminating the need for long-term Site management controls.

Alternative 5 would achieve RAOs within an estimated timeframe of approximately 30 years. During this period, there would be a significant level of daily activity associated with thermal treatment operations. This activity would pose increased risk to the workers and would be visible to the community. Therefore, Alternative 5 would perform only moderately well relative to the short-term effectiveness criteria. This alternative also performs moderately well for implementability due to scale of thermal treatment operations, which requires a significant level of infrastructure and O&M resources and skilled operators.

The total present worth cost of this alternative is $134.1 million. A detailed breakdown of costs is provided in **Table 4-5**.

4.2.6 Alternative 6—Excavation/Thermal Desorption and Thermal Enhanced Extraction

Alternative 6, like Alternative 5, addresses the NCP requirement to develop an alternative that removes or destroys contaminants to the maximum extent feasible, eliminating or minimizing, to the degree possible, the need for long-term management. However, Alternative 6 would utilize excavation and thermal desorption in lieu of thermal enhanced extraction to address the NAPL-contaminated material present in the Upper (e.g., top 20 feet) Core Area. By using sheet pile wall to subdivide the Upper Core Area into three smaller cells, and dewatering each cell to dry the material before excavation, Alternative 6 would be expected to achieve a higher level of treatment in the Upper Core Area than the other alternatives. Unfortunately, the full benefit of the excavation and thermal desorption technology would not be realized under this alternative because most NAPL present in the Core Area lies at depths below 20 feet. As discussed previously in Section 3.3, excavation at depths greater than 20 feet is not technically practicable given Site conditions.

Like Alternative 5, Alternative 6 would use thermal enhanced extraction, preceded by up to 3 years of enhanced NAPL recovery, to draw NAPL from the Lower Core Area, and the North Shallow (LNAPL) and East Shallow (LNAPL) zones; destroying the NAPL in an aboveground thermal oxidation unit. Alternative 6 also would use thermal enhanced extraction to remove NAPL from the North Deep (DNAPL) zone. EAB would be used as a polishing technology, following thermal treatment, to biodegrade residual NAPL that may remain and in the Other Periphery target zone where NAPL is more disperse and present at lower concentrations. Passive groundwater treatment also would be a component of this alternative that may be implemented if post-EAB performance monitoring indicates it is necessary.

Evaluation of Alternative 6 against the CERCLA threshold criteria (**Table 4-6**) indicates this alternative would protect current human health by restricting land use and Upper Aquifer and Lower Aquifer groundwater use. Protecting HHE in the future would be achieved by removing NAPL and treating the soil and groundwater to reduce COC concentrations to PRGs that are protective of HHE. Chemical-specific ARARs in marine surface water would be achieved by reducing COC concentrations in FPA soil and groundwater to PRGs.

Relative to the CERCLA balancing criteria (**Table 4-6**), Alternative 6 performs moderately well for long-term effectiveness and permanence and reduction of TMV because only 14 percent of the NAPL source material would be treated using excavation/thermal desorption and 64 percent treated using enhanced NAPL recovery and thermal enhanced extraction, respectively. The remaining fraction would be treated using EAB, which may place more dependence on long-term Site controls if EAB treatment rates are lower than estimated. Relative to short-term effectiveness, Alternative 6 would perform moderately well. Although excavation and thermal desorption activities unlikely would pose a risk to the community, the remedial action would create noise, light, and atmospheric discharges that would be visible to the community. Additionally, the thermal desorption equipment would be housed in an enclosed building resulting in a temporary visible impact. Excavation to depths of 20 feet and handling of high temperature steam, vapor, and fluids may also pose increased risk to workers. The time required to achieve RAOs of 28 years would be greater than Alternatives 4 and 5, which justifies a moderately well rating for the short-term effectiveness criteria.

Alternative 6 would perform moderately well for implementability due to its overall technical complexity and the magnitude of resources needed for full implementation.

4.2.7 Alternative 7— In Situ Solidification/Stabilization of Core Area and Thermal Enhanced Extraction

Alternative 7 merges the key technologies of ISS from Alternative 4 and thermal enhanced extraction and EAB from Alternative 5 into a standalone option. Under this alternative, ISS would be used to treat the Core Area and the FPA periphery, where 44 percent of the NAPL mass occurs. This action would be coupled with thermal enhanced extraction used to treat the East Shallow (LNAPL), North Shallow (LNAPL), and North Deep (DNAPL) zones in an adaptive management approach. If it is shown that the RAOs could be met with only ISS, then the thermal enhanced extraction would not be implemented. Passive groundwater treatment also would be a component of this alternative and would be implemented with ISS.

Thermal enhanced extraction would be preceded by enhanced NAPL recovery and followed by EAB, which would be used as a polishing technology to biodegrade residual NAPL that may remain and in the Other Periphery target zone where NAPL is more disperse and present at lower concentrations.

Evaluation of Alternative 7 against the CERCLA threshold criteria (**Table 4-7**) indicates this alternative would protect current human health by restricting land use and Upper Aquifer and Lower Aquifer groundwater use until RAOs are achieved. Protecting HHE in the future would be achieved by immobilizing NAPL present in the Core Area and the FPA periphery, thereby reducing its toxicity and mobility, and thermally destroying (e.g., off-Site incineration) NAPL recovered from the East Shallow (LNAPL), North Shallow (LNAPL), and North Deep (DNAPL) zones. Chemical-specific ARARs in marine surface water would be achieved by immobilizing and removing NAPL to reduce COC concentrations in FPA soil and groundwater to PRGs.

Relative to the CERCLA balancing criteria (**Table 4-7**), this alternative would performs very well for long-term effectiveness and permanence and TMV reduction through treatment because 37 percent of the NAPL source material is treated using ISS and 63 percent treated using the enhanced NAPL recovery/thermally enhanced extraction/EAB pairing. Within the Core Area, and around the perimeter of the FPA, the NAPL-soil-cement monolith would have durability and low leachability, thus minimizing the need for long-term maintenance. The soil cap would provide protection against surface erosion that could potentially expose the ISS treated zone. Using the adaptive management approach in the remaining target zones, thermal enhanced extraction and thermal destruction of the NAPL, coupled with enhanced NAPL recovery and EAB, would remove the remaining NAPL minimizing or eliminating the need for long-term Site controls if needed to meet the RAOs.

Relative to the CERCLA balancing criteria of short-term effectiveness and implementability, Alternative 7 would perform moderately well for the reasons similar to those described for Alternatives 4 and 5. One notable distinction for Alternative 7 is its ability to achieve RAOs with less reliance on the need for passive groundwater treatment.

The total present worth cost of this alternative is $85.2 million. A detailed breakdown of costs is provided in **Table 4-7**.

4.3 Comparative Analysis of Remedial Alternatives

This section summarizes the comparative analysis of alternatives, which is designed to assess the advantages and disadvantages of each alternative relative to one another to identify key tradeoffs that should be noted during remedy selection. The comparative evaluation is summarized in **Table 4-8**.

4.3.1 Overall Protection of Human Health and the Environment

All of the alternatives, except Alternative 1 – No Action, would protect current human health by restricting land and groundwater use.

Alternatives 4 through 7 would protect HHE in the future by treating NAPL source material to reduce COC concentrations in soil and groundwater to PRGs. Alternative 2 would protect HHE in the future by reducing or eliminating NAPL and dissolved-phase plume migration, reducing COC concentrations in groundwater, and installing a soil cap across the FPA to provide a barrier against direct contact with contaminated soil.

4.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternatives 4 through 7 would achieve chemical-specific ARARs in the intertidal area within timeframes that are estimated to be near 8 years for Alternative 7, 10 years for Alternative 5, 12 years for Alternative 4, and 23 years for Alternative 6. Alternative 2 would comply with chemical-specific ARARs while the hydraulic containment system remains in operation, but there is some uncertainty on whether compliance would be maintained if the system is turned off after 100 years. All alternatives except Alternative 1 – No Action would be designed and operated to comply with action and location-specific ARARs.

4.3.3 Long-Term Effectiveness and Permanence

The balancing criterion of long-term effectiveness and permanence considers the following: (1) magnitude of residual risk from untreated waste or treatment residuals remaining at the conclusion of the remedial activities, and the (2) adequacy and reliability of controls such as containment systems and ICs that are necessary to manage treatment residuals and untreated waste. With respect to this criterion, Alternatives 4, 5 and 7 were rated as performing very well, while Alternative 6 was rated as performing moderately well and Alternative 2 less well.

Under Alternative 4, 100 percent of the NAPL source material would be treated using the ISS technology, while in Alternatives 5 and 7, ISS would be used to treat 12 and 37 percent of the NAPL source material, respectively, with the balance of the treatment performed using enhanced NAPL recovery/thermal enhanced extraction/EAB. 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 direct contact and overall treatment. Alternatives 5 and 7 would rely on enhanced NAPL extraction and thermal enhanced extraction to remove the NAPL and EAB to biodegrade any residual NAPL. All three of these technologies would be influenced by subsurface heterogeneities that control transport pathways, which could result in untreated or partially treated zones. Therefore, while Alternatives 4, 5, and 7 were rated as performing very well, Alternative 4 is expected to perform superior followed by Alternative 7 and Alternative 5.

Alternative 6 was rated as performing moderately well primarily because there would be greater reliance on EAB following the thermal treatment step. The performance of the EAB technology in this FFS is judged based on its ability to biodegrade naphthalene. The other LPAHs, and high-molecular weight PAHs (HPAHs), do not biodegrade as easily as naphthalene, therefore, other PAHs could persist, even though most of the naphthalene has been degraded. Alternative 2 was rated lowest because it is estimated that 47 percent of the NAPL source material would remain untreated at the end of the 100-year O&M timeframe.

4.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This balancing criterion assesses the degree to which an alternative employs recycling or treatment to reduce TMV, specifically the following:

- The treatment or recycling processes used and materials they would treat
- The amount of hazardous substances that would be destroyed, treated, or recycled
- The degree of expected reduction in TMV of the waste due to treatment or recycling and the specification of which reduction(s) are occurring
- The degree to which the treatment is irreversible
- The type and quantity of residuals that would remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents
- The degree to which treatment reduces the inherent hazards posed by principal threats at the Site.

With respect to this criterion, Alternatives 5 and 7 were rated as performing very well, while Alternatives 4 and 6 were rated as performing moderately well and Alternative 2 as less well.

Alternatives 5 and 7 were rated higher because thermal enhanced extraction, in combination with enhanced NAPL recovery and EAB, would result in a high level of NAPL TMV reduction, including thermal destruction of NAPL brought to the surface. While Alternative 6 also includes a major thermal enhanced extraction component because there is more reliance on EAB, it was rated lower than Alternatives 5 and 7. Alternative 4 was also rated lower because, while it would reduce NAPL toxicity and mobility, it would not reduce volume of contaminants contained in NAPL impacted soil. Additionally, although ISS treatment is considered irreversible, there is no performance data to show that the ISS columns can hold up for multigenerational timeframes. Alternative 2 was rated lowest due to the large volume of NAPL that would remain at the end of the 100-year O&M period.

4.3.5 Short-Term Effectiveness

This balancing criterion considers the following:

- Short-term risks that might be posed to the community during implementation of an alternative
- Potential impacts on workers during remedial action and the effectiveness/reliability of protective measures
- Potential environmental impacts of the remedial action and the effectiveness/reliability of mitigation measures during implementation
- Time until protection is achieved

With respect to this criterion, Alternative 4 was rated as performing very well, while Alternatives 2, 5, 6, and 7 were rated as performing moderately well. Alternative 4 was rated higher because the ISS treatment phase would be completed within an approximate 2-year timeframe, whereas under Alternatives 5, 6, and 7 thermal treatment would continue for 8 or more years resulting in long-term visibility to the community, greater risk to workers, and increased potential for environmental impacts. Alternative 2 was rated similar to Alternatives 5, 6, and 7 because, even though O&M continues for 100 years, the level of activity would be significantly lower with less community visibility and risk to workers and the environment.

Alternatives 4, 5, and 7 have remedial action timeframes that range from about 8 to 16 years, while Alternative 6 is estimated to require about 23 years. Alternative 2 is not expected to achieve RAOs within the 100-year O&M timeframe specified in this FFS.

4.3.6 Implementability

This balancing criterion considers the ease or difficulty of implementing an alternative including the following as appropriate:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy
- Administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-Site actions)
- Availability of services and materials, including the availability of adequate off-Site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and availability of prospective technologies

With respect to this criterion, all alternatives were rated as performing moderately well, with each alternative posing its own unique set of technical challenges. For Alternative 2, the primary implementation challenge would be the overall O&M timeframe of 100 years, which would require replacing extraction wells and portions of the GWTP every 30 years, and long-term staffing, off-Site NAPL disposal, and off-Site GAC media changeout commitments. For Alternative 4, the primary implementation challenge would be the scale of ISS treatment, which 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 type of equipment, therefore, treatment rates could be slower than initially estimated. For Alternatives 5, 6, and 7, the overall complexity of enhanced NAPL recovery, thermal enhanced extraction, and EAB in terms of the number of wells, piping, treatment equipment, and sequencing of each phase across the Site would pose significant implementation challenges.

4.3.7 Cost

As described previously in **Table 4-1**, the remedial action alternative cost estimates include allowances for the following:

- Common elements, including the items listed in **Table 3-1**
- Capital costs, including costs for construction of the key technology components
- Annual O&M costs, including costs for operation of the key technology components
- Periodic costs, including costs for nonrecurring items like equipment replacement

The total present worth cost (**Table 4-9**) for the alternatives ranges from $86.3 million for Alternative 2 to $185.7 million for Alternative 6. Although cost sensitivity analysis was not specifically performed for this FFS, Alternatives 4 and 5 were evaluated to assess the sensitivity of the present worth cost if capital cost expenditures were limited to a maximum of $15 million per year. These two variations of Alternatives 4 and 5 are shown as Alternative 4a and Alternative 5a, respectively, on **Table 4-8**. Limiting capital costs to $15 million per year increases the present worth cost of Alternative 4 from $86.3 million to $91.4 million while decreasing the cost of Alternative 5 from $134.1 million to $130.8 million.

Remedial action alternative costs were also compared by developing a 25-year cash-flow projection for each alternative; although some alternatives incur costs for more than 25 years (Alternative 2 at 100 years, Alternative 5 at 29 years, Alternative 5a at 32 years, and Alternative 6 at 29 years) and others costs for less than 25 years (Alternative 4 at 12 years, Alternative 4a at 15 years, and Alternative 7 at 22 years). The cost flow projections are presented on **Figure 4-1**.

SECTION 5

Recommended Alternative

Due to a shorter estimated timeframe to achieve RAOs (see Exhibit ES-2), and a lower level of long-term Site management, Alternative 4 was initially identified during stakeholder discussions as the recommended alternative. Further, EPA and Ecology discussions are planned, and a presentation to the National Remedy Review Board may result in a different recommended alternative or identification of new technology combinations and new alternatives. Selection of the final alternative will occur in a CERCLA decision document following completion of the public participation process.

SECTION 6

References

American Petroleum Institute. 2001. *Methods for Determining Inputs to Environmental Petroleum Hydrocarbon Mobility and Recovery Models, Regulatory and Scientific Affairs*. API Publication No. 4711. July.

Bedient, P.B., A.C. Rodgers, T.C. Bouvette, M.B. Tomson, T.H. Wang. 1984. "Groundwater Quality at a Creosote Waste Site." *Ground Water*, 22:318–329.

CH2M HILL. 1997. *Feasibility Study, Wyckoff Soil and Groundwater Operable Units, Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington*. Prepared for U.S. Environmental Protection Agency, Region 10. June.

CH2M HILL. 2004. *Geotechnical Data Report, Borings and Piezometer Installation-Upgradient Cut-off Wall, Wyckoff/Eagle Harbor Superfund Site.* Prepared for U.S. Environmental Protection Agency, Region 10. September.

CH2M HILL. 2012. *Initial Work Plan, Revision 1, Wyckoff Groundwater and Soils Operable Units.* Prepared for U.S. Environmental Protection Agency, Region 10. April.

CH2M HILL. 2013a. *Groundwater Conceptual Site Model Update Report for the Former Process Area, Wyckoff/Eagle Harbor Superfund Site, Soil and Groundwater Operable Units*. Prepared for U.S. Environmental Protection Agency, Region 10. October.

CH2M HILL. 2013b. *Wyckoff Sheet Pile Wall – Nonaqueous Phase Liquid and Plume Migration Barrier Effectiveness Evaluation.* Prepared for U.S. Environmental Protection Agency, Region 10. December.

CH2M HILL. 2013c. *2013 Wyckoff Upland NAPL Field Investigation Technical Memorandum Field Summary Report*. June. Prepared for U.S. Environmental Protection Agency, Region 10. June.

CH2M HILL. 2013d. *Technical Memorandum - Groundwater Quality Sampling Results for Wyckoff/Eagle Harbor Superfund Site—June 2012.* Prepared for U.S. Environmental Protection Agency, Region 10. January.

CH2M HILL. 2014a. *Wyckoff/Eagle Harbor Soil and Groundwater Operable Units Focused Feasibility Study - Remedial Technology Screening and Preliminary Remedial Action Alternatives Technical Memorandum*. Prepared for U.S. Environmental Protection Agency, Region 10. February 5.

CH2M HILL. 2014b. *2014 Conceptual Site Model Update for OU2 and OU4 Former Process Area*. Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington. Prepared for U.S. Environmental Protection Agency, Region 10. February.

Federal Remediation Technologies Roundtable (FRTR). 2010. *Federal Remediation Technologies Roundtable*. http://www.frtr.gov.

Forsey, S.P. 2004, "In situ Chemical Oxidation of Creosote/Coal Tar Residuals: Experimental and Numerical Investigation." Ph.D., University of Waterloo, IA.

Frans, L.M., M.P. Bachmann, S.S. Sumioka, and T.D. Olsen. 2011, *Conceptual model and numerical simulation of the groundwater-flow system of Bainbridge Island*, Washington: U.S. Geological Survey Scientific Investigations Report 2011–5021, 96 p.

Haselow, J.S., R.L. Siegrist, M. Crimi, and T. Jarosch. 2003. "Estimating the Total Oxidant Demand for In Situ Chemical Oxidation Design." *Remediation* Autumn 2003.

Interstate Technology and Regulatory Council (ITRC). 2009. *Interstate Technology and Regulatory Council*. http://www.ITRCweb.org.

Interstate Technology and Regulatory Council (ITRC). 2011. *Development of Performance Specifications for Solidification/Stabilization*. July.

Liao, X., D. Zhao and X. Yan. 2011. "Determination of potassium permanganate demand variation with depth for oxidation–remediation of soils from a PAHs-contaminated coking plant." *Journal of Hazardous Materials*, Volume 193, 15 October 2011, Pages 164-170.

McDade, J.M., T.M. McGuire, and C.J. Newell. 2005. *Analysis of DNAPL Source Zone Depletion Costs at 36 Field Sites*.

Snider, Floyd I. 2013. *Wyckoff Eagle Harbor Superfund Site – OUs 2 and 4 DRAFT Remedial Action Objective Meeting Minutes*. June.

United States Army Corps of Engineers (USACE). 1998. *Onshore Field Investigation Report for the Barrier Wall Design Project, Wyckoff Groundwater Operable Unit.* Report prepared for USEPA. January.

United States Army Corps of Engineers (USACE). 1998. *Offshore Field Investigation Report for the Barrier Wall Design Project, Wyckoff Groundwater Operable Unit.* Report prepared for USEPA. April.

United States Army Corps of Engineers (USACE). 2000. *Comprehensive Report, Wyckoff NAPL Field Exploration, Soil and Groundwater Operable Units, Wyckoff/Eagle Harbor Superfund Site, Bainbridge, Island, WA*. May.

United States Army Corps of Engineers (USACE). 2005. *Thermal Remediation Pilot Study Summary Report, Wyckoff/Eagle harbor Superfund Site, Soil and Groundwater Operable Units.* Prepared for U.S. Environmental Protection Agency, Region 10. April.

United States Army Corps of Engineers (USACE). 2006. *Thermal Remediation Pilot Study Summary Report, Revision 3.0, Wyckoff/Eagle Harbor Superfund Site, Soil and Groundwater Operable Units.* Report prepared for USEPA. October.

U.S. Environmental Protection Agency (EPA). 1986. *Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy.* Final Draft. WH-560G. Available at http://www.epa.gov/epawaste/hazard/correctiveaction/resources/guidance/gw/gwclass.htm. U.S. Environmental Protection Agency, Office of Groundwater Protection. December.

U.S. Environmental Protection Agency (EPA). 1988b. *CERCLA Compliance with Other Laws Manual: Interim Final*. EPA/540/G-89/006. Available at http://www.epa.gov/superfund/policy/remedy/pdfs/540g-89006-s.pdf. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. August.

U.S. Environmental Protection Agency (EPA). 1988a. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* EPA/540/G-89/004. OSWER Directive 9355.3-01. Available at http://www.epa.gov/superfund/policy/remedy/pdfs/540g-89004-s.pdf. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. October.

U.S. Environmental Protection Agency (EPA). 1989a. *CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes and State Requirements.* EPA/540/G-89/009. OSWER Directive 9234.1-02. Available at http://www.epa.gov/superfund/policy/remedy/pdfs/540g-89009-s.pdf. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. August.

U.S. Environmental Protection Agency (EPA). 1989b. *The Feasibility Study Development and Screening of Remedial Action Alternatives.* Directive 9355.3-01FS3. Available at http://www.epa.gov/superfund/policy/remedy/pdfs/93-55301fs3-s.pdf. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. November.

U.S. Environmental Protection Agency (EPA). 1991. *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites.* EPA/540/G-91/001. Available at http://www.epa.gov/superfund/policy/remedy/pdfs/540p-91001-s.pdf. U.S. Environmental Protection Agency, Office of Emergency Remedial Response. February.

U.S. Environmental Protection Agency (EPA). 1991. *A Guide to Principal Threat and Low Level Wastes*. Quick Reference Fact Sheet. OSWER Publication 9380.3-06FS. Available at http://www.epa.gov/superfund/health/conmedia/gwdocs/pdfs/threat.pdf. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. November.

U.S. Environmental Protection Agency (EPA). 1995. *Presumptive Remedies for Soils, Sediments, and Sludges at Wood Treater Sites*. EPA/540/R-95/128. OSWER Directive 9200.5-162. Available at http://www.epa.gov/superfund/policy/remedy/presump/wood/wodtreat.pdf. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. December.

U.S. Environmental Protection Agency (EPA). 1996a*. EPA Superfund Record of Decision Amendment: Wyckoff/Eagle Harbor (West Harbor Operable Unit), WA*. EPA ID: WAD009248295. Report No. EPA/AMD/R10-96/131. Available at http://cfpub.epa.gov/ols/catalog/advanced_brief_record.cfm?&FIELD1=SUBJECT&INPUT1=Remedial%20Action&TYPE1=EXACT&LOGIC1=AND&COLL=&SORT_TYPE=MTIC&item_count=3501. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response.

U.S. Environmental Protection Agency (EPA). 1996b. *A Citizen's Guide to Thermal Desorption.* EPA/542/F-96/005). Available at http://www.clu-in.org/download/remed/thermdsp.pdf. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. April.

U.S. Environmental Protection Agency (EPA). 1999a. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites.* OSWER Directive 9200.4-17P. Available at http://www.epa.gov/oust/directiv/d9200417.pdf. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. April 21.

U.S. Environmental Protection Agency (EPA). 1999b. *Aerobic Biodegradation Rates of Organic Chemicals Field and Laboratory Studies*.

U.S. Environmental Protection Agency (EPA). 2000a*. Superfund Record of Decision: Wyckoff Co./Eagle Harbor EPA ID WAD009248295, OU 02, 04, Bainbridge Island, WA*. EPA/ROD/R10-00-047. Available at http://www.epa.gov/superfund/sites/rods/fulltext/r1000047.pdf**.** February.

U.S. Environmental Protection Agency (EPA). 2000b. *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study*. EPA 540-R-00-002. OWSER 9355.0-75. Available at http://www.epa.gov/superfund/policy/remedy/pdfs/finaldoc.pdf. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. July.

Washington State Department of Ecology (Ecology). 2010. The *Wyckoff Point, Bainbridge Island Washington, Generational Remedy Evaluation.* Prepared by Floyd | Snider and Aspect Consulting, Seattle, Washington. Prepared for Washington State Department of Ecology, Olympia, Washington. Available at https://fortress.wa.gov/ecy/gsp/Sitepage.aspx?csid=2683. August.

White House. 1992. *Guidelines and Discount Rates for Benefit Cost Analysis of Federal Programs*. OMB Circular A-94. Revised June 2014. Available at http://www.whitehouse.gov/omb/circulars_a094. The White House, Office of Management and Budget.

Tables

TABLE 1-1
Chronology of Soil and Groundwater OUs Investigation and Remediation Activities
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Approximate Date	Activity
1971	Environmental investigation begins at the Site in response to report of oil observed on the beach.
August 1984	EPA issues a Consent Order requiring Wyckoff Company (renamed Pacific Sound Resources) to conduct environmental investigations.
July 1987	Wyckoff site listed on Superfund NPL.
July 1988	Wyckoff Company ordered by EPA to install groundwater pump-and-treat system to halt continuing release of wood treatment contaminants to Eagle Harbor.
December 1988	Wyckoff Company ceases wood-preserving operations.
January 1990	Groundwater pump-and-treat system begins operation.
June 1992 - April 1994	EPA conducts time-critical removal action that removed approximately 29,000 tons of creosote sludges; disposed of 100,000 gallons of contaminated oils; disposed of 430 cubic yards of asbestos; installed 300 feet of sheet piling; repaired and constructed 150 feet of bulkhead; and recycled 660 long tons of steel from onsite structures.
1993	EPA assumes control of the Site and the pump-and-treat system. Inspection reveals the system is in state of disrepair.
1994	Consent Decree creates PSR Environmental Trust to partially fund investigation and cleanup costs.
July 1994	Focused RI/FS completed for the Groundwater OU (OU4).
September 1994	EPA issued an Interim ROD for the Groundwater OU that included the following elements: 1) replacing the existing groundwater treatment plant, 2) evaluate, maintain, and upgrade the existing extraction system 3) installation of a physical barrier (i.e. slurry wall) to prevent further releases of contaminants to Eagle Harbor and Puget Sound, and 4) plugging and abandonment of onsite water supply wells.
November 1994	EPA and Ecology sign the SSC for the interim groundwater remedy.
January - June 1995	EPA sealed and abandoned 12 on-site production wells.
June - December 1995	The seven original extraction wells were replaced by eight new extraction wells. Other plant upgrades were also made.
January - June 1996	A non-time-critical removal action was conducted in the FPA. Site structures were demolished, and debris was removed and disposed of offsite.
November 1997	Removal of some upland subsurface structures, such as process piping, utility lines, foundations, concrete pads, and asphaltic concrete completed.
November 1997	Soil and Groundwater OU Proposed Plan issued. Containment identified as the preferred cleanup strategy for soil and groundwater.
July 1998	EPA completed the design for the replacement groundwater treatment plant but it was not constructed pending a final decision on the groundwater remedy.
	EPA presented the results of the thermal technologies evaluation activities and proposed a new remedy for the removal of contaminants in soil and groundwater at the Wyckoff Site to the NRRB.

TABLE 1-1
Chronology of Soil and Groundwater OUs Investigation and Remediation Activities
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Approximate Date	Activity
1998-1999	Long-term O&M associated with the containment strategy were of concern to Ecology. Therefore, EPA evaluated thermal technologies for possible application at the Wyckoff Site, conducting laboratory studies, meeting several times with the ITTAP, and evaluating the results of various other thermal technologies studies and site demonstrations.
April 1999	Focused Feasibility Study Comparative Analysis of Containment and Thermal Technologies completed.
September 1999	Conceptual design for thermal remediation of Soil and Groundwater OU completed. Second Proposed Plan issued for Soil and Groundwater OUs.
January 2000	Approximately 88,700 gallons of NAPL recovered and 316 million gallons of contaminated groundwater treated to date.
February 2000	EPA issued the ROD for the Wyckoff Soil and Groundwater OUs, conditionally selecting steam injection as the cleanup remedy. Components of this remedy included: 1) constructing a sheet pile wall around the highly contaminated zone of the FPA; 2) conducting a pilot study to test the applicability and effectiveness of steam injection; 3) consolidating hotspots from the Former Log Storage/Peeler Area to the FPA; 4) monitoring the lower-aquifer groundwater; and 5) implementing institutional controls.
May 2000	EPA and Ecology sign SSC for the Soil and Groundwater OUs.
February 2001	Over 1,800 lineal feet of sheet pile installed around the FPA (two acres of beach were created to mitigate habitat loss) and over 530 lineal feet of sheet pile was installed within a one-acre area of the site for the steam injection pilot.
February 2002	In the stem injection pilot area, a vapor cap, 16 injection wells, and seven extraction wells were installed. Approximately 600 thermal monitoring devices, a boiler building, and production well were also installed. Soil cleanup of the Former Log Storage/Peeler Area was completed.
September 2002	Modifications of the treatment system were made and the boiler system was installed, including water softeners, heat exchangers, a thermal oxidizer, compressors, pumps, and balance of plant equipment.
October 2002 – April 2003	Steam pilot conducted. Operation reached approximately 25 percent capacity with approximately 50 percent up-time. Groundwater extraction in the FPA continued during the steam pilot.
April 2004	Soils and Groundwater OU Contingent Containment Remedy implemented.
September 2004	An upgradient cutoff wall soil and groundwater investigation was completed.
February 2006	Soil and Groundwater OU property sold to the City of Bainbridge.
October 2006	Thermal Remediation Pilot Study Summary Report completed.
March 2007	Construction contract for the replacement groundwater treatment plant awarded.
April 2010	Replacement GWTP construction complete and online.
Summer 2011	Old GWTP demolished.
April 2012	SSC signed with Ecology. Ecology takes over operation and maintenance of groundwater treatment plant until April 2014. EPA agrees to conduct FFS to evaluate additional source removal options for the Soils and Groundwater OUs.

TABLE 1-1
Chronology of Soil and Groundwater OUs Investigation and Remediation Activities
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Approximate Date	Activity
May 2012	Soil and Groundwater OU FFS begins. The FFS was preceded by a comprehensive investigation using the TarGOST technology to delineate NAPL distribution within the FPA. The TarGOST investigation results were used to define the areas to be addressed in the FFS.

Notes:

Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FFS	focused feasibility study
FPA	Former Process Area
FS	feasibility study
GWTP	groundwater treatment plant
IITTAP	In-situ Thermal Technologies Advisory Panel
NAPL	non-aqueous phase liquid
NPL	National Priority List
NRRB	National Remedy Review Board
O&M	operations and maintenance
OU	operable unit
RI	remedial investigation
ROD	Record of Decision
SSC	State Superfund Contract
TarGOST	Tar-specific green optical screening tool

TABLE 1-2

Volume Estimates of NAPL-Contaminated Soil and NAPL Present in the Upper Aquifer

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Compartments and Remedial Action Target Zones	Total Sampled Soil Volume (CY)	NAPL-Contaminated Soil Volume (NCY)	Volume Estimate of NAPL Present (gallons)	NAPL Concentration (gallons per NCY)
Upper Aquifer	**755,000**	**109,000**	**679,000**	**6.2**
Compartment 1	383,000	56,600	302,000	5.3
Compartment 2	199,000	24,800	128,000	5.2
Compartment 3	173,000	27,700	249,000	9.0
Core Area	**106,000**	**38,700**	**302,000**	**7.8**
East Shallow (LNAPL)	277,000	43,200	208,000	4.8
North Deep (DNAPL)	109,000	14,300	87,000	6.1
Other Periphery	44,000	4,300	33,100	7.7
North Shallow (LNAPL)	49,200	4,700	29,700	6.3
North Shallow and North Deep (Overlap of LNAPL and DNAPL Areas)[a]	45,800	3,400	18,400	5.4
No Treatment	**125,000**	**400**	**1,000**	**2.5**

[a] North Shallow and Deep is an overlap area encompassing zones from the LNAPL and DNAPL Areas, and is not called out as a separate target zone except in this table. For the purposes of remedial action alternative development and the detailed evaluation of alternatives, 50 percent of this volume (9,200 gallons) was allocated to the North Shallow (LNAPL) and 50 percent (9,200) to the North Deep (DNAPL) remedial action target zones.

CY cubic yards
DNAPL dense non-aqueous phase liquid
FFS focused feasibility study
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
NCY NAPL cubic yards
OU operable unit

TABLE 2-1
Wyckoff Soil and Groundwater OUs Remedial Action Objectives
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Narrative Objective	PRGs
1. Prevent human health risks associated with direct contact, ingestion or inhalation of shallow soil contaminated above levels for unrestricted outdoor recreational use.	MTCA Method B – Unrestricted Use (see Table 2-2)
2. Prevent use of upper aquifer groundwater for drinking water, irrigation, or industrial purposes which would result in unacceptable risks to human health.	Not applicable [1]
3. Prevent discharge of contaminated upper aquifer groundwater to Eagle Harbor and Puget Sound resulting in surface water contaminant concentrations exceeding the levels protective of beach play, aquatic life, and human consumption of resident fish and shellfish.	Marine AWQC adjusted upward to account for dilution – attenuation [2] (see Table 2-3)
4. Restore the lower aquifer to beneficial use within a reasonable timeframe. Prevent use of lower aquifer groundwater which would result in unacceptable risk to human health until restoration goals are met.	MTCA groundwater or MCLs [3] (see Table 2-4)

Notes:

[1] It is assumed that institutional controls will remain in place to permanently prohibit withdrawal of upper aquifer groundwater for drinking water, irrigation, or other beneficial uses.

[2] Per the MTCA, where groundwater highest beneficial use is discharge to surface water, the point of compliance is at the point of discharge. Proposed monitoring locations and numeric criteria are presented in this FFS and based on previous modeling.

[3] It is assumed that institutional controls will remain in place during the restoration timeframe to prohibit withdrawal of lower aquifer groundwater for drinking water, irrigation, or other beneficial uses.

AWQC ambient water quality control
FFS focused feasibility statement
MCL maximum contaminant level
MTCA Model Toxics Control Act
NAPL non-aqueous phase liquid
OU operable unit
PRG preliminary remediation goal

TABLE 2-2
Soil Preliminary Remediation Goals – Protection of Human Health Only
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
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)**	**For Comparison Only OU1 Sediment PRG (mg/kg)**
Naphthalene	3,200	1,600 (nc)	0.099
Acenaphthylene	Not specified	Not specified	0.066
Acenaphthene	4,800	4,800 (nc)	0.016
Fluorene	3,200	3,200 (nc)	0.023
Phenanthrene	Not specified		0.100
Anthracene	24,000	24,000 (nc)	0.220
Fluoranthene	3,200	3.200 (nc)	0.160
Pyrene	2,400	2,400 (nc)	1.0
Benz(a)anthracene	0.137	1.37 (c)	0.11
Chrysene	0.137	137 (c)	0.11
Benzo(b)fluoranthene	0.137	1.37 (c)	0.23
Benzo(k)fluoranthene	0.137	137 (c)	
Benzo(a)pyrene	0.137	0.137 (c)	0.099
Indeno(1,2,3 c,d) Pyrene	0.137	1.37 (c)	0.034
Dibenzo (a,h) Anthracene	0.137	0.137 (c)	0.012
Benzo(g,h,i)perylene	Not applicable		Not specified
Pentachlorophenol	8.33	2.50 (c)	Not specified
Dioxin (2,3,7,8-TCDD)	0.000007	0.0000013 (c)	Not specified

Notes:

[a] From Table 14

[b] Lowest concentration of non-cancer (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)

FFS focused feasibility study
mg/kg milligrams per kilogram
MTCA Model Toxics Control Act
OU operable unit
NAPL non-aqueous phase liquid
PRG preliminary remediation goal
ROD Record of Decision
WAC Washington Administrative Code

TABLE 2-3

Upper Aquifer Groundwater Preliminary Remediation Goals - Protection of Human Health and the Marine Environment

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

COC	Surface Water Aquatic Life Marine/ Chronic 173-201A WAC (µg/L)	Surface Water Aquatic Life Marine/ Chronic CWA §304 (µg/L)	Surface Water Aquatic Life Marine/ Chronic NTR 40 CFR 131 (µg/L)	Surface Water Human Health Marine Waters CWA §304 (µg/L)	Surface Water Human Health Marine Waters NTR 40 CFR 131 (µg/L)	Freshwater Single Component Aqueous Solubility (µg/L)	Dilution-Attenuation Factor	Upper Aquifer Groundwater PRG (µg/L)
Naphthalene	--	--	--	--	--	31,000	20	Not applicable
Acenaphthylene	--	--	--	--	--	--	20	Not applicable
Acenaphthene	--	--	--	990	--	4,240	20	2,120
Fluorene	--	--	--	5,300	14,000	1,980	20	990
Phenanthrene	--	--	--	--	--	--	20	Not applicable
Anthracene	--	--	--	40,000	110,000	43.4	20	22
Fluoranthene	--	--	--	140	370	260	20	130
Pyrene	--	--	--	4,000	11, 000	135	20	63
Benz(a)anthracene	--	--	--	0.018	0.0311	9.4	20	0.4
Chrysene	--	--	--	--	--	1.6	20	Not applicable
Benzo(b)fluoranthene				0.018	0.0311	1.5	20	0.4
Benzo(k)fluoranthene	--	--	--	0.018	0.0311	0.8	20	0.4
Benzo(a)pyrene	--	--	--	0.018	0.0311	1.62	20	0.4
Indeno(1,2,3 c,d) Pyrene	--	--	--	0.018	0.0311	0.22	20	0.11
Dibenzo (a,h) Anthracene	--	--	--	0.018	0.0311	2.49	20	0.4
Benzo(g,h,i)perylene	--	--	--	--	--	--	20	Not applicable
Pentachlorophenol	7.9 (d)	7.9	7.9	3.0	8.2	1,950,000	20	60

Notes:

--: no value specified

µg/L	micrograms per liter
CFR	Code of Federal Regulations
COC	contaminant of concern
CWA	Clean Water Act
FFS	focused feasibility study
NAPL	non-aqueous phase liquid
NTR	National Toxics Rule
OU	operable unit
PRG	preliminary remediation goal
WAC	Washington Administrative Code

TABLE 2-4

Lower Aquifer Groundwater Preliminary Remediation Goals – Drinking Water Beneficial Use

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Contaminant of Concern	Preliminary Remediation Goal – MTCA Method B for Unrestricted Use [a] (µg/L)	Federal Drinking Water MCL [b] (µg/L)	Proposed PRG [b] (µg/L)
Naphthalene	160 (nc)	--	160
Acenaphthylene	--	--	--
Acenaphthene	960 (nc)	--	960
Fluorene	640 (nc)	--	640
Phenanthrene	--	--	--
Anthracene	480 (nc)	--	480
Fluoranthene	640 (nc)	--	640
Pyrene	480 (nc)	--	480
Benz(a)anthracene	0.12 (c)	--	0.12
Chrysene	12 (c)	--	12
Benzo(b)fluoranthene	0.12 (c)	--	0.12
Benzo(k)fluoranthene	1.2 (c)	--	1.2
Benzo(a)pyrene	0.012 (c)	0.2	0.012
Indeno(1,2,3 c,d) Pyrene	0.12 (c)	--	0.12
Dibenzo (a,h) Anthracene	0.012 (c)	--	0.012
Benzo(g,h,i)perylene	--	--	--
Pentachlorophenol	0.219 (c)	1.0	0.219
Dioxin (2,3,7,8-TCDD)	6.73E-07	3.0E-05	6.73E-07

Notes:

[a] From CLARC May 2014

[b] Lowest concentration of non-cancer (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 $1x10^{-5}$ for multiple carcinogens per WAC 173-340-708 (5).

µg/L micrograms per liter
FFS focused feasibility study
MCL maximum contaminant level
MTCA Model Toxics Control Act
NAPL non-aqueous phase liquid
OU operable unit
PRG preliminary remediation goal
WAC Washington Administrative Code

TABLE 2-5
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
No Action	No Action	Not Applicable	No action	NAPL in soil and groundwater is left untreated.	**Poor.** Not effective, because no active measures are taken to remove, treat, and/or immobilize NAPL.	**Poor.** While technically implementable, no action does not address CERCLA threshold criteria and principal threats.	**None.**	**Retained** per the NCP.
Access Restrictions	Fencing	All Zones Soil/Groundwater NAPL/All COCs	Cyclone perimeter fence	Exposure pathway controlled with engineering measures.	**Poor to Moderate.** Generally effective for protecting human health, but must be maintained over time. May not eliminate entry (trespass) or remedial action worker exposure. Does not contribute to NAPL source zone treatment.	**Good.** A fence currently encloses the Former Process Area.	**Low.**	**Retained.** Fencing is a component of the current remedy and is needed, as a component of a broader alternative, until RAOs achieved.
	ICs		Land use zoning, deed restrictions, restrictive covenants	Exposure pathway controlled with administrative measures.	**Poor to Moderate.** Relies on administrative measures to limit exposure to contaminated soil and groundwater. ICs expected to be effective short term, but uncertainty on long-term effectiveness over periods of 100 years or more exists. Does not contribute to NAPL source zone treatment.	**Moderate.** Readily implemented using existing EPA (EPA 540-F-00-005) guidance, however, requires land-owner concurrence. Some uncertainty on enforcement tools and responsibility over long term.	**Low.**	**Retained.** ICs are a component of the current remedy and are needed, as a component of a broader alternative, until RAOs achieved.
Containment	Surface Barrier	All Zones Soil NAPL/All COCs	Low permeability asphalt barrier (MATCON)	An impermeable cover (asphalt) is placed over ground surface to provide a direct contact barrier and to deter surface water infiltration away from contaminated soil. Typical asphalt mix is modified to use smaller aggregate, higher binder content, and/or proprietary binder additives.	**Moderate.** Low permeability asphalt covers are effective at reducing direct contact with contaminants and reducing infiltration ($1x10^{-8}$ cm/sec permeability), but require routine inspection, maintenance (crack repair and sealing), and periodic replacement to maintain long-term effectiveness. Not effective in eliminating lateral COC migration unless coupled with vertical barrier. Does not reduce NAPL source zone. Reduces mobility in vadose zone by minimizing infiltration. Does not reduce mobility in Upper Aquifer.	**Good.** Readily implemented. Low permeability asphalt requires special asphalt mix designs (generally proprietary) and high levels of QA/QC to demonstrate impermeability of the barrier. Asphalt barrier can be a benefit or detriment to future site development depending on intended use. Future use would need to be known and accounted for in remedial design.	**High.** Moderate to high capital and periodic cost with low initial O&M cost. O&M cost rises as asphalt ages, eventually requiring replacement. O&M and periodic costs incurred for an indefinite period of time.	**Not Retained** due to long-term site use considerations, and high O&M and periodic costs.
			Multi-layer impermeable barrier	Contaminated surface soil graded and capped with low permeability materials that may include flexible membrane liner, drainage (gravel), sand/silt/clay, and vegetation or combination thereof.	**Moderate.** Mature technology with demonstrated ability to limit infiltration and direct contact with contaminants. Would need to be coupled with other process options (for example, sheet pile wall) to address groundwater contamination, and ICs to protect against intrusion. Reduces mobility in vadose zone by minimizing infiltration. Does not reduce overall source zone.	**Moderate.** Readily implemented using standard construction practices. Requires long-term inspection and maintenance (mowing, erosion repair). Future site use may be restricted to ensure barrier integrity is maintained.	**Moderate.** Moderate capital cost, with low annual O&M and periodic costs for an indefinite duration.	**Retained.** Is a component of the current remedy. Also expected to be a component of a broader alternative to support long-term reuse.

TABLE 2-5
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
			ET barrier	An engineered soil and native vegetation cover placed over contaminated soil to increase ET rates, and decrease surface water infiltration.	**Moderate.** Most effective in arid climates, but with appropriate design and vegetation selection, can be applied in wetter climates. Barrier layer thickness, soil gradation, vegetation, grading, and drainage, if carefully designed, can effectively limit infiltration beneath the cap. Not effective in eliminating horizontal migration of contaminants unless implemented in conjunction with vertical barrier (for example, slurry wall). Differential settlement can compromise barrier effectiveness. Reduces mobility in vadose zone by minimizing infiltration. Does not reduce overall source zone	**Moderate to Good.** Easily implementable with standard construction equipment and materials. May not require mowing (depending on vegetation type), but would still require periodic inspection and repair of any erosion. Long-term maintenance required and future site uses are limited by need to protect barrier integrity. Administrative acceptance may be a barrier to implementation.	**Low to Moderate.** Very low capital and inspection and maintenance costs (does not require mowing). O&M costs incurred for an extended period of time.	**Retained** as a component of a broader alternative.
Containment (Continued)	Subsurface Barrier	All Zones Groundwater NAPL/All COCs	Physical containment wall (for example, sheet pile, slurry wall) with interior fluids pumping	Vertical wall generally keyed into low permeability natural geologic unit to fully or partially enclose an NAPL source area. Often coupled with fluid pumping inside the containment wall to maintain an inward/upward hydraulic gradient.	**Moderate.** Well suited to site conditions. Effective at minimizing horizontal NAPL and dissolved-phase contaminant migration. Low level pumping necessary to maintain inward/upward hydraulic gradient to offset surface, upland, and Lower Aquifer recharge. Does not provide timely reductions in NAPL source zone. Reduces horizontal mobility in the Upper Aquifer, but less effective at reducing vertical mobility.	**Good.** Readily implemented with conventional construction equipment. Higher level of QA/QC required to confirm that a contiguous barrier is achieved and joint sealer is properly installed. Requires shoreline protection system to guard against corrosion. Effectiveness may decrease over time without this system. Requires periodic replacement (est. at 50 years).	**Moderate to High.** Moderate capital cost due to barrier length. High annual O&M cost for interior fluids pumping, treatment, and discharge. High periodic costs for replacement of various components.	**Retained.** Component of the current remedy. However, must be coupled with other technologies, as a component of a broader alternative, to achieve Performance Objectives and RAOs. Not retained as a stand-alone technology.
	Hydraulic Containment	All Zones Groundwater NAPL/PAHs/PCP	Groundwater extraction, treatment, and discharge	Vertical extraction wells placed throughout the Wyckoff Site to control dissolved-phase plume migration and discharge to surface water.	**Poor to Moderate.** Effective for minimizing dissolved-phase contaminant migration; however, tidal influences and Lower Aquifer hydraulic communication and routine/non-routine O&M downtime may allow some contaminant discharge to Lower Aquifer and surface water. Unlikely to contain vertical and horizontal NAPL migration. Does not provide timely reductions in NAPL source zone.	**Moderate.** All of the process options for this technology are already in place. Requires ongoing O&M operator presence, resource commitment, and vendor support network for transportation and residuals disposal. Dioxin and sulfide in recovered NAPL pose additional implementation challenges.	**Moderate to High.** Low capital cost because infrastructure already in place. High annual O&M and periodic costs based on current information.	**Retained.** Is a component of the current remedy, and expected to be short-term component of a broader alternative. Not retained as a stand-alone alternative.

TABLE 2-5
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
Removal	Shallow Excavation (less than 15 feet)	All Zones Debris/Soil/Upper Aquifer Solids NAPL/All COCs	Standard excavation equipment/methods Benching/sloping/shoring Dewatering Stockpiles/Run-off and Run-on controls Air monitoring	Excavation using trackhoe(s). Excavated soil direct loaded for offsite treatment and disposal or stockpiled for onsite treatment and reuse. Shoring potentially needed for depths below 4 feet. Dewatering for excavation below the water table (5 to 7 feet) also requires treatment, and offsite discharge. Air monitoring (worker and perimeter) for fugitive emissions associated with large excavation footprints or excavations in highly concentrated areas.	**Good.** Highly effective because contaminants are permanently removed from excavation zone. Reduces NAPL source zone.	**Moderate to Good.** Readily implemented to depths of 5 to 7 feet using conventional equipment with limited benching/sloping required. At depths greater than 5 to 7 feet (below water table), implementation challenges grow due to shoring and dewatering additions.	**Moderate** (not including ex situ treatment or disposal costs).	**Retained.**
	Deep Excavation (more than 15 feet)	All Zones Soil/Upper Aquifer Solids NAPL/All COCs	Long-reach excavation equipment/methods Benching/sloping/shoring Dewatering Stockpiles/Run-off and Run-on controls Air monitoring		**Poor to Moderate.** Effectiveness decreases at greater depths because there is increased potential for residual contamination to be left behind due to inaccessibility (material against sheet pile wall or material in shoring setback-non excavation zone). Reduces NAPL source zone. However, due to depth of contamination present at the Wyckoff Site, unlikely that all NAPL down to top of Aquitard can be removed.	**Poor to Moderate.** Shoring and dewatering complexity increases with depth. May have to be implemented using grid approach to better manage shoring and dewatering volumes. Poses significant hazards to remedial action workers.	**Moderate to High.** Costs increase in proportion to excavation depth.	**Retained.** Although no complete direct contact exposure pathway for contaminated media present at depths below 15 feet exists, this material poses a sediment and surface water quality threat through the leaching and transport pathway.
	Extraction	All Zones Groundwater NAPL/All COCs	Fluids pumping from horizontal and vertical wells. Can be coupled with treated water injection, and injection amendments.	Similar to the current groundwater extraction and treatment system. Includes aggressive optimization and potential enhancements to accelerate NAPL and dissolved-phase mass removal.	**Poor to Moderate.** NAPL characteristics are less favorable for recovery via direct pumping, but mass reductions can be achieved over extended time periods. Decreases NAPL source zone.	**Moderate.** All of the process options for this technology are already in place. Requires ongoing O&M operator presence, resource commitment, and vendor support network for transportation and residuals disposal. Dioxin and sulfide in recovered NAPL pose additional implementation challenges.	**High.** Low capital cost because infrastructure already in place. High annual O&M and high periodic costs based on current information.	**Retained.** Experience with this technology at other wood treating sites indicates this technology, as a stand-alone alternative, would be unable to achieve the Performance Objectives and RAOs established for the Wyckoff Site in reasonable timeframe. However, this technology will likely be needed to support targeted DNAPL recovery, dewatering, and as a polishing step.
			Enhanced Mobilization/Solubilization (water flood)	Treated water, potentially heated, injected to enhance transport of mobile NAPL and solubilization of residual NAPL from the Upper Aquifer for extraction and ex situ treatment.	**Moderate.** Direct contact required. Heterogeneity controls injected water flow in the subsurface and can lessen effectiveness if significant heterogeneity exists. Poor injection control can mobilize NAPL to less accessible areas. More effective for LPAHs and less effective for HPAHs.	**Moderate.** Can be implemented using existing site infrastructure supplemented with additional injection wells or infiltration trenches.	**Low to Moderate.** Injection wells and trenches have low capital and O&M costs. If enhanced with heat, costs will rise. Majority of treatment can be performed in existing GWTP with minor modifications (if heating used).	**Retained.** Water flooding and gradient induced recovery used at other wood-treating sites to recovery mobile NAPL. This technology retained as a component of a larger alternative or potential standalone alternative.

TABLE 2-5
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
					Temporary short-term increase in NAPL mobility provides long-term reductions in NAPL source zone.			
			Enhanced Mobilization/Solubilization (surfactant)	Potable/treated water amended with agent and injected to enhance flushing of mobile and residual NAPL and sorbed PAHs from the Upper Aquifer for extraction and ex situ treatment.	**Poor to Moderate.** Direct contact required. Heterogeneity controls distribution in the subsurface, and can lessen effectiveness. Poor injection control can also mobilize NAPL to less accessible areas. More effective for LPAHs and less effective for HPAHs. Temporary short-term increase in NAPL mobility provides long-term reductions in NAPL source zone.	**Moderate.** Can be implemented using existing site infrastructure supplemented with additional wells or infiltration trenches. Modifications to GWTP potentially required depending on surfactant used.	**Moderate.** Injection wells and trenches have low capital and O&M costs. Chemical costs will be high due to volume and duration of injection required.	**Not Retained** no experience with surfactants and injection enhanced recovery at this site results in significant uncertainty on this technology's effectiveness and overall implementability.
Disposal	Onsite RCRA Landfill	All Zones Debris/Soil/Upper Aquifer Solids NAPL/All COCs	Standard transportation methods Clean offsite backfill material required	Waste materials are excavated and placed in an onsite landfill constructed with liner, leachate collection, and impermeable cap per regulatory standards.	**Good.** Effective because contaminants are contained in a landfill designed to RCRA standards. Requires long-term monitoring and maintenance to ensure effectiveness.	**Poor.** Site conditions within Former Process Area not compatible with RCRA TSD requirements. Would require identification of location further inland. May limit future site use but design work-arounds possible. Technology used at several Region 6 wood-treating sites (Bayou Bonfouca, Conroe Creosote, Hart Creosote, Jasper Creosote Superfund sites). CERCLA AOC policy allows waste materials exceeding LDRs to be disposed onsite.	**Moderate to High.** High capital cost; low O&M cost.	**Not Retained** due to current site conditions and future land use considerations.
	Offsite RCRA TSD	All Zones Debris/Soil/Upper Aquifer Solids NAPL/All COCs	Transport and dispose of waste at offsite RCRA TSD Pretreatment to meet LDRs Clean offsite backfill material required	Waste materials are excavated and transported offsite to a permitted disposal facility. Offsite disposal may require treatment of some or all waste material if subject to LDR.	**Good.** Effective because contaminants are contained in a permitted facility with a high level of monitoring and controls. Pretreatment to meet LDRs required.	**Moderate.** May require pretreatment prior to disposal or obtaining an LDR variance. Obtaining an LDR variance would require a mobility determination. Uncertainty exists on whether such waivers have been granted in Region 10. Potentially requires segregation of dioxin- and non-dioxin-bearing waste.	**High.** Transportation and treatment costs high given the Wyckoff Site's remote location. Rail may be lower cost option. Dioxin-bearing waste may further increase cost. Facility must be in compliance with CERCLA offsite rule.	**Retained** due to limited alternative offsite options.
	Offsite Subtitle D	All Zones Debris/Soil/Upper Aquifer Solids NAPL/All COCs	Transport and dispose of waste at offsite Subtitle D subject to waste acceptance criteria Clean backfill material required	Waste materials are excavated and transported offsite to a permitted disposal facility. Waste subject to receiving facility's acceptance criteria.	**Good.** Effective because contaminants are contained in a permitted facility with a high level of monitoring and controls.	**Moderate.** Applicable for characteristic non-hazardous materials exceeding cleanup levels and listed wastes that have received a no-longer-contained-in determination and require disposal for other technical reasons.	**Moderate to High.** Transportation and treatment costs contingent on facility approved to accept waste. Facility must be in compliance with CERCLA offsite rule.	**Retained** for non-hazardous debris and non-hazardous via characteristic rule material.

TABLE 2-5
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
Ex Situ Treatment (assume soil excavated)	Biological Treatment	All Zones Soil/Upper Aquifer Solids NAPL/All COCs	Biopiles/Landfarming	Excavated waste materials are mixed with amendments and placed in a treatment cell with aeration and leachate collection systems. Temperature, moisture, nutrients, oxygen, and pH are controlled to enhance biodegradation of contaminants. Soil is periodically remixed/tilled to promote aeration and stimulate further treatment.	**Poor.** Not effective for HPAHs and dioxin. High concentration wastes may be toxic to microbes, thus limiting effectiveness. Field scale pilot ex situ biological treatment has performed poorly at other wood-treating sites (for example, Hart Creosote and North Cavalcade Superfund sites).	**Poor to Moderate.** Readily implementable using conventional equipment, but may be difficult to implement for very large volumes of contaminated materials due to space limitations. High rainfall amounts at the site will require extensive run-on and run-off controls.	**Moderate.** Moderate capital cost and O&M cost.	**Not Retained** due to ineffectiveness for HPAHs and past performance at other wood-treating sites.
			Slurry phase biological	Contaminated materials are mixed with water to form aqueous slurry that is aerated and amended with nutrients, microbes, and pH adjustment. The slurry is mixed to keep solids in suspension and to promote contact between microbes and contaminants. Following treatment, the slurry is dewatered and the treated solids disposed. Water generated from the dewatering and treatment process is recycled into existing treatment process.	**Poor.** More effective for LPAHs and PCP, and less effective for HPAHs and dioxin. Slurry-phase bioremediation of PAHs is generally more effective than solid-phase biological treatment due to more direct contact between contaminants and microbes and ability to control environmental factors (pH, temperature, nutrients).	**Poor to Moderate.** Generally requires less land area than biopiles, but requires more infrastructure. Implementation on a large scale would require treatment of contaminated soil in batches. Large volumes of soil requiring treatment may require long-term operation of a bioreactor to treat all contaminated materials due to time requirement to degrade HPAHs. Also requires screening step to remove debris, gravel, and to break up clayey soils. Soil particles greater than 2 millimeters are not recommended for slurry phase bioreactors (Sopanaro et al., 2001).	**Moderate.**	**Not retained** due to ineffectiveness for HPAHs and dioxin. Subsurface soil contains fill and marine gravel that would have to be removed through screening. This material would have to be handled using another technology.
	Thermal Treatment	All Zones Soil/Upper Aquifer Solids NAPL/All COCs	Onsite incineration	Waste materials are excavated, and stockpiled onsite prior to treatment in a mobile incinerator unit, which uses high temperatures (typically greater than 1,400 ºF) to destroy organic contaminants. Offgas stream requires air pollution control equipment.	**Good.** Highly effective in destruction of organic contaminants. Requires additional offgas and scrubber water treatment for halogenated contaminants (PCP). Effectiveness is affected by need to do extensive pretreatment, including screening to adjust particle size, chemical treatment to adjust the pH, and dewatering to adjust moisture content (prior to incineration). Used at other wood-treating sites in the 1990s.	**Moderate.** Onsite incinerators are required to meet RCRA incinerator regulations (40 CFR Parts 264 and 265, Subpart O). Incinerator performance standards include 99.99% DRE for organic contaminants and 99.9999% DRE for dioxins and furans (EPA-542-R-97-012). Will likely face opposition from local community. Large ash volume would require onsite or offsite disposal. Very high energy (natural gas) operational requirements.	**High.** High capital cost for treatment equipment mobilization/demobilization and operations. Requires ash handling and disposal, which may incur additional capital and O&M costs if managed onsite.	**Not Retained** due to high cost and implementability (public acceptance) concerns.
			Offsite incineration	Waste materials are transported offsite to a permitted treatment facility for incineration prior to offsite landfill disposal.	**Good.** Treatment efficiencies must meet RCRA incinerator regulations (40 CFR Parts 264 and 265, Subpart O) performance standards of 99.99 percent DRE for organic contaminants and 99.9999 percent DRE for dioxins and furans (EPA-542-R-97-012). Requires additional offgas and scrubber water treatment for halogenated contaminants. Dedicated offsite treatment facilities can better	**Good.** Readily implementable with conventional construction equipment and permitted incineration facilities. Very high energy requirements for treatment. This technology is containment remedy residuals (NAPL and spent GAC media).	**High.** High capital cost for transportation and incineration due to volume of material. No O&M and periodic costs because waste material is removed from the site.	**Retained** for dioxin-contaminated material exceeding land disposal restriction treatment standards.

TABLE 2-5
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
					handle varying waste materials by blending with other feed streams and utilization of pretreatment steps to maximize treatment efficiency.			
Ex Situ Treatment (assume soil excavated) (Continued)	Thermal Treatment	All Zones Soil/Upper Aquifer Solids NAPL/All COCs	Onsite thermal desorption with onsite reuse	Soil excavated, stockpiled, and screened prior to treatment in a mobile treatment unit. Thermal desorption uses heat and mechanical agitation to volatilize contaminants from soils into a gas stream. The offgas stream is then treated to destroy or remove vapor-phase contaminants. Treated/sterile soil reused to backfill excavation footprints. Top soil cover required to promote future vegetation growth.	**Moderate.** Likely requires offgas treatment because desorption is not a 100 percent destructive process. Less effective for soils with high silt and clay content (EPA 542-F-96-005). Higher temperature is required for desorption of HPAHs. PCP can lead to formation of dioxins/furans in the stack or air pollution control devices (EPA, 1996). Dioxin treatment uncertain.	**Moderate.** More implementable with granular material; difficult in silt/clayey type soil. Uniform heating of cohesive soils is problematic, and fine particulates can disrupt air emissions equipment (EPA 542-F-96-005) leading to difficulty in meeting air permit requirements. High energy requirement, though lower than incineration. High moisture content increases reaction time and fuel requirements. Equipment poses hazards to remedial action workers. Community acceptance may be low, but not as poor as for onsite incineration. Has been used at other wood treating sites (Central Wood Superfund Site).	**Moderate to High.** Capital cost dependent on volume of material to be treated. No O&M or periodic costs expected.	**Retained**
			Offsite thermal desorption Clean backfill material placement	Soils are excavated and transported offsite for treatment (as described above) at a permitted treatment facility.	**Moderate to High.** Effectiveness is similar to onsite thermal desorption; however, improved treatment performance expected from a permitted/fixed commercial thermal desorption facility.	**Moderate.** Offsite treatment facilities are designed and permitted to handle offgas treatment. High energy requirement, though lower than incineration. Requires offsite transport, which adds transportation risks. Offsite thermal desorption would need to be implemented in conjunction with offsite disposal.	**High.** Cost does not include offsite disposal of treated waste material. Offsite thermal desorption would typically be coupled with offsite disposal, which would increase cost significantly over onsite treatment and disposal.	**Not Retained** due to high cost

TABLE 2-5

Soil and Groundwater OU Remedial Technology Screening

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
In Situ Treatment	MNA	All Zones Soil/Groundwater NAPL less than 1-foot thickness/ PAHs/PCP	Non-degradation (dispersion, dilution, sorption) Degradation (abiotic and biotic)	Contaminants attenuate over time through natural physical, chemical, and biological processes.	**Poor to Moderate.** HPAHs are relatively stable and not amenable to degradation processes; however, these characteristics render them relatively immobile. LPAHs, and PCP are amenable to degradation through biotic processes under aerobic conditions. Provides nominal contribution to achievement of Performance Objectives and RAOs.	**Moderate.** Implementable using standard monitoring, testing, and data evaluation methods but may be more difficult to prove specific processes and attenuation rates, especially for HPAHs. Limited hazards to remedial action workers and community.	**Moderate.** Long attenuation timeframe will require extended monitoring duration.	**Retained** as a component of a broader alternative.
		All Zones Soil – Dioxin Groundwater NAPL more than 1-foot thickness			**Poor.** Dioxin toxicity and volume not reduced; dioxin has low mobility under typical environmental conditions. Mobile NAPL toxicity, mobility, and volume not reduced. Does not contribute significantly to achievement of Performance Objectives and RAOs.	**Poor.** Not implementable due to poor effectiveness.	**Moderate High.** Undefined attenuation timeframe will likely require extended monitoring period.	**Not Retained** due to poor effectiveness.
	Thermal Treatment	All Zones Soil Upper Aquifer Solids Groundwater NAPL/All COCs	Electrical resistance heating	Electrical current is passed through electrodes spaced approximately 15 to 20 feet apart. The electrical resistance of the formation creates heat, which vaporizes water, creating steam and volatilizing VOC and SVOC contaminants. Volatilized contaminants captured by a vapor extraction system and treated ex situ.	**Moderate to High.** Effective for VOCs and LPAH in permeable soil. Less effective for HPAH/dioxin compounds. Requires capture and treatment of offgas/condensate containing contaminants for destruction or transfer to another medium for disposal. Reduces NAPL source zone.	**Poor to Moderate.** Removal of debris improves implementability. Typically, requires a minimum treatment thickness of 10 feet. Energy requirements greater for sites with higher fraction of HPAHs/dioxins. Complex energy, treatment, and supporting infrastructure requirements. Uncertainty on energy source and availability. Electrical generation and distribution equipment can pose hazards to remedial action workers.	**High.** DNAPL source zone treatment costs range from $32 to $300 per cubic yard (McDade et al., 2005).	**Not Retained.** Steam identified as preferred process option for thermal treatment.
			In situ Thermal Destruction (NAPL smoldering - STAR technology)	Contaminants are used as a fuel source for in situ combustion to destroy NAPL. A heating element is inserted into the treatment zone to heat the NAPL to between 200 and 400 °C, and then air is injected to ignite the NAPL. The heat released through combustion preheats NAPL in adjacent areas. With the continued injection of air, combustion may become self-sustaining and the heating element can be turned off.	**Unknown.** This is an emerging remediation technology with little field-scale data available to sufficiently evaluate the technology's effectiveness. Vendor information suggests treatment efficiencies in the range of 95 to 99 percent (http://star.siremlab.com/overview.php).	**Poor.** The implementability of this technology is difficult to assess. Based on vendor information, the technology has been demonstrated at the pilot-scale, but full-scale field implementation information is not yet available. Requires a bench-scale and pilot-scale test prior to implementation at estimated cost of $350,000 to $450,000.	**Moderate to High.** No definitive cost information due to lack of full-scale projects. Vendor reports that costs for full-scale implementation are projected to be around $80 per cubic yard.	**Not Retained.** Technology not proven at large enough scale for application at the Wyckoff Site.
			Steam generation and injection	Steam is injected into vadose zone and Upper Aquifer through injection wells to vaporize VOCs/SVOCs for recovery via vapor extraction and ex situ treatment.	**Moderate to High.** Effective for removal of VOCs and SVOCs. Used effectively at similar sites.	**Poor to Moderate.** High energy and complex infrastructure requirements. Uncertainty on energy source and availability.	**High.** Capital Cost range from $100 to $300 per cubic yard (Clu-in.org).	**Retained** due to effectiveness in reducing NAPL mobility and thickness.

TABLE 2-5
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
					Reduces NAPL source zone.	Steam generation and handling equipment can pose hazards to remedial action workers, while noise may be objectionable to community.		
In Situ Treatment (Continued)	Physical Treatment	All Zones Soil Upper Aquifer Solids Groundwater NAPL/All COCs	Solidification/stabilization	Injection and mixing of solidifying reagents with the soil to form a monolithic, low-permeability, solid mass with high structural integrity. The resulting matrix reduces the mobility and solubility of contaminants originally present in the soil. Reagents may include Portland cement, fly ash, blast furnace slag, and organic sorbents, such as GAC, Zeolite, and organophilic clay.	**Moderate to Good.** Effectiveness depends on stabilization reagent's ability to demonstrate reduction in leaching of organic contaminants. Sorbents can be added to enhance immobilization of organic contaminants. Process yields a solidified stable mass with high structural strength and low leaching potential. Also results in an increase in overall volume of contaminated media (swell). Increased pH from stabilization increases solubility of naphthalene, which can bleed from the monolith. Technology used at North Cavalcade and Texarkana Superfund (former creosote – wood treating) sites. Decreases NAPL source zone. NAPL in S/S areas no longer exists as a separate liquid phase.	**Moderate to Good.** Large mixing augers (5- to 10-foot diameter) or jet injection equipment used to blend and homogenize reagents with soil. Specialty mixing equipment (augers) can be impeded at sites with debris or coarse granular material (cobbles). Implementation difficulty increases with depth. Large equipment can pose hazards to remedial action workers, while noise may be objectionable to community.	**Moderate.** A majority of cost is capital cost; low O&M cost. Cost increases if swell material is disposed offsite, particularly if pre-treatment required to meet LDRs.	**Retained** based on ability to immobilize NAPL and experience at other sites.
		Periphery Areas Groundwater Dissolved COCs	Funnel and Gate	This is a passive treatment technology that would be deployed following active treatment phase. Consists of a perimeter collection system that routes contaminated groundwater through a treatment media. Depending on media selected and contaminant loading (flux), periodic rejuvenation or change out likely required. For Wyckoff site, may be able to use natural flow gradients and tidal action in lieu of pumps.	**Moderate.** Treatment portion of this technology highly effective, but will require O&M to maintain effectiveness. Some uncertainty on effectiveness of collection system due to unknown vertical contaminant distribution at end of active treatment phase.	**Poor to Moderate.** Technology not as well developed for thick aquifers. More difficult to implement if treatment across the Upper Aquifer's full saturated thickness required.	**Low to High.** Cost will vary depending on length, depth and system flow rate, and treatment media changeout and disposal requirements.	**Retained** in the event some localized groundwater treatment is required following active treatment phase.
	Chemical Treatment	All Zones Upper Aquifer Solids Groundwater Residual NAPL/All COCs	ISCO	Liquid reagents injected to form strong oxidants that chemically destroy contaminants. Generally requires multiple injections.	**Moderate to Good.** Proven technology at multiple sites. High oxidant demand for NAPL and PAHs. Less full-scale wood-treating sites.	**Poor to Moderate.** Implementable using array of injection points and trailer/skid-mounted equipment. Uniform distribution of reagents in heterogeneous soil is necessary and represents the primary challenge associated with this and other direct contact treatment technologies. Depending on reagent chosen, may pose increased hazard to remedial action workers.	**Moderate to High** capital cost due to extensive infrastructure and chemical volume requirements. Low O&M costs if treatment objectives are met quickly without need for repeat injections.	**Retained.** Will be incorporated as polishing step within a broader alternative for use in addressing immobile NAPL or areas with limited NAPL thickness.

TABLE 2-5
Soil and Groundwater OU Remedial Technology Screening
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Actions	Remedial Technology	Target Zone, Media, and COCs	Process Options	Description	Effectiveness (Target Zone and RAOs, Impacts to HHE during Construction, Reliability)	Implementability (Technical and Administrative)	Relative Cost	Screening Comment
	Biological Treatment	All Zones Groundwater	Biosparging Enhanced aerobic	Air injection into an array of horizontal or vertical wells to stimulate aerobic biodegradation and volatilization of residual NAPL and dissolved-phase contaminants.	**Moderate.** Technology more favorable for LPAHs.	**Good.** Technology design and equipment well developed; lots of experience.	**Low to Moderate** capital and O&M costs depending on size of injection array.	**Retained** as a polishing component within broader based alternative.

Sources: EPA, 1995, 1996; McDade et al., 2005.

ºC degrees centigrade
ºF degrees Fahrenheit
AOC Area of concern
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
CFR Code of Federal Regulations
cm/sec centimeter(s) per second
COC contaminant of concern
DNAPL dense non-aqueous phase liquid
DRE destruction and removal efficiency
EPA U.S. Environmental Protection Agency
ET evapotranspiration
FFS focused feasibility study
GAC granular-activated carbon
GWTP groundwater treatment plan
HHE human health and the environment
HPAH high molecular weight PAHs
IC institutional control
ISCO in situ chemical oxidation
LDR land disposal restrictions
LPAH low molecular weight PAHs
MNA monitored natural attenuation
NAPL non-aqueous phase liquid
NCP National Contingency Plan
O&M operations and maintenance
OU operable unit
PAH polycyclic aromatic hydrocarbons
PCP pentachlorophenol
QA/QC quality assurance/quality control
RAO remedial action objective
RCRA Resource Conservation and Recovery Act
SVOC semivolatile organic compound
TSD treatment, storage, and disposal
VOC volatile organic compound

TABLE 2-6
Summary of Retained Remedial Technologies
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Action	Technology Type	Key Process Options	Target Zone, COCs
No Action	No Action	No Action	Not applicable
Access Restrictions	Fencing	Signs/cyclone fence	All Zones and COCs
	ICs	Land use zoning, deed restrictions, restrictive covenants	
Containment	Surface Barrier	Multi-layer impermeable barrier and ET barrier	All Zones and COCs
	Subsurface Barrier	Sheet pile wall	All Zones, NAPL, PAHs, PCP
	Hydraulic Containment	Groundwater extraction, treatment, and discharge	All Zones, NAPL, PAHs, PCP
Removal	Shallow Excavation (less than 15 feet)	Standard equipment, shoring, dewatering, stockpiles/run-on and run-off controls	All Zones and COCs
	Deep Excavation (more than 15 feet)	Standard equipment, shoring, dewatering, stockpiles/run-on and run-off controls	All Zones and COCs
	Extraction	Groundwater extraction, treatment, and discharge	All Zones, NAPL, PAHs, PCP
	Enhanced Extraction	NAPL and groundwater extraction, treatment, and discharge	All Zones, NAPL, PAHs, PCP
	Thermal	Steam	All Zones, NAPL, PAHs, PCP
Disposal	Offsite RCRA Landfill/TSD Offsite Subtitle D landfill	Standard transportation methods (truck, rail), waste acceptance	Debris - All Zones and COCs
Ex situ Treatment	Thermal Treatment	Offsite incineration	Dioxin-contaminated soil
		Onsite thermal desorption	All Zones and COCs
	Ex Situ Stabilization	Backhoe mixing	All Zones (shallow soil) and COCs
	Physical	Existing GWTP - Gravity settling; Dissolved air floatation; Granular activated carbon filtration	Groundwater-All Zones, NAPL, PAHs, PCP
In Situ Treatment	MNA	Naturally occurring non-degradation and degradation processes	All Zones, NAPL, PAHs, PCP

TABLE 2-6

Summary of Retained Remedial Technologies

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

General Response Action	Technology Type	Key Process Options	Target Zone, COCs
	In Situ Stabilization	Auger mixing, jet grouting	All Zones and COCs
	Physical	Funnel/Tidal gate with reactive media	
	Biological	Biosparging/EAB	

COC contaminant of concern
ET evapotranspiration
EAB enhanced aerobic biodegradation
FFS focused feasibility study
GWTP groundwater treatment plant
MNA monitored natural attenuation
NAPL non-aqueous phase liquid
OU operable unit
PAH polycyclic aromatic hydrocarbons
PCP pentachlorophenol
RCRA Resource Conservation and Recovery Act
TSD treatment, storage, or disposal

TABLE 2-7

Remedial Technologies Applied to Each Target Zone

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

	Remedial Action Target Zone				
Technology and Technology Pairings	**Core Area**	**East Shallow (LNAPL)**	**North Shallow (LNAPL)**	**North Deep (DNAPL)**	**Other Periphery**
Soil Cap	X	X	X	X	X
Sheet Pile Wall	X	X	X	X	X
Hydraulic Containment/GWTP	X	X	X	X	X
In situ Solidification/Stabilization	X	X	X	X	X
Excavation/Thermal Desorption	X	X	X	X	
Enhanced NAPL Recovery/Thermal Enhanced Extraction/Enhanced Aerobic Biodegradation	X	X	X	X	
Enhanced Aerobic Biodegradation					X
Passive Groundwater Treatment	X	X	X	X	X
Access Controls/Institutional Controls	X	X	X	X	X
Monitored Natural Attenuation	X	X	X	X	X

Notes:

LNAPL Light non-aqueous phase liquid
DNAPL dense non-aqueous phase liquid
FFS focused feasibility study
GWTP groundwater treatment plant
NAPL no-aqueous phase liquid
OU operable unit

TABLE 3-1
Remedial Action Alternative Technology Pairings
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

	Remedial Action Target Zone				
Remedial Action Alternative Key Technology Components	**Core Area**	**East Shallow (LNAPL)**	**North Shallow (LNAPL)**	**North Deep (DNAPL)**	**Other Periphery**
Alternative 1					
Natural Attenuation	X	X	X	X	X
Alternative 2 - Containment					
Hydraulic Containment/GWTP	X	X	X	X	X
Alternative 3 – Excavation, Thermal Desorption, and ISCO					
Excavation/Thermal Desorption/EAB	X	X	X		
ISCO				X	X
Alternative 4 –ISS					
In situ Solidification/Stabilization	X	X	X	X	X
Alternative 5 – Thermal Enhanced Extraction and ISS					
Enhanced NAPL Recovery/Thermal Enhanced Extraction/EAB	X	X	X		
In situ Solidification/Stabilization				X	
EAB					X
Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction					
Excavation/Thermal Desorption	X (upper)				
Enhanced NAPL Recovery/Thermal Enhanced Extraction/EAB	X (Lower)	X	X	X	
EAB					X
Alternative 7 – ISS of Core Area and Thermal Enhanced Extraction					
ISS	X				
Enhanced NAPL Recovery/Thermal Enhanced Extraction/EAB		X	X	X	
EAB					X

Notes:
DNAPL dense non-aqueous phase liquid
EAB enhanced aerobic biodegradation
FFS focused feasibility study
GWTP groundwater treatment plant
ISCO In situ chemical oxidation
ISS In situ solidification/stabilization
NAPL non-aqueous phase liquid
LNAPL light non-aqueous phase liquid
OU operable unit

TABLE 3-2

Remedial Action Alternative–Common Elements

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

		Alternatives						
Common Element	**Estimated Cost**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Preconstruction Activities	$869,000		X	X	X	X	X	X
Access Roads	$288,000		X	X	X	X	X	X
Concrete Demolition, Decontamination/Reuse	$2,195,000			X	X	X	X	X
Debris Removal	$3,194,000			X	X	X	X	
	$1,127,000							X
Bulkhead Removal	$8,762,000		X	X	X	X	X	X
Other Demolition	$1,127,000		X					
	$2,993,000			X	X	X	X	X
Stormwater Infiltration Trench	$214,000			X	X	X	X	X
New Perimeter Sheet Pile Wall	$13,287,000		X	X		X	X	
Concrete Perimeter Wall	$11,176,000		X	X		X	X	
	$7,931,000				X			X
New Outfall	$3,293,000		X	X	X	X	X	X
Passive Groundwater Treatment (passive drainage)	$1,303,000			X	X			
	$1,129,000					X	X	X
Site Cap	$4,100,000		X	X	X	X	X	X
Monitored Natural Attenuation	Included In Annual operations and maintenance cost		X	X	X	X	X	X
Access Controls			X	X	X	X	X	X
5-year reviews [a]			X	X	X	X	X	X

[a] 5-year reviews provided here for completeness. For the purposes of this FFS, it is assumed that the cost of 5-year reviews is included within the scope of the remedial action alternative.

FFS focused feasibility study
NAPL non-aqueous phase liquid
OU operable unit

TABLE 3-3

Components of Alternative 2 – Containment

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
Sitewide	Common Elements	Preconstruction activities Access roads Bulkhead removal Other demolition New perimeter sheet pile wall Concrete perimeter wall New outfall for GWTP and stormwater discharge Soil cap MNA, access controls, and 5 year reviews
Sitewide	NAPL/Groundwater Extraction Wells	Install 4 new recovery wells. Redevelop 9 existing recovery wells. Install 2.100 feet of aboveground HDPE conveyance piping for new wells. Define new recovery well locations and pumping rates during remedial design. Assume recovery wells require replacement every 30 years.
	Groundwater Treatment	Utilize existing GWTP. Upgrade electrical and I&C. Existing fiberglass tanks and piping don't require replacement within the 100-year operations period.
	GWTP - Operations and Maintenance	O&M of the extraction well network, conveyance infrastructure, and GWTP and other remedy components would be performed for 100 years.
	Groundwater Monitoring and Reporting	Groundwater monitoring consists of quarterly Upper Aquifer and annual Lower Aquifer sampling and preparation of an annual report. Hydraulic containment assessed quarterly using water level measurements in Upper and Lower Aquifer well pairs.
	Remedial Action Timeframe	Operations limited to 100 years.
	Cost	Common elements (total): $43.0 million. Capital (total – 2016 base year): $1.6 million. O&M (annual): $515,000 to $535,000. O&M and periodic (total): $14.2 million. Total present worth: $70.6 million. Total nondiscounted: $109.8 million.

Notes:

CY cubic yard
DNAPL dense non-aqueous phase liquid
FFS focused feasibility study
GWTP groundwater treatment plant
HDPE high-density polyethylene
I&C instrumentation and control
IC institutional control
LNAPL light non-aqueous phase liquid
MNA monitored natural attenuation
NAPL non-aqueous phase liquid
O&M operations and maintenance
OU operable unit

TABLE 3-4

Components of Alternative 4 – In situ Solidification/Stabilization

Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
Sitewide	Common Elements	Preconstruction activities Access roads Concrete demolition, decontamination/reuse Debris removal Bulkhead removal Other demolition Storm water infiltration trench Concrete perimeter wall New outfall for GWTP and stormwater discharge Passive groundwater treatment Site cap MNA, ICs, 5 five-year reviews
Core Area North Shallow (LNAPL) East Shallow (LNAPL) Periphery	ISS - Auger	Core Area—Treat of 85,300 CY of NAPL contaminated material to depths of 50 feet. North Shallow (LNAPL) Zone—Treat 17,700 CY of NAPL contaminated material present at depths of 25 to 45 feet. East Shallow (LNAPL) Zone—Treat 120,000 CY of NAPL contaminated material present at depths ranging from 25 to 45 feet. Periphery Zone—Treat 43,100 CY of NAPL contaminated material present at depths ranging from 10 to 45 feet. Excavated Soil—Treat 86,00 CY of material, removed to offset ISS swell, using ex situ ISS methods and reuse this material for grading – contouring. The perimeter of the NAPL contaminated zone would be treated using higher strength – low leachability reagent material to create a “rind” or hardened shell to provide increased durability.
North Deep (DNAPL)	ISS – Jet Grouting	North Deep (DNAPL)—About 59,200 CY of contaminated material would be treated to depths up to 76 feet (treatment in this area includes auger mixing of more shallow impacts and jet grout mixing of discreet deeper zones of impacts).
Sitewide	GWTP – Operations and Maintenance	Existing GWTP operated for 3 years (assume through year 2016). Passive groundwater treatment system operated for 8 years (assume through year 2024).
	Passive Groundwater Treatment	Estimate that each of the 10 systems would treat 357,000 gallons per year using tidal induced gradient to draw low-level contaminated groundwater through a granular activated carbon filter media housed in a manhole type station. Estimate four media changeouts per year for each of the 10 stations.

TABLE 3-4

Components of Alternative 4 – In situ Solidification/Stabilization

Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
	Groundwater Monitoring and Reporting	Includes quarterly Upper Aquifer and annual Lower Aquifer sampling and analysis and preparation of an annual report.
	Remedial Action Timeframe	Estimate 12 years (concludes in 2026 based on year 2016 start).
	Cost	Common Elements (total): $35.1 million Capital (total – 2016 base year): $50.1 million O&M (annual): $788,000 for Years 1, 2 and 3. $333,000 for Years 4 through 11 O&M and Periodic (total): $4.2 million Total Present Worth: $86.3 million Total Non-discounted: $91.8 million

Notes:
CY cubic yard
DNAPL dense non-aqueous phase liquid
FFS focused feasibility study
GWTP groundwater treatment plant
HDPE high-density polyethylene
I&C instrumentation and control
IC institutional control
ISS In situ Solidification/Stabilization
LNAPL light non-aqueous phase liquid
MNA monitored natural attenuation
NAPL non-aqueous phase liquid
O&M operations and maintenance
OU operable unit

TABLE 3-5a

Components of Alternative 5 – Thermal Enhanced Extraction and ISS

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
Sitewide	Common Elements	Preconstruction activities Access Roads Concrete Demolition, Decontamination/Reuse Debris removal Bulkhead removal Other demolition Stormwater infiltration trench Sheetpile wall Concrete perimeter wall New outfall for GWTP and stormwater discharge Passive groundwater treatment (passive drainage) Site cap MNA, ICs, and five-year reviews
Sitewide	Enhanced NAPL Recovery	Installation of 147 multi-purpose wells Pumping of NAPL and groundwater for 3 years NAPL and groundwater separation/treatment performed in GWTP equipped with new oil-water separator NAPL disposed offsite, groundwater discharged to harbor via new outfall
North Deep (DNAPL)	ISS – Jet Grouting	About 59,200 CY of contaminated material treated to depths up to 76 feet (treatment in this area includes auger mixing of more shallow impacts and jet grout mixing of discreet deeper zones of impacts).
Core Area East Shallow (LNAPL) North Shallow (LNAPL)	Thermal Enhanced Extraction	Core Area divided into three smaller cells (Core A, Core B, and Core C) using sheet pile to balance injection/extraction while maintaining hydraulic containment during treatment phase East Shallow (LNAPL) divided into two smaller cells (North and South) to allow for similar approach as Core Area; North Shallow (LNAPL) addressed as a single area. Installation of shallow vapor barrier Installation of 27 de-watering wells, 172 multi-purpose steam injection and EAB wells, 201 temperature monitoring wells, and 31 EAB wells Re-purposing of 147 NAPL recovery wells as fluid/vapor extraction wells Installation of above ground vapor/condensate treatment system and steam generation equipment

TABLE 3-5a

Components of Alternative 5 – Thermal Enhanced Extraction and ISS

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
	Thermal Enhanced Extraction Operations and Maintenance	Treatment sequence is as follows: Core A, followed by Core B, Core C, East Shallow (LNAPL) South, East Shallow (LNAPL) North, and North Shallow (LNAPL) Treatment steps include: dewatering, steam injection, fluids/vapor extraction, and fluids/vapor treatment Steam injected at higher rate, initially, over an estimated 18 day period to raise subsurface temperature and promote recovery of remaining mobile NAPL; rate then decreased with injection continuing for 255 days to complete balance of NAPL recovery Performance monitoring during operations to optimize steam injection/fluid/vapor extraction rates Initiate EAB after steam injection turned off Disassemble aboveground components and move to next treatment cell in the sequence
Periphery	EAB	Inject air through multi-purpose wells at rates varying from 100 to 200 scfm. Assume 8 scfm flow rate per well In situ biodegradation performance enhanced by residual heat from thermal treatment operations
Sitewide	GWTP – Operations and Maintenance	Utilizes existing GWTP to treat groundwater from dewatering operations, groundwater generated from hydraulic containment pumping, and water generated from thermal extraction operations Operations continue for 9 years (assume 2016 through 2024)
	Passive Groundwater Treatment	Performed as described for Alternative 4 Performed for approximately 20 years (year 2024 to 2043 based on 2016 start)
	Groundwater Monitoring and Reporting	Includes quarterly Upper Aquifer and annual Lower Aquifer sampling and analysis and preparation of an annual report.
	Remedial Action Timeframe	Estimate 29 years (concludes in year 2043 based on year 2016 start)
	Cost	Common Elements (total): $51.5 million Capital (total – 2016 base year): $41.0 million O&M (annual): Ranges from $284,000 to $9.3 million (during thermal treatment) O&M and Periodic (total): $49.5 million Total Present Worth: $134.1 million Total Non-discounted: $149.1 million

Notes:

CY	cubic yard
DNAPL	dense non-aqueous phase liquid
EAB	enhanced aerobic biodegradation
FFS	focused feasibility study
GWTP	groundwater treatment plant
IC	institutional control
ISS	In situ Solidification/Stabilization
LNAPL	light non-aqueous phase liquid
MNA	monitored natural attenuation
NAPL	non-aqueous phase liquid
O&M	operations and maintenance
OU	operable unit
scfm	standard cubic foot per minute

TABLE 3-5b
Durations of Steam Injection in Treatment Volumes
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Target	Treated Soil Volume (CY)	Duration of Steam Pre-Heating (days)	Duration of Steam Distillation (days)	Total Steam Duration[a] (months)	Steam per Unit Soil Volume[b] (lbs/cy)
Core Area					
Core A	30,800	18	255	9.0	1,427
Core B	36,100	21	221	8.0	1,094
Core C	44,800	26	277	9.9	1,100
East Shallow (LNAPL)					
East South	65,000	38	323	11.9	913
East North	78,000	45	366	13.5	868
North Shallow (LNAPL)					
North Shallow	18,600	11	94	3.5	920
Total (All Zones)	**272,900**	**Not Applicable**	**1,536**	**56**	**1,013**

Notes
[a] This column includes the initial heating and presents the total duration of steam injection.
[b] This column presents the calculated mass of steam injected divided by the treated soil volume.

CY cubic yard
FFS focused feasibility study
Lbs/cy pounds per cubic yard
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
OU operable unit

TABLE 3-5c

Estimates of NAPL Recovery during Thermal Treatment

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

	NAPL Volumes (gallons)				
Remedial Target Zone	**Pre-Steam [a]**	**Steam Enhanced NAPL Recovery [b]**	**Post-Heating Residual NAPL[c]**	**Recovered via Distillation (76.6 percent efficiency)**	**Residual for EAB Treatment [d]**
Core Area					
Core A	100,600	16,600	84,000	64,300	19,600
Core B	87,500	14,500	73,000	56,000	17,000
Core C	108,000	17,900	90,100	69,100	21,100
East Shallow (LNAPL)					
East South	64,000	10,600	53,400	40,900	12,500
East North	70,800	11,700	59,100	45,300	13,800
North Shallow (LNAPL)					
North Shallow	17,500	2,900	14,600	11,200	13,800
Total (All Zones) [d]	448,000	74,200	374,000	287,000	87,500

Notes:

[a] This is the volume of NAPL present at the start of steam injection (e.g. following enhanced NAPL recovery). [b] This is the volume of NAPL recovered during the initial steam injection or pre-heating phase (i.e., 75% of the remaining mobile NAPL after enhanced NAPL recovery and no immobile NAPL).

[c] This is the residual NAPL remaining after initial heating and is calculated by subtracting the steam enhanced NAPL recovery from the pre-steam NAPL volume.

[d] Due to significant figure and rounding carry over, Residual for EAB Treatment and Total (All Zones) volumes may not sum exactly.

EAB enhanced aerobic biodegradation
FFS focused feasibility study
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
OU operable unit

TABLE 3-6

Components of Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
Not Applicable	Common Elements	Preconstruction activities Access Roads Concrete demolition, decontamination/reuse Debris removal Bulkhead removal Other demolition Stormwater infiltration trench Sheet pile wall Concrete perimeter wall Passive groundwater treatment Site cap MNA, access controls, and 5 year reviews
Upper Core Area	Soil Excavation and Thermal Desorption	Excavate an estimated 81,300 CY of NAPL contaminated soil to depth of 20 feet Excavation area divided into nine smaller cells using sheet pile to allow for dewatering and treatment of dewatering fluids in the GWTP Excavated soil transferred to staging area for drying and blending Thermal desorption treatment performed inside a new building. Exhaust gases discharged to the atmosphere. Treated soil staged, sampled to confirm treatment effectiveness, and used to backfill the excavation
Lower Core Area, East Shallow (LNAPL), North Shallow (LNAPL), North Deep (DNAPL)	Thermal Enhanced Extraction	Performed as described for Alternative 5
Periphery	EAB	Performed as described for Alternative 5
Sitewide	GWTP – Operations and Maintenance	Utilizes existing GWTP to treat groundwater from dewatering operations, groundwater generated from hydraulic containment pumping, and water generated from thermal extraction operations Operations continue for 10 years (assume 2016 through 2025)
	Passive Groundwater Treatment	Performed as described for Alternative 4 Performed for approximately 19 years (year 2025 to 2043 based on 2016 start)
	Groundwater Monitoring and Reporting	Includes quarterly Upper Aquifer and annual Lower Aquifer sampling and analysis and preparation of an annual report.

TABLE 3-6

Components of Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
	Remedial Action Timeframe	Estimate 28 years (concludes in year 2043 based on year 2016 start)
	Cost	Common Elements (total): $51.5 million Capital (total – 2016 base year): $99.9 million O&M (annual): Ranges from $284,000 to $9.4 million (during thermal treatment) O&M and Periodic (total): $49.6 million Total Present Worth: $185.7 million Total Non-discounted: $208.9 million

Notes:

CY cubic yard
DNAPL dense non-aqueous phase liquid
EAB enhanced aerobic biodegradation
FFS focused feasibility study
GWTP groundwater treatment plant
LNAPL light non-aqueous phase liquid
MNA monitored natural attenuation
NAPL non-aqueous phase liquid
O&M operations and maintenance
OU operable unit
Scfm standard cubic foot per minute

TABLE 3-7a

Components of Alternative 7 – ISS of Core Area and Thermal Enhanced Recovery

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
Sitewide	Common Elements	Preconstruction activities Access Roads Concrete Demolition, Decontamination/Reuse Debris removal Bulkhead removal Other demolition Stormwater infiltration trench Concrete perimeter wall New outfall for GWTP and stormwater discharge Passive groundwater treatment (passive drainage) Site cap MNA, ICs, and 5-year reviews
Core Area and Perimeter	ISS - Auger	Core Area. Treat of 85,300 CY of NAPL contaminated material to depths of 50 feet. Excavated Soil. Treat 20,600 CY of material, removed to offset ISS swell, using ex situ ISS methods and reuse this material for grading – contouring. The perimeter of the NAPL contaminated zone would be treated using higher strength – low leachability reagent material to create a "rind" or hardened shell to provide increased durability.
East Shallow (LNAPL) North Shallow (LNAPL) North Deep (DNAPL) Periphery	Enhanced NAPL Recovery	Installation of 92 NAPL extraction wells Pumping of NAPL and groundwater for 2 years NAPL and groundwater separation/treatment performed in GWTP equipped with new oil-water separator and equipment to handle higher temperature water NAPL disposed offsite, groundwater discharged to harbor via new outfall
	Thermal Enhanced Extraction	East Shallow (LNAPL) divided into two smaller cells (North and South) as described for Alternative 5. North Shallow (LNAPL) and North Deep (DNAPL) addressed as a single area. Installation of shallow vapor barrier Installation of 66 multi-purpose thermal and EAB wells, 92 temperature monitoring wells, and 31 EAB wells Re-purposing of 92 NAPL recovery wells as fluid/vapor extraction and EAB wells Installation of above ground vapor/condensate treatment system and steam generation equipment

TABLE 3-7a

Components of Alternative 7 – ISS of Core Area and Thermal Enhanced Recovery

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Remedial Action Target Zone	Component	Description
	Thermal Enhanced Extraction O&M	Treatment sequence is as follows: East Shallow (LNAPL) South, East Shallow (LNAPL) North, and North Shallow (LNAPL)/North Deep (DNAPL) Treatment steps include: dewatering, steam injection, fluids/vapor extraction, and fluids/vapor treatment Steam injected at higher rate, initially, over an estimated 18 day period to raise subsurface temperature and promote recovery of remaining mobile NAPL; rate then decreased with injection continuing for 255 days to complete balance of NAPL recovery Performance monitoring during operations to optimize steam injection/fluid/vapor extraction rates Initiate EAB after steam injection turned off Disassemble aboveground components and move to next treatment cell in the sequence
	EAB	Inject air through multi-purpose wells at rates varying from 100 to 200 scfm. Assume 8 scfm flow rate per well In situ biodegradation performance enhanced by residual heat from thermal treatment operations
Sitewide	GWTP – Operations and Maintenance	Utilizes existing GWTP to treat groundwater from dewatering operations, groundwater generated from hydraulic containment pumping, and water generated from thermal extraction operations Operations continue for 11 years (assume 2016 through 2026)
	Passive Groundwater Treatment	Performed as described for Alternative 4 Performed for approximately 6 years (year 2026 to 2031 based on 2016 start)
	Groundwater Monitoring and Reporting	Includes quarterly Upper Aquifer and annual Lower Aquifer sampling and analysis and preparation of an annual report.
	Remedial Action Timeframe	Estimate 16 years (concludes in year 2031 based on year 2016 start)
	Cost	Common Elements (total): $32.9 million Capital (total – 2016 base year): $30.7 million O&M (annual): Ranges from $284,000 to $5.0 million (during thermal treatment) O&M and Periodic (total): $23.7 million Total Present Worth: $85.2 million Total Non-discounted: $95.9 million

Notes:

CY	cubic yard	LNAPL	light non-aqueous phase liquid
DNAPL	dense non-aqueous phase liquid	MNA	monitored natural attenuation
EAB	enhanced aerobic biodegradation	NAPL	non-aqueous phase liquid
FFS	focused feasibility study	O&M	operations and maintenance
GWTP	groundwater treatment plant	OU	operable unit
IC	institutional control	scfm	standard cubic foot per minute
ISS	In situ Solidification/Stabilization		

TABLE 3-7b

Estimates of Soil and NAPL Treatment Volumes for Alternative 7

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Target Zone	Target Soil Volume (CY)	Treated NAPL Volume (gallons)	NAPL Density (gallons per CY)	Technology
Core	112,000	384,000	3.4	ISS
East Shallow and North Shallow (LNAPL)	162,000	198,000	1.2	NAPL Recovery and EAB
North Deep (DNAPL)	29,900	29,400	1.0	NAPL Recovery and EAB
Other Periphery	327,000	66,700	0.2	EAB
Treatment Total	630,000	678,000	1.1	
No Treatment	125,000	1,000	0.01	-
Site Total	755,000	679,000	0.9	

Notes:

CY cubic yard
DNAPL dense non-aqueous phase liquid
EAB enhanced aerobic biodegradation
FFS focused feasibility study
ISS In situ Solidification/Stabilization
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
OU operable unit

TABLE 3-7c

Estimates of NAPL Recovery during Pumping of Treatment Volumes

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Target Zone	Initial NAPL Volume (gallons)	NAPL Recovery Volume (gallons)	Remaining NAPL Volume (gallons)
Core	384,000	-	0*
East Shallow and North Shallow (LNAPL)	198,000	67,200	130,000
North Deep (DNAPL)	29,400	10,000	19,400
Other Periphery	66,700	0	66,700
Treatment Total	678,000	77,200	216,000
No Treatment	1,000	0	1,000
Site Total	679,000	77,200	217,000

Notes:

* Treated with ISS before NAPL recovery is initiated.

DNAPL dense non-aqueous phase liquid
FFS focused feasibility study
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
OU operable unit

TABLE 3-7d

Duration Estimates for Initial Heating of Volumes to Optimal Degradation Temperatures

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Target Zone	Heated Soil Volume (CY)	Duration of Heating (days)
East Shallow and North Shallow (LNAPL)	162,000	154
North Deep (DNAPL)	29,900	24
Other Periphery	327,000	255
TOTAL	519,000	433

Notes:

CY cubic yard
DNAPL dense non-aqueous phase liquid
FFS focused feasibility study
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
OU operable unit

TABLE 3-7e

Estimates of Naphthalene Concentration Reduction in Groundwater after 8 Years of Thermal Enhanced Treatment

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Target Zone	Treated Soil Volume (CY)	NAPL Volume Treated (gallons)	Treatment Temperature (°C)	Bulk NAPL Mass Transfer Coefficient (1 per day)	Assumed Naphthalene Half Life (days)	Groundwater Naphthalene Reduction (percent)
East Shallow and North Shallow (LNAPL)	162,000	130,000	40	0.1	7.5	86
North Deep (DNAPL)	29,900	19,400	40	0.1	7.5	95
Other Periphery	327,000	66,700	22	0.05	15	97
Treatment Total	630,000	216,000	--	-	-	94
No Treatment	125,000	1,000	12	-	258	11
Non-ISS Site Total	643,000	217,000	--	-	-	96*

Notes:

*Estimated reduction in naphthalene concentration of combined influent entering passive treatment system compared to no NAPL recovery or enhanced biological degradation following ISS in the Core.

--: not applicable

°C degrees Celsius
CY cubic yard
DNAPL dense non-aqueous phase liquid
FFS focused feasibility study
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-1
CERCLA Remedial Action Alternative Evaluation Criteria
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Threshold Criteria	
Overall Protection of Human Health and the Environment	Alternatives are assessed to determine whether they can adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site by eliminating, reducing, or controlling exposures to levels established during development of remediation goals consistent with §300.430(e)(2)(i). Overall protection of human health and the environment draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The assessment against this criterion describes how the alternative, as a whole, achieves and maintains protection of human health and the environment.
Compliance with Applicable or Relevant and Appropriate Requirements	Alternatives are assessed to determine whether they attain Applicable or Relevant and Appropriate Requirements under federal environmental laws and state environmental or facility siting laws or provide grounds for invoking one of the waivers identified in Code of Federal Regulations, Title 40, Section 300.430 (f)(1)(ii)(C). This assessment also addresses other information from advisories, criteria, and guidance that the lead and support agencies have agreed is "to be considered."
Balancing Criteria	
Long-Term Effectiveness and Permanence	Alternatives are assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered, as appropriate, include the following: (1) Magnitude of residual risk from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. The characteristics of the residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate. (2) Adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste. This factor addresses in particular the uncertainties associated with land disposal for providing long-term protection from residuals; the assessment of the potential need to replace technical components of the alternative, such as a cap, a slurry wall, or a treatment system; and the potential exposure pathways and risks posed should the remedial action need replacement.
Reduction of Toxicity Mobility or Volume through Treatment	Alternatives are evaluated to assess the degree to which they employ recycling or treatment that reduces toxicity mobility or volume, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include the following: (1) The treatment or recycling processes the alternatives employ and materials they will treat; (2) The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled; (3) The degree of expected reduction in TMV of the waste due to treatment or recycling and the specification of which reduction(s) are occurring; (4) The degree to which the treatment is irreversible; (5) The type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents; and (6) The degree to which treatment reduces the inherent hazards posed by principal threats at the site.
Short-Term Effectiveness	Alternatives are evaluated to assess the short-term impacts considering the following:

TABLE 4-1
CERCLA Remedial Action Alternative Evaluation Criteria
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

	(1) Short-term risks that might be posed to the community during implementation of an alternative; (2) Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures; (3) Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; and (4) Time until protection is achieved
Implementability	Alternatives are evaluated to assess the ease or difficulty of implementation considering the following as appropriate: (1) Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy. (2) Administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions); (3) Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and availability of prospective technologies.
Cost	Alternatives are evaluated with respect to the capital cost, annual operation and maintenance cost, periodic cost, and total life-cycle cost (present worth cost). Present worth costs were estimated using the real discount rate published in Appendix C (“Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analyses”) of “Guidelines and Discount Rates for Benefit Cost Analysis of Federal Programs” (OMB Circular A 94), effective through June 2014. The cost estimates were prepared in accordance with A Guide to Developing and Documenting Cost Estimates During the Feasibility Study (EPA 540 R 00 002), along with Cost Estimating Guide (DOE G 430.1 1). The cost estimates are for comparison purposes and are prepared to meet the 30 to +50 percent range of accuracy recommended in CERCLA Remedial Investigation/Feasibility Study Guidance (EPA/540/G 89/004). The cost estimates are based on specific response action scenarios and assumptions. Detailed sensitivity analyses were not performed to quantify the potential effect of changing key parametric assumptions.
Modifying Criteria (not evaluated in the FFS report)	
State Acceptance	This assessment reflects the state’s (or support agency’s) apparent preferences among or concerns about alternatives.
Community Acceptance	This assessment reflects the community’s apparent preferences among or concerns about alternatives.

Note:
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
LNAPL light non-aqueous phase liquid
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-2
Detailed Evaluation for Alternative 1 – No Action
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Threshold Criteria		
Overall Protection of Human Health and the Environment	No	**Does not protect human health and the environment:** – No land or groundwater use controls established to protect human health. – NAPL and dissolved phase contaminants would continue to migrate resulting in potential for human and ecological receptor exposure within the intertidal area.
Compliance with Applicable or Relevant and Appropriate Requirements	No	**Does not achieve Applicable or Relevant and Appropriate Requirements:** – Since there is no action, chemical-specific ARARs for marine surface water quality protection would not be achieved.
Balancing Criteria		
Long-term Effectiveness and Permanence	N/A	Alternative 1 fails the threshold criteria, and cannot be selected. Therefore, an evaluation against the balancing criteria was not performed.
Reduction of Toxicity Mobility or Volume through Treatment	N/A	
Short-term Effectiveness	N/A	
Implementability	N/A	
Cost	$ 0	Although this alternative assumes that routine operations and maintenance of the hydraulic containment remedy would continue through 2015, no costs are included in this FFS.
Modifying Criteria		
State Acceptance		Not evaluated in this FFS. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan
Community Acceptance		

Notes:
FFS focused feasibility study
N/A not applicable
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-3

Detailed Evaluation for Alternative 2 – Containment

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Threshold Criteria		
Overall Protection of Human Health and the Environment	Yes	**Protects human health and the environment:** – Land use institutional controls and soil cover prevent contact with untreated soil present in top 15 feet. – Groundwater use institutional controls in the Upper and Lower Aquifer protect against direct contact by prohibiting use. – Upper Aquifer containment pumping prevents transport of dissolved phase contaminants to intertidal area. Pumping also removes NAPL lessening the potential for future migration. – Natural attenuation processes reduce dissolved phase contaminant concentrations in Aquitard and Lower Aquifer. – Replacement of the sheet pile wall reduces potential for NAPL migration.
Compliance with Applicable or Relevant and Appropriate Requirements	Yes	**Complies with Applicable or Relevant and Appropriate Requirements:** - Hydraulic and physical containment expected to achieve soil and groundwater preliminary remediation goals that achieve chemical-specific Applicable or Relevant and Appropriate Requirements for marine water quality in the intertidal area. – Modification of existing remedy components and installation of new components would be performed in accordance with action and location-specific Applicable or Relevant and Appropriate Requirements.
Balancing Criteria		
Long-term Effectiveness and Permanence	★☆☆	**Performs less well:** – Estimate 53 percent of the NAPL mass (based on naphthalene removal) would remain at the end of the 100-year remedial action period resulting in significant residual risk. – Maintenance of containment systems (hydraulic, groundwater treatment plant, sheet pile wall, and soil cap) and enforceable land and groundwater use institutional controls would continue during the 100-year remedial action period. However, this maintenance would discontinue after 100 years, therefore, the adequacy and reliability of these controls would decrease over time.
Reduction of Toxicity Mobility or Volume through Treatment	★☆☆	**Performs less well:** – Estimate a 47 percent reduction in NAPL mass through recovery/treatment employing hydraulic containment. Natural attenuation processes (anaerobic biodegradation) would also reduce toxicity mobility or volume but some uncertainty on the actual rate of biodegradation that would occur. – Addresses principal threat (NAPL mobility) through containment strategy.
Short-term Effectiveness	★★☆	**Performs moderately well:** – Poses minimal risk to the community because majority of work occurs onsite with vehicle traffic limited to groundwater treatment plant operators (daily), media changeout (annual), and NAPL transport (annual). – Onsite workers and subcontractors have training and experience that minimize their risk.

TABLE 4-3

Detailed Evaluation for Alternative 2 – Containment

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		– Construction of remaining alternative elements and remedy operations and maintenance poses little risk to the environment if the system remains operational. – This alternative not expected to achieve the NAPL performance goals or remedial action objectives within the 100 -year remedial action timeframe.
Implementability	★★☆	**Performs moderately well:** – Many of the technologies employed by this alternative are currently in use at the Wyckoff site or have been implemented at similar CERCLA wood-treating sites. However, there is limited experience operating these systems for up to 100 years. – It is expected that some administrative coordination will be required for new construction associated with the outfall and sheet pile wall due to site's proximity to waters of the State. – Given the site's location, and longevity of this alternative, there is some uncertainty on whether the materials and services will be readily available for the duration.
Present Worth Cost (base year 2016)	$70.6 million	– Common elements: $43.0 million – Capital cost remedial technology: $1.6 million – Annual operations and maintenance cost: $0.52 million per year for years 1 to 100 – Total operations and maintenance and periodic costs:$14.2 million
Modifying Criteria		
State Acceptance		Not evaluated in this FFS report. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan
Community Acceptance		

Notes:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
N/A not applicable
NAPL non-aqueous phase liquid
O&M operations and maintenance
OU operable unit

TABLE 4-4

Detailed Evaluation for Alternative 4 – In situ Solidification/Stabilization

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		Threshold Criteria
Overall Protection of Human Health and the Environment	Yes	**Protects human health and the environment** – Land use institutional controls and soil cover protect human health and ecological receptors from contact with ISS treated soil present in top 15 feet. – Groundwater use institutional controls for the Upper and Lower Aquifer's protect human health by prohibiting groundwater use. – Treatment of NAPL source material protects the environment by reducing the potential for NAPL migration and dissolved phase plume regeneration. – Passive groundwater treatment intercepts low concentration dissolved phase polycyclic aromatic hydrocarbons and pentachlorophenol present in lower portion of Upper Aquifer following ISS treatment thereby preventing transport to intertidal zone. – Natural attenuation processes reduce dissolved phase contaminant concentrations in the Aquitard and Lower Aquifer.
Compliance with Applicable or Relevant and Appropriate Requirements	Yes	**Complies with Applicable or Relevant and Appropriate Requirements:** - Soil and groundwater preliminary remediation goals protective of sediment and surface water chemical-specific Applicable or Relevant and Appropriate Requirements achieved in the treatment zone. – Remedy design and construction would be performed to assure compliance with action and location-specific Applicable or Relevant and Appropriate Requirements.
		Balancing Criteria
Long-term Effectiveness and Permanence	★★★	**Performs very well:** – Estimate that 2 percent of the NAPL source material would remain following in situ solidification/stabilization treatment. This material addressed through passive groundwater treatment and natural attenuation processes. – NAPL source material physically/chemically converted in situ to a durable and insoluble solid posing limited risk to human health and the environment. In situ solidification/stabilization columns evaluated at other sites after 10 years of weathering showed no loss of integrity. – Technology promotes excellent contact between reagent and contaminated material resulting in high degree of treatment effectiveness. – Land use institutional controls would be maintained to prevent intrusion into the ISS treatment zone. However, no restrictions on above-grade land use or construction are necessary. – Groundwater use institutional controls would be maintained for the Upper and Lower Aquifers. These controls used at many CERCLA sites, and are expected to be reliable based on site's proposed future recreational use.

TABLE 4-4

Detailed Evaluation for Alternative 4 – In situ Solidification/Stabilization

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Reduction of Toxicity Mobility or Volume through Treatment	★★☆	**Performs moderately well:** – Estimate 98 percent of the NAPL source zone is treated. – Toxicity reduced by decreasing the concentration and bioavailability of contaminants present in the NAPL. – Mobility reduced by physically/chemically alternating the characteristics of NAPL source material to make it immobile and insoluble. – Volume of NAPL source material is not reduced. Contaminants are not destroyed. – Addresses the principal threat (NAPL mobility and toxicity) through mobility and toxicity reduction.
Short-term Effectiveness	★★★	**Performs very well:** – Community impacts from heavy construction traffic, extended work hours, and heavy equipment noise will occur for 3 years, less than other alternatives. – Onsite workers and subcontractors have training and experience that minimize their risk. Work around rotational, pressurized equipment poses greater risk to workers but controls will be established. – Potential for short-term environmental impacts from heavy equipment use, excavated materials handling, cement batch plant, ex situ treatment, staging and material reuse along a marine shoreline setting. Storm water best management practices would be used to control run-on and run-off effects. – This alternative achieves NAPL mobility reduction performance objective in the shortest time frame (estimate 3 years). Passive groundwater treatment to address remaining 2 percent of non-ISS treated zone completed within about 10 years.
Implementability	★★☆	**Performs moderately well:** – Deep auger mixing and jet grouting are mature technologies used for remediation and ground improvement applications. Large, heavy equipment will pose mobilization and maneuvering challenges. – Deployment is relatively straightforward and quality assurance and quality control processes are well developed. – Several ISS vendors are available, although none are local. – A mix design, similar to that used at other sites assumed. Actual mix design will be developed during remedial design. – It is expected that some administrative coordination will be required for new construction associated with the outfall and sheet pile wall common elements due to site's proximity to waters of the State. – Successful implementation is dependent on locating and removing large subsurface debris that could interfere with the equipment. Excavation of soil to a depth of 7 feet should lessen the potential for obstructions or debris to interfere with equipment. Direct push technology has been used to drill borings to depths of 70 feet at the site, however treatment depths approach auger mixing equipment limits. – The passive groundwater treatment component uses familiar technology but in an innovative manner.

TABLE 4-4

Detailed Evaluation for Alternative 4 – In situ Solidification/Stabilization

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Present Worth Cost (base year 2016)	$86.3 million	− Capital cost common elements: $35.1 million − Capital cost remedial technology: $50.1 million − Annual operations and maintenance cost: $0.8 million in years 1, 2 and 3, and $0.3 million in years 4 through 11. − Total operations and maintenance and periodic costs: $4.2 million.
Modifying Criteria		
State Acceptance **Community Acceptance**		Not evaluated in this FFS report. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan.

Notes:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-5

Detailed Evaluation for Alternative 5 – Thermal Enhanced Extraction and ISS

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

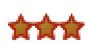
Criterion	Rating	Detailed Analysis
		Threshold Criteria
Overall Protection of Human Health and the Environment	Yes	**Protects human health and the environment:** – Groundwater institutional controls protect human health by prohibiting Upper Aquifer and Lower Aquifer groundwater use. – Human health is protected by extracting and thermally destroying the NAPL thereby reducing contaminant concentrations in subsurface soil and Upper Aquifer groundwater. – Environment is protected by removing NAPL, thereby preventing its migration, and lessening the potential for the formation and transport of soluble NAPL contaminants to the Lower Aquifer and intertidal areas. – Enhanced aerobic biodegradation reduces residual NAPL concentrations in Upper Aquifer groundwater. Residual thermal effects will increase degradation rates and overall effectiveness. Increased dissolved oxygen concentrations may also improve pore water quality in the intertidal zone. – Natural attenuation processes reduce dissolved phase contaminant concentrations in Aquitard and Lower Aquifer groundwater.
Compliance with Applicable or Relevant and Appropriate Requirements	Yes	**Complies with Applicable or Relevant and Appropriate Requirements:** – Soil and groundwater preliminary remediation goals protective of sediment and surface water quality Applicable or Relevant and Appropriate Requirements achieved within the treatment zone. – Remedy design and construction would be performed to assure compliance with action and location-specific Applicable or Relevant and Appropriate Requirements.
Balancing Criteria		
Long-term Effectiveness and Permanence		**Performs very well:** – Estimate 2 percent of the NAPL source material would remain following thermal and in situ solidification/stabilization treatment. This material would be addressed through enhanced aerobic biodegradation. – NAPL source material heated to enhance mobility and recovery. High-molecular weight polycyclic aromatic hydrocarbons, which comprise less than 15 percent of NAPL source material, may be more difficult to remove due to their physical/chemical properties. However, these contaminants unlikely to pose risk to HHE due to limited mobility and bioavailability. – Employs an array of complementary technologies that are expected to increase overall treatment effectiveness. – Groundwater use controls may have to be maintained for the Upper and Lower Aquifers. These controls are used at many CERCLA sites, and would be reliable based on the site's future recreational use.

TABLE 4-5

Detailed Evaluation for Alternative 5 – Thermal Enhanced Extraction and ISS

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Reduction of Toxicity Mobility or Volume through Treatment	★★★	**Performs very well:** – Estimate that 98 percent of the NAPL source zone treated using thermal and ISS technologies. – Toxicity reduced by removing NAPL mass and decreasing contaminant of concern concentrations in subsurface soil and Upper Aquifer groundwater. – Mobility of NAPL, pentachlorophenol and low-molecular weight polycyclic aromatic hydrocarbons decreased. – Volume of NAPL source material greatly reduced. Vapor phase NAPL constituents destroyed in an above ground thermal oxidation system. Contaminants present in aqueous phase are removed in the groundwater treatment plant and thermally destroyed when the granular-activated carbon media is regenerated. – Addresses the principal threat (NAPL mobility and toxicity) by removing and thermally destroying the NAPL.
Short-term Effectiveness	★★☆	**Performs moderately well:** – Community impacts from increased construction activity, facility operations and maintenance traffic, operations lighting and noise for approximately 10 years. Thermal oxidation and steam generation equipment discharge exhaust to the atmosphere. – Onsite workers and subcontractors have training and experience that minimizes their risks. Steam generation and conveyance pose additional hazards to onsite workers. Piping placed on racks to minimize hazards. – Potential for short-term environmental impacts from construction activity, and thermal oxidation and steam generation equipment operations. Storm water best management practices would be used to reduce the potential for run-on and run-off effects. – This alternative achieves NAPL mobility reduction performance objective in about 10 years. Enhanced aerobic biodegradation requires about 5 more years to degrade remaining NAPL and passive groundwater treatment 14 additional years. – Expected to have the largest greenhouse gas footprint of all the alternatives.

TABLE 4-5

Detailed Evaluation for Alternative 5 – Thermal Enhanced Extraction and ISS

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Implementability	★★☆	**Performs moderately well:** – Employs a large number of injection and extraction wells, above ground conveyance piping, and treatment system equipment. Intensive process control monitoring required. – Uses technologies that have been successfully deployed elsewhere. However, employs an innovative piece of equipment to manage naphthalene crystallization that resulted in early shutdown of the previous steam pilot. This piece of equipment is not off-the-shelf and will have to be custom fabricated. – Requires close coordination/sequencing of the NAPL recovery, thermal, in situ solidification/stabilization and enhanced anaerobic biodegradation treatment phases. Complex remedy. – Energy intensive requiring onsite energy generation using non-renewable (propane) energy source. – Passive groundwater treatment is included as a polishing step for low concentration aqueous contamination. Reliance on tidal induced gradient to induce flow through granular-activated carbon treatment vessels is innovative but unproven.
Present Value Cost	$134.1 million	– Capital cost common elements: $51.5 million – Capital cost remedial technology: $41.0 million – Annual operations and maintenance costs: Range from $0.3 million to $9.3 million – Total operations and maintenance and periodic costs: $49.5 million
Modifying Criteria		
State Acceptance		Not evaluated in this FFS report. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan.
Community Acceptance		

Notes:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-6

Detailed Evaluation for Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
Threshold Criteria		
Overall Protection of Human Health and the Environment	Yes	**Protects human health and the environment** – Human health protected by excavation and MTTD treatment of NAPL contaminated material to a depth of 20 feet in the Core Area, followed by NAPL recovery and thermal enhanced extraction from remainder of the treatment zones. – Excavation and MTTD treatment provides the highest level of protection for human health in the ground surface to 15 foot depth exposure horizon. – Groundwater institutional controls protect human health by prohibiting Upper Aquifer and Lower Aquifer groundwater use. – Environment is protected by removing mobile NAPL and soluble NAPL contaminants from subsurface soil and Upper Aquifer groundwater thereby preventing migration to the intertidal area. – Enhanced anaerobic biodegradation reduces residual NAPL concentrations in the Upper Aquifer further. Residual thermal effects increase degradation rates and overall effectiveness. Increased dissolved oxygen concentrations may also improve pore water quality in intertidal zone. – Natural attenuation processes reduce dissolved phase contaminant concentrations in Aquitard and Lower Aquifer groundwater. Residual heat from thermal treatment may increase attenuation rates.
Compliance with Applicable or Relevant and Appropriate Requirements	Yes	**Complies with Applicable or Relevant and Appropriate Requirements:** – Soil and groundwater preliminary remediation goals protective of sediment and surface water quality Applicable or Relevant and Appropriate Requirements achieved within the treatment zone. – This alternative expected to achieve unrestricted use/unrestricted exposure Applicable or Relevant and Appropriate Requirements within the ground surface to 15 foot depth exposure interval in the Core Area. – Remedy design and construction would be performed to assure compliance with action and location-specific Applicable or Relevant and Appropriate Requirements.
Balancing Criteria		
Long-term Effectiveness and Permanence	★★☆	**Performs moderately well:** – Estimate 14 percent of the NAPL would remain following excavation, NAPL recovery, and thermal treatment. Balance of NAPL source material treated using EAB. – Excavation and MTTD treatment in Upper Core Area may eliminate need for land use controls in portion of the site. – NAPL source material in Lower Core Area and remaining target zones heated to mobilize contaminants thus facilitating their removal. High-molecular weight polycyclic aromatic hydrocarbon, which comprise less than 15 percent of NAPL source material, may be more difficult to remove due to their physical/chemical properties. However, these contaminants unlikely to pose a threat to human health and the environment due to their limited mobility and bioavailability. – Employs an array of complementary technologies to increase effectiveness.

TABLE 4-6

Detailed Evaluation for Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		– Groundwater use controls may have to be maintained for the Upper and Lower aquifers. These controls used at many CERCLA sites, and would be reliable based on the site's future recreational use.
Reduction of Toxicity Mobility or Volume through Treatment	★★☆	**Performs moderately well:** – Estimate 87 percent of the NAPL source zone treated using excavation, MTTD, NAPL recovery, and thermal technologies. – Toxicity reduced by removing NAPL mass and decreasing contaminant concentrations in subsurface soil and groundwater. – Mobility reduced by removing NAPL mass especially the pentacholorophenal and low molecular weight polycyclic aromatic hydrocarbon fraction. – Volume of NAPL source material is reduced. Soil contaminants and vapor phase contaminants are destroyed in an above ground thermal oxidation unit. Contaminants present in aqueous phase are removed in the groundwater treatment plant and thermally destroyed when the granular-activated carbon media is reactivated. – Addresses the principal threat (NAPL mobility) by removing the NAPL, and treating the waste streams to destroy the contaminants.
Short-term Effectiveness	★★☆	**Performs moderately well:** – Community impacts associated with increased construction activity, and facility operations and maintenance traffic, operations lighting and noise for approximately 15 years. Thermal oxidation and steam generation equipment discharge exhaust to the atmosphere. – Onsite workers and subcontractors have training and experience that minimize their risks. Excavation to depths of 20 feet poses additional hazards to workers. Steam generation and conveyance piping, and thermal oxidation equipment also pose additional hazards to onsite workers. Piping placed on racks to minimize hazards. – Potential for short-term environmental impacts from construction activity, and thermal oxidation and steam generation equipment operations. Stormwater best management practices would be used to reduce the potential for run-on and run-off effects. – This alternative achieves NAPL mobility reduction performance objective in about 15 years. Passive groundwater treatment required for an 18 additional years. – Expected to have a greenhouse gas footprint comparable to Alternative 5.
Implementability	★★☆	**Performs moderately well:** – Excavation to depths of 20 feet requires 9 separate sheet pile wall cells and dewatering. – Employs a large number of injection and extraction wells, above ground conveyance piping, and treatment system equipment. Intensive process control monitoring required. – Uses technologies that have been successfully deployed elsewhere. However, employs an innovative piece of equipment to manage naphthalene crystallization that resulted in early shutdown of the previous steam pilot. This piece of equipment is not off-the-shelf and will have to be custom fabricated.

TABLE 4-6

Detailed Evaluation for Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		− Requires close coordination/sequencing of the excavation/MTTD, NAPL recovery, thermal, and enhanced aerobic biodegradation treatment phases. More complex remedy. − Energy intensive requiring onsite energy generation. − The passive treatment technology to be implemented following active NAPL source treatment is innovative but unproven.
Present Value Cost	$185.7 million	− Capital cost common elements: $51.5 million − Capital cost remedial technology: $99.9 million − Annual operations and maintenance costs: Range from $0.3 million to $9.4 million − Total operations and maintenance and periodic costs: $49.6 million
Modifying Criteria		
State Acceptance **Community Acceptance**		Not evaluated in this FFS report. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan

Notes:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
MTTD medium temperature thermal desorption
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-7

Detailed Evaluation for Alternative 7 – ISS of Core Area and Thermal Enhanced Recovery

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		Threshold Criteria
Overall Protection of Human Health and the Environment	Yes	**Protects human health and the environment:** – Land use institutional controls and soil cover protect human health and ecological receptors from contact with in situ solidification/stabilization treated soil present in the Core Area within top 15 feet. – Groundwater use institutional controls for the Upper and Lower Aquifer's protect human health by prohibiting groundwater use. – Thermal and in situ solidification/stabilization treatment of NAPL source material protects the environment by reducing the potential for NAPL migration and dissolved phase plume regeneration. – Enhanced anaerobic degradation treats residual NAPL and dissolved phase contaminants following thermal treatment. – Passive groundwater treatment intercepts low concentration dissolved phase polycyclic aromatic hydrocarbons and pentachlorophenol present in lowermost portion of Upper Aquifer following in situ solidification/stabilization treatment of the Core Area preventing migration to intertidal zone. – Natural attenuation processes reduce dissolved phase contaminant concentrations in Aquitard and Lower Aquifer.
Compliance with Applicable or Relevant and Appropriate Requirements	Yes	**Complies with Applicable or Relevant and Appropriate Requirements:** – Soil and groundwater PRGs protective of sediment and surface water quality Applicable or Relevant and Appropriate Requirements achieved within the treatment zone. – Remedy design and construction would be performed to assure compliance with action and location-specific Applicable or Relevant and Appropriate Requirements.
Balancing Criteria		
Long-term Effectiveness and Permanence	★★★	**Performs very well:** – Estimate 62 percent of the NAPL source material would be treated using in situ solidification/stabilization and the remainder using thermal technology. Less than 2 percent would require treatment using enhanced anaerobic degradation. – NAPL source material in the Core Area physically/chemically converted in situ to a durable and insoluble solid posing limited threat to human health and the environment. In the other target zones, NAPL source material heated to enhance mobility and recovery. – In situ solidification/stabilization technology promotes excellent contact between reagent and contaminated material resulting in high degree of treatment effectiveness in the Core Area. Thermal and enhanced anaerobic degradation treatment of NAPL source material present in the other target zones provides for a high level of treatment though use of complementary technologies. – Land use institutional controls would be maintained to prevent intrusion into the in situ solidification/stabilization treatment zone. However, no restrictions on above-grade land use or construction are necessary.

TABLE 4-7
Detailed Evaluation for Alternative 7 – ISS of Core Area and Thermal Enhanced Recovery
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		– Groundwater use institutional controls would be maintained for the Upper and Lower Aquifers. These controls used at many CERCLA sites, and are expected to be reliable based on site's proposed future recreational use.
Reduction of Toxicity Mobility or Volume through Treatment	★★★	**Performs very well:** – Estimate that 98 percent of the NAPL source material treated using in situ solidification/stabilization and thermal technology. – Toxicity reduced by decreasing the concentration and bioavailability of contaminants present in the NAPL. – NAPL mobility in the Core Area reduced by physically/chemically alternating its characteristics rendering it relatively immobile and insoluble. In the other target zones, NAPL is removed and thermally destroyed. – Volume of NAPL source material present in the Core Area is not reduced and contaminants are not destroyed using in situ solidification/stabilization technology. In the other target zones, significant toxicity mobility or volume is achieved through thermal enhanced extraction and destruction. – Addresses the principal threat (NAPL mobility and toxicity) through mobility reduction and removal.
Short-term Effectiveness	★★☆	**Performs moderately well:** – Community impacts from heavy construction traffic, extended work hours, and heavy equipment noise in the Core Area will occur for about 1 year. Impacts from thermal treatment operations will occur for about 8 years. – Onsite workers and subcontractors have training and experience that minimize their risks. Work around in situ solidification/stabilization rotational and pressurized equipment poses greater risk to workers but controls will be established. Thermal treatment requires conveyance of steam and high temperature vapor and liquids also posing hazards to remedial action workers. – Potential for short-term environmental impacts from heavy equipment use, excavated materials handling, batch plant, ex situ treatment, staging and material reuse along a marine shoreline setting. Dewatering/hydraulic containment in the thermal treatment areas will reduce potential for environmental impacts. Storm water best management practices would be used control run-on and run-off to minimize effects. – This alternative achieves NAPL mobility reduction performance objective in the approximately 10 years. Passive groundwater treatment can be implemented as necessary to address any residual dissolved phase contaminants remaining.
Implementability	★★☆	**Performs moderately well:** – Deep auger mixing is a mature technology used for remediation and ground improvement applications. Large, heavy equipment will pose mobilization and maneuvering challenges. – In situ solidification/stabilization deployment is relatively straightforward and quality assurance and quality control processes are well developed. – Several in situ solidification/stabilization vendors are available, although none are local.

TABLE 4-7

Detailed Evaluation for Alternative 7 – ISS of Core Area and Thermal Enhanced Recovery

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Rating	Detailed Analysis
		– A mix design, similar to that used at other sites assumed. Actual mix design will be developed during remedial design. – Employs a large number of injection and extraction wells, above ground conveyance piping, and treatment system equipment. Intensive process control monitoring required. – Successful in situ solidification/stabilization implementation is dependent on locating and removing large subsurface debris that could interfere with the equipment. Soil excavation to a depth of 7 feet should lessen the potential for obstructions or debris to interfere with equipment. – The passive groundwater treatment component uses familiar technology but in an innovative manner.
Present Value Cost	$85.2 million	– Capital cost common elements: $32.9 million – Capital cost remedial technology: $30.7 million – Annual operations and maintenance costs: Range from $0.3 million to $5.0 million – Total operations and maintenance and periodic costs: $23.6 million
Modifying Criteria		
State Acceptance **Community Acceptance**		Not evaluated in this FFS report. This criterion will be evaluated during the public comment period to be held following issuance of the Proposed Plan.

Notes:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
FFS focused feasibility study
NAPL non-aqueous phase liquid
OU operable unit

TABLE 4-8

Comparative Evaluation of Alternatives

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Alternative 1 – No Action	Alternative 2 - Containment	Alternative 4 - ISS	Alternative 5 – Thermal Enhanced Extraction and ISS	Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction	Alternative 7 – ISS of Core Area and Thermal Enhanced Recovery
Key Treatment Technologies						
- Core Area	Natural attenuation	Soil cap, hydraulic containment, and ICs	ISS, soil cap	Enhanced NAPL recovery, thermal enhanced extraction, EAB	Upper Core - Excavation, thermal desorption Lower Core – Enhanced NAPL recovery, thermal enhanced extraction, EAB	ISS
- East Shallow (LNAPL)					Enhanced NAPL recovery, thermal enhanced extraction, EAB	Enhanced NAPL recovery, thermal enhanced extraction, EAB
- North Shallow (LNAPL)						
- North Deep (DNAPL)				ISS		
- Other Periphery				EAB	EAB	EAB
Percent of NAPL Treated using Key Technologies						
– Hydraulic Containment	--	7	--	--	--	--
– NAPL Recovery	--	34	--	--	--	--
– ISS	--	--	95	12	--	37
– Enhanced NAPL Recovery/Thermal/EAB	--	--	--	26/52/8 (86 total)	21/43/18 (82 total)	26/31/6 (63 total)
– Excavation	--	--	--	--	14	--
– Passive Groundwater Treatment	--	--	1	1	1	1
– Natural Attenuation	100	12	4	1	3	--
Threshold Criteria						
Protects HHE	No	Yes	Yes	Yes	Yes	Yes
Complies with ARARs	No	Yes	Yes	Yes	Yes	Yes
Balancing Criteria						
Long-term Effectiveness and Permanence	Not evaluated	★☆☆	★★★	★★★	★★☆	★★★
Reduction of TMV through Treatment	Not evaluated	★☆☆	★★☆	★★★	★★☆	★★★

TABLE 4-8

Comparative Evaluation of Alternatives

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Criterion	Alternative 1 – No Action	Alternative 2 - Containment	Alternative 4 - ISS	Alternative 5 – Thermal Enhanced Extraction and ISS	Alternative 6 – Excavation, Thermal Desorption, and Thermal Enhanced Extraction	Alternative 7 – ISS of Core Area and Thermal Enhanced Recovery
Short-term Effectiveness		★★☆ O&M limited to 100 years	★★★	★★☆	★★☆	★★☆
Implementability		★★☆	★★☆	★★☆	★★☆	★★☆
Cost – Total Present Worth Cost (millions) – Total Non-discounted Cost (millions)	 $0 $0	 $70.6 $109.8	 $86.3 $91.8	 $134.1 $149.1	 $185.7 $208.8	 $85.2 $95.9
Modifying Criteria						
State Acceptance	Not evaluated in this FFS					
Community Acceptance						

★★★ = The alternative performs very well against the CERCLA balancing criterion with minimal disadvantages or uncertainties

★★☆ = The alternative performs moderately well against the CERCLA balancing criterion but with some disadvantages or uncertainties

★☆☆ = The alternative performs less well against the CERCLA balancing criterion with more disadvantages or uncertainty

TABLE 4-9

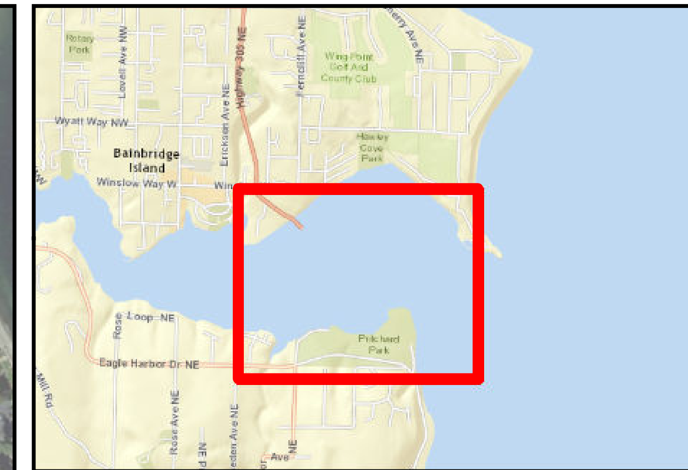
Remedial Action Alternative Cost Estimate Comparison

Soil and Groundwater OUs - Former Process Area

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

		Alternative 2	Alternative 4	Alternative 4a	Alternative 5	Alternative 5a	Alternative 6	Alternative 7
Pre-construction Activities		$869,000	$869,000	$869,000	$869,000	$869,000	$869,000	$869,000
Access Roads		$288,000	$288,000	$288,000	$288,000	$288,000	$288,000	$288,000
Concrete Demo		N/A	$2,195,000	$2,195,000	$2,195,000	$2,195,000	$2,195,000	$2,195,000
Debris Removal-Sitewide		N/A	$3,194,000	$3,194,000	$3,194,000	$3,194,000	$3,194,000	$1,127,000
Bulkhead Removal		$8,762,000	$8,762,000	$8,762,000	$8,762,000	$8,762,000	$8,762,000	$8,762,000
Other Demo		$1,271,000	$2,993,000	$2,993,000	$2,993,000	$2,993,000	$2,993,000	$2,993,000
Storm Water Infiltration Trench		N/A	$214,000	$214,000	$214,000	$214,000	$214,000	$214,000
Sheet Pile Wall		$13,287,000	N/A	N/A	$13,287,000	$13,287,000	$13,287,000	$0
Concrete Perimeter Wall		$11,176,000	$7,931,000	$7,931,000	$11,176,000	$11,176,000	$11,176,000	$7,931,020
Outfall		$3,293,000	$3,293,000	$3,293,000	$3,293,000	$3,293,000	$3,293,000	$3,293,000
Passive Drainage		N/A	$1,303,000	$1,303,000	$1,129,000	$1,129,000	$1,129,000	$1,129,275
Site Cap		$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000
	COMMON ELEMENTS SUBTOTALS:	***$43,046,000***	***$35,142,000***	***$35,142,000***	***$51,500,000***	***$51,500,000***	***$51,500,000***	***$32,901,295***
REMEDIAL TECHNOLOGIES								
Alternative 2 - Hydraulic Containment		$1,560,000						
Alternative 4 - ISS Treatment			$50,069,000	$57,457,000				
Alternative 5 - Thermal + Jet Grouting North Unit					$41,046,000	$41,046,000		
Alternative 6 - Thermal + MTTD							$99,917,000	
Alternative 7 - ISS Core + Thermal								$30,696,000
	REMEDIAL TECHNOLOGY SUBTOTALS:	***$1,560,000***	***$50,069,000***	***$57,457,000***	***$41,046,000***	***$41,046,000***	***$99,917,000***	***$30,696,000***
WTP O&M Costs								
WTP Operations		$50,985,000	$2,364,000	$4,728,000	$7,092,000	$9,456,000	$7,880,000	$8,668,000
100-yr O&M and Periodic Costs (non-discounted)								
Replace WTP Equipment/Piping		$600,000	$0	$0	$0	$0	$0	$0
Replace WTP Electrical/Mechanical		$12,000,000	$0	$0	$0	$0	$0	$0
Maintain Onsite Roads		$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000
Passive Treatment System Operations		$0	$2,664,000	$2,664,000	$5,396,000	$5,396,000	$5,396,000	$2,840,000
EAB		$0	$0	$0	$1,128,000	$1,128,000	$940,000	$1,504,000
NAPL Recovery		$0	$0	$0	$2,562,000	$2,562,000	$2,562,000	$0
Steam Enhancement		$0	$0	$0	$0	$0	$0	$8,064,000
Thermal Operations		$0	$0	$0	$37,455,000	$37,455,000	$37,760,000	$8,334,000
Well Abandonment		$0	$0	$0	$1,357,489	$1,357,489	$1,412,323	$1,357,489
5-yr Reviews		$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
GWTP Demolition		$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
Final Completion Report		$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
		$14,175,000	**$4,239,000**	**$4,239,000**	**$49,473,489**	**$49,473,489**	**$49,645,323**	**$23,674,489**
	50%	**$164,649,000**	**$137,721,000**	**$152,349,000**	**$223,666,500**	**$227,212,500**	**$313,413,000**	**$143,910,000**
Non-Discounted Cost (2014)		**$109,766,000**	**$91,814,000**	**$101,566,000**	**$149,111,000**	**$151,475,000**	**$208,942,000**	**$95,940,000**
	-30%	**$76,836,200**	**$64,270,000**	**$71,100,000**	**$104,380,000**	**$106,030,000**	**$146,260,000**	**$67,160,000**
	50%	**$105,885,000**	**$129,465,000**	**$137,145,000**	**$201,165,000**	**$196,215,000**	**$278,535,000**	**$127,725,000**
Present Worth Cost		**$70,590,000**	**$86,310,000**	**$91,430,000**	**$134,110,000**	**$130,810,000**	**$185,690,000**	**$85,150,000**
	-30%	**$49,413,000**	**$60,417,000**	**$64,001,000**	**$93,877,000**	**$91,567,000**	**$129,983,000**	**$59,605,000**

Figures



LEGEND

Approximate Operable Unit (OU) boundaries

- OU2 - Soil
- OU4 - Groundwater
- OU-1 FFS Project Area
- Harbor boundary

Sources:
Operable Units approximated from Superfund Fact Sheet Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington (USEPA, 1999).
Aerial: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

N

0 250 500 1,000 Feet

Figure 1-1
Location of Operable Units
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

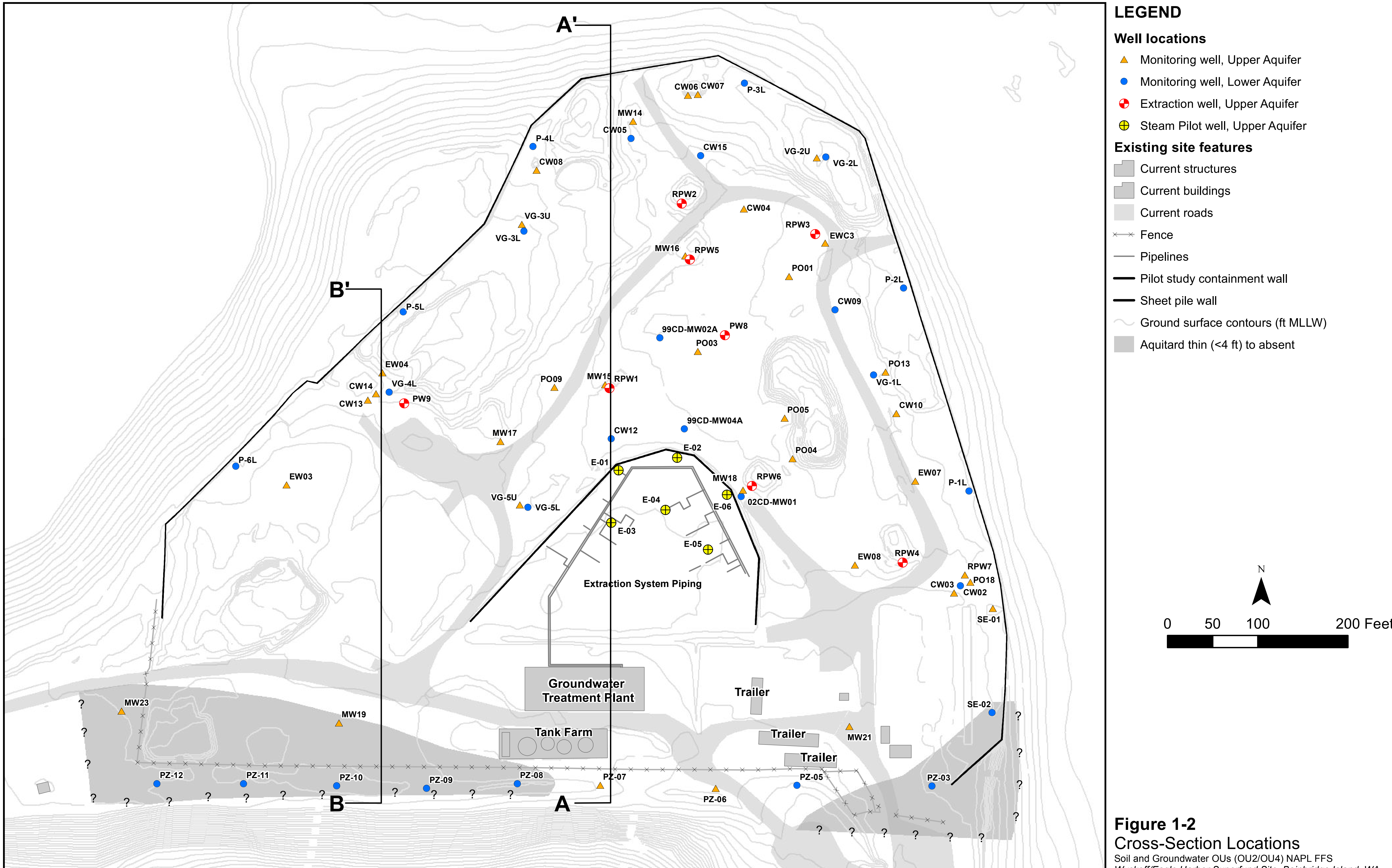
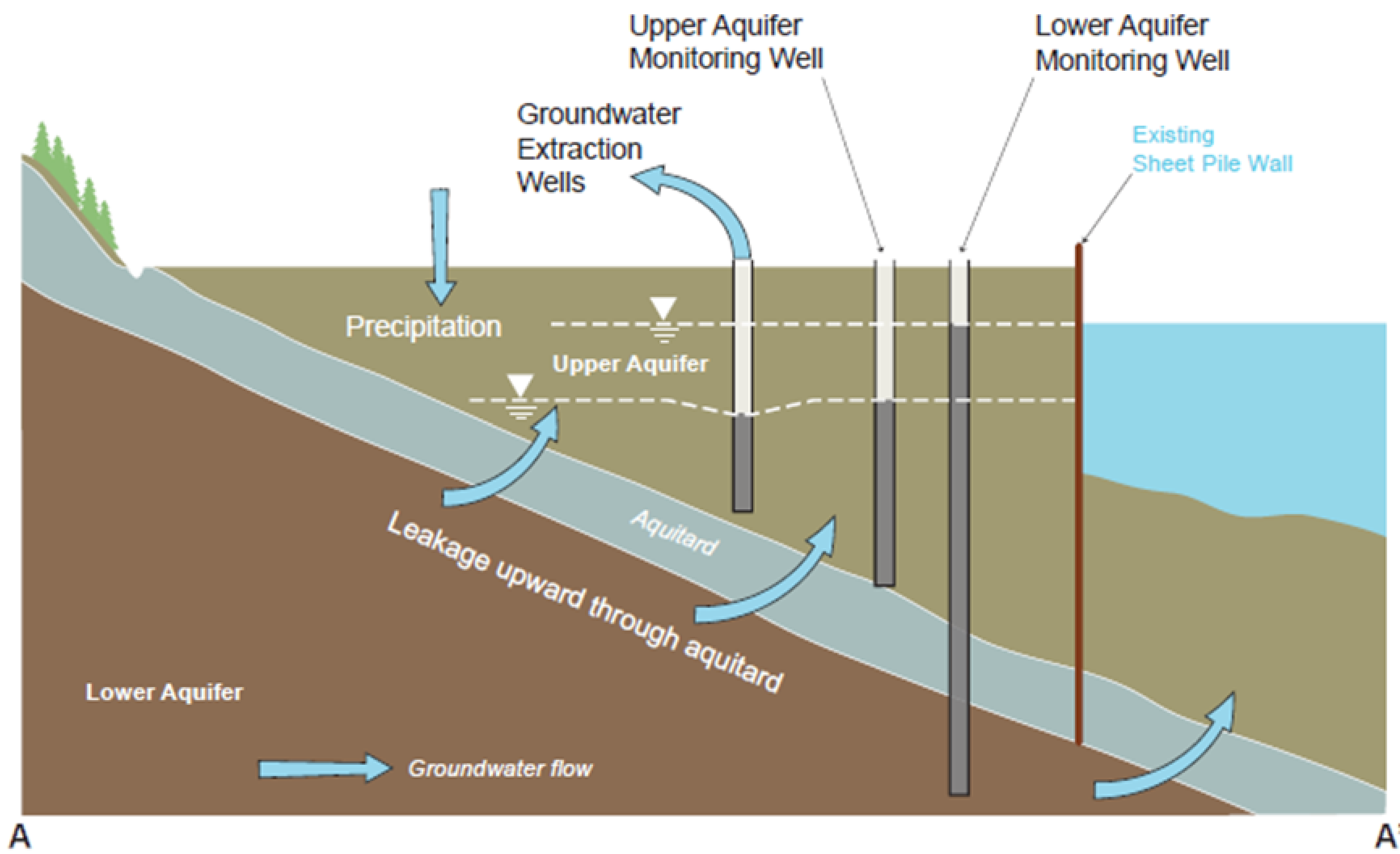
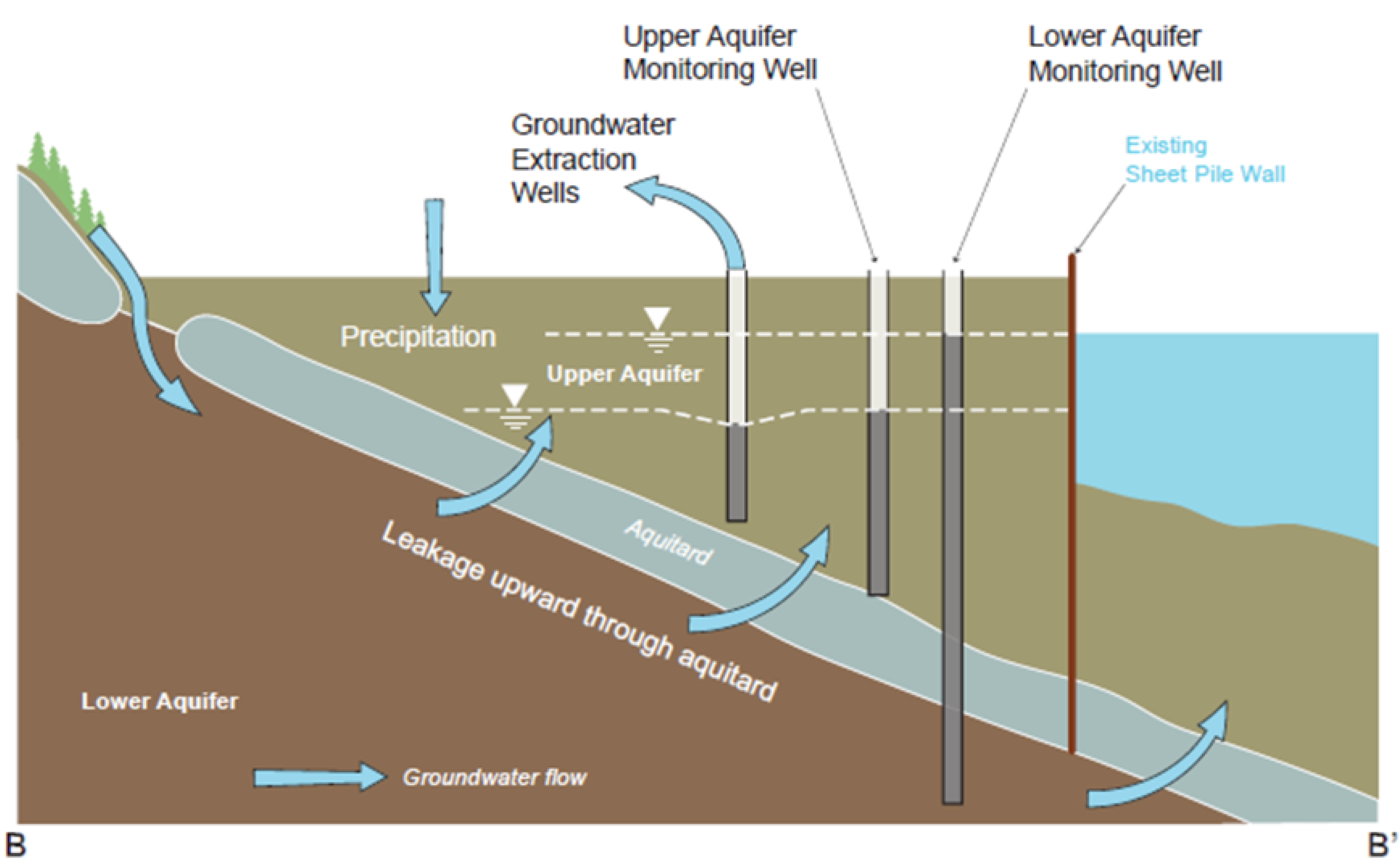


Figure 1-2
Cross-Section Locations
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-2_CROSSSECTIONS.MXD GGEE 9/18/2014 12:27:44 PM



Current Groundwater Conditions at A-A'



Current Groundwater Conditions at B-B'

Figure 1-3
Hydrogeologic Cross-Sections
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

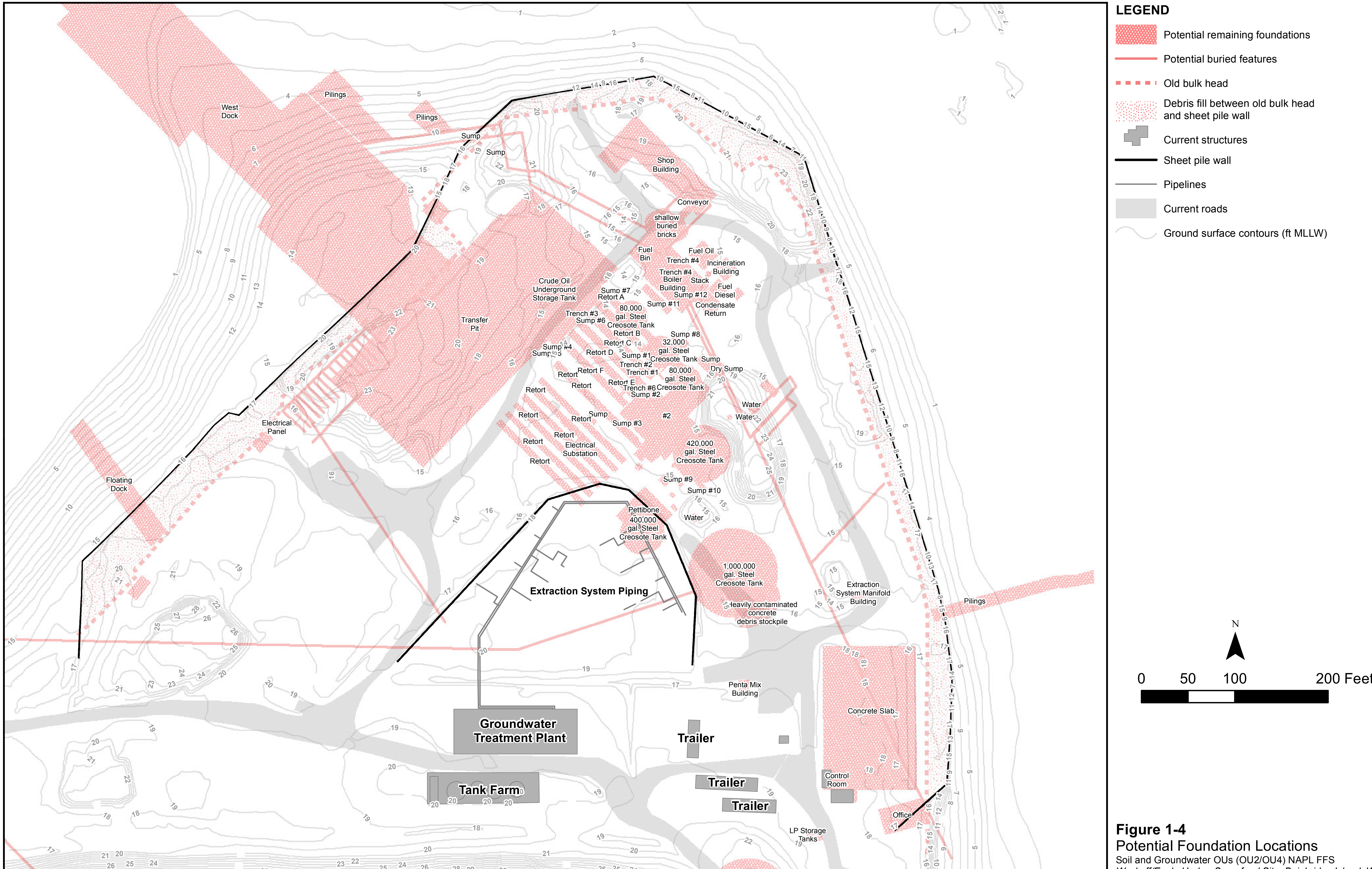


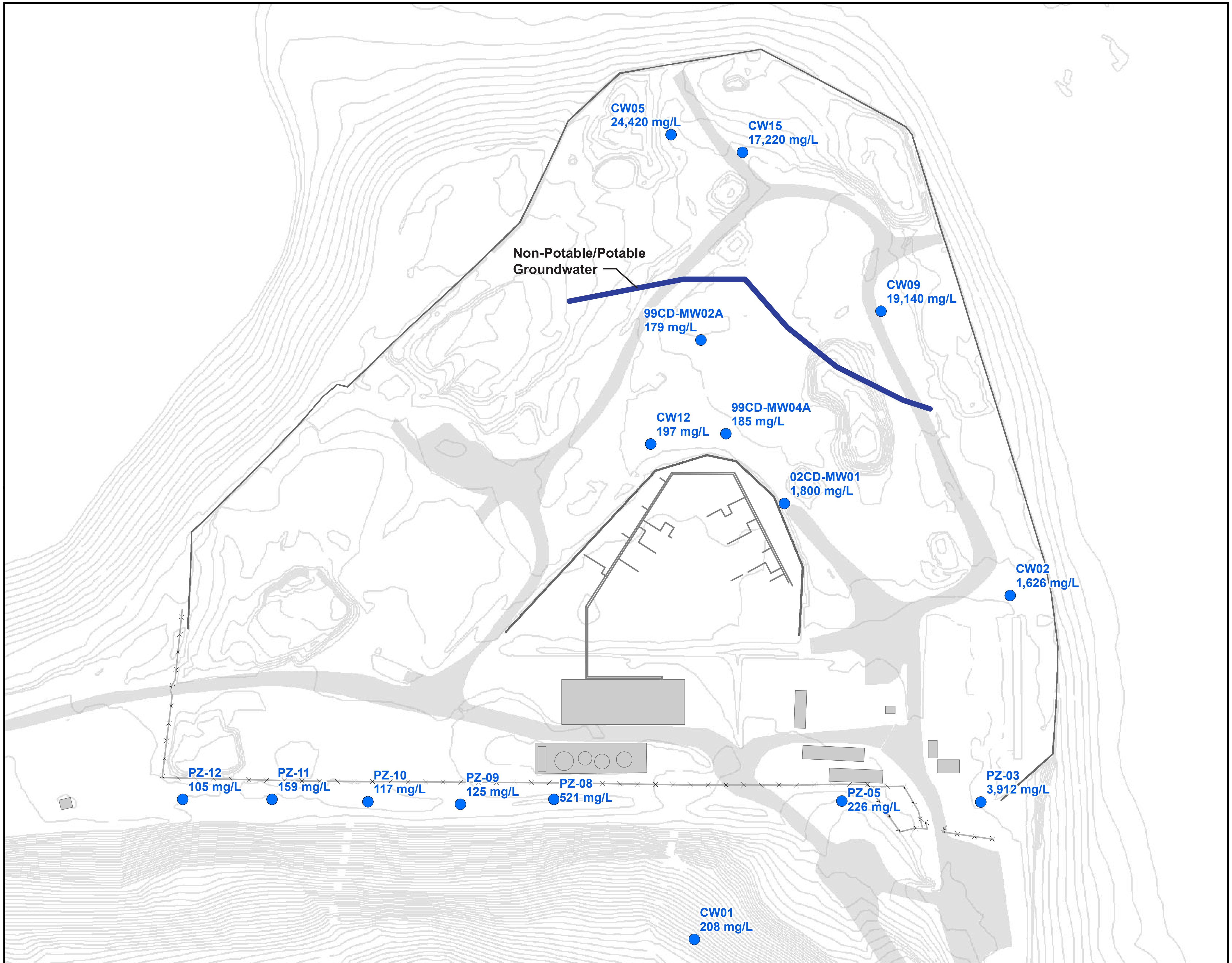
Figure 1-4

Potential Foundation Locations

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-4_POTENTIALFOUNDATIONLOCATIONS.MXD GGEE 9/18/2014 1:10:57 PM



LEGEND

- Lower Aquifer well and calculated TDS (mg/L)

Existing site features

- Current structures
- Current buildings
- Current roads
- Fence
- Pipelines
- Pilot study containment wall
- Sheet pile wall
- Ground surface contours (ft MLLW)

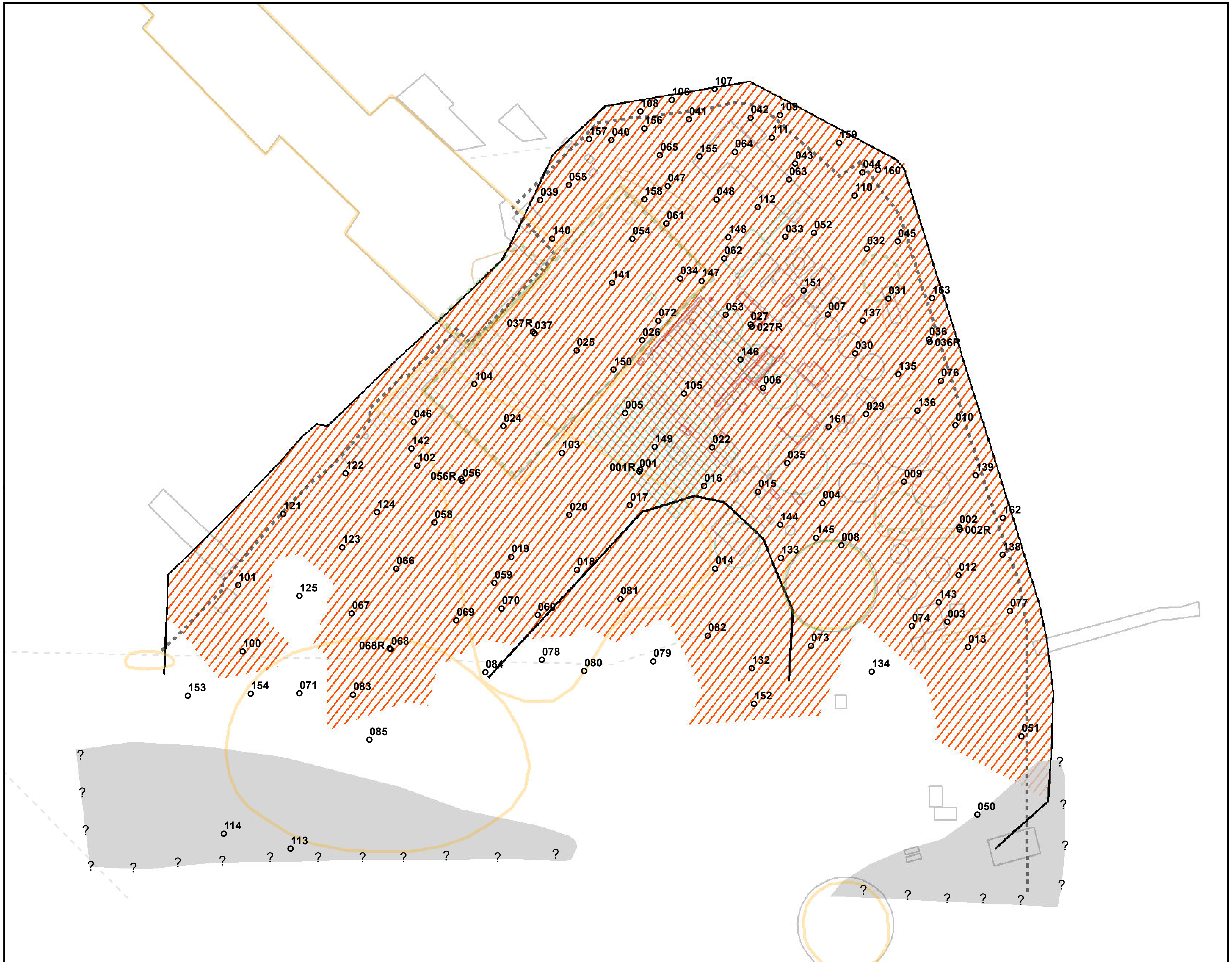
Labels

CW09 Well ID
19,140 mg/L Calculated TDS (mg/L)

Note:
TDS = Total dissolved solids
mg/L = milligrams per Liter

Figure 1-5
Lower Aquifer Calculated Total Dissolved Solids
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-5_CALCULATEDTDS.MXD GGEE 9/18/2014 1:14:47 PM



LEGEND

- Remedial action target area for Upper Aquifer (TarGOST >= 10%RE)
- TarGOST Location

Historic features and potential source areas

- Historic features
- Historic features identified from 1917 Sanborn map
- Trenching and other features of interest identified in April 1989 map
- Site remediation excavation performed in 1992 through 1994
- Potential primary NAPL sources (sumps, trenches, and other features with observed contamination)
- Potential secondary NAPL source areas
- Bulk head prior to current sheet pile wall
- Current outer and inner sheet pile wall
- Aquitard thin (<4 ft) to absent

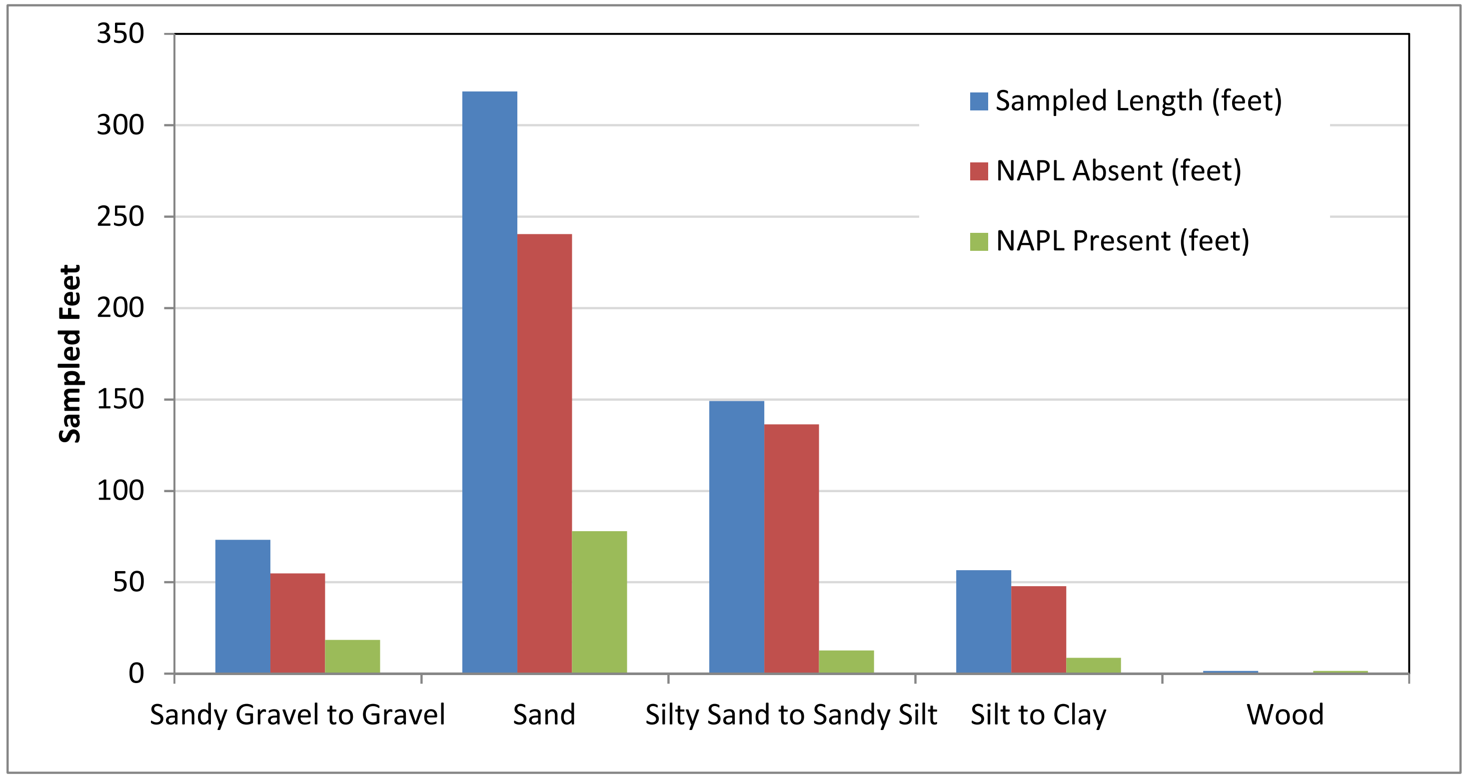
Sources:
Bulk Head Prior to Current Sheet Pile Wall digitized from current sheet pile wall design drawings (USACE, 2000)
Some sumps and trenches were digitized from "Figure 1 Site Location" (Environment and Ecology, 1995)
Sumps and Trenches were digitized from "Figure B Area 1 Trenches and Sumps"; "Figure C Area 2 Drums, Sumps, 7 Tanks"; "Figure D Area 3 Containers, Drums, Sumps, Tanks & Trenches" (Environment and Ecology, 1995)
Secondary NAPL Source Locations digitized from "Figure 2-1 Wycoff Site Vicinity Map" (CH2M HILL, 1993)
Trenching observations digitized from 1989 hand markup.
Prioritizing of source areas conducted 2012.
Prior remediation excavation areas from 1992 through 1994 digitized from Ecology and Environment, Inc., 1995.

N

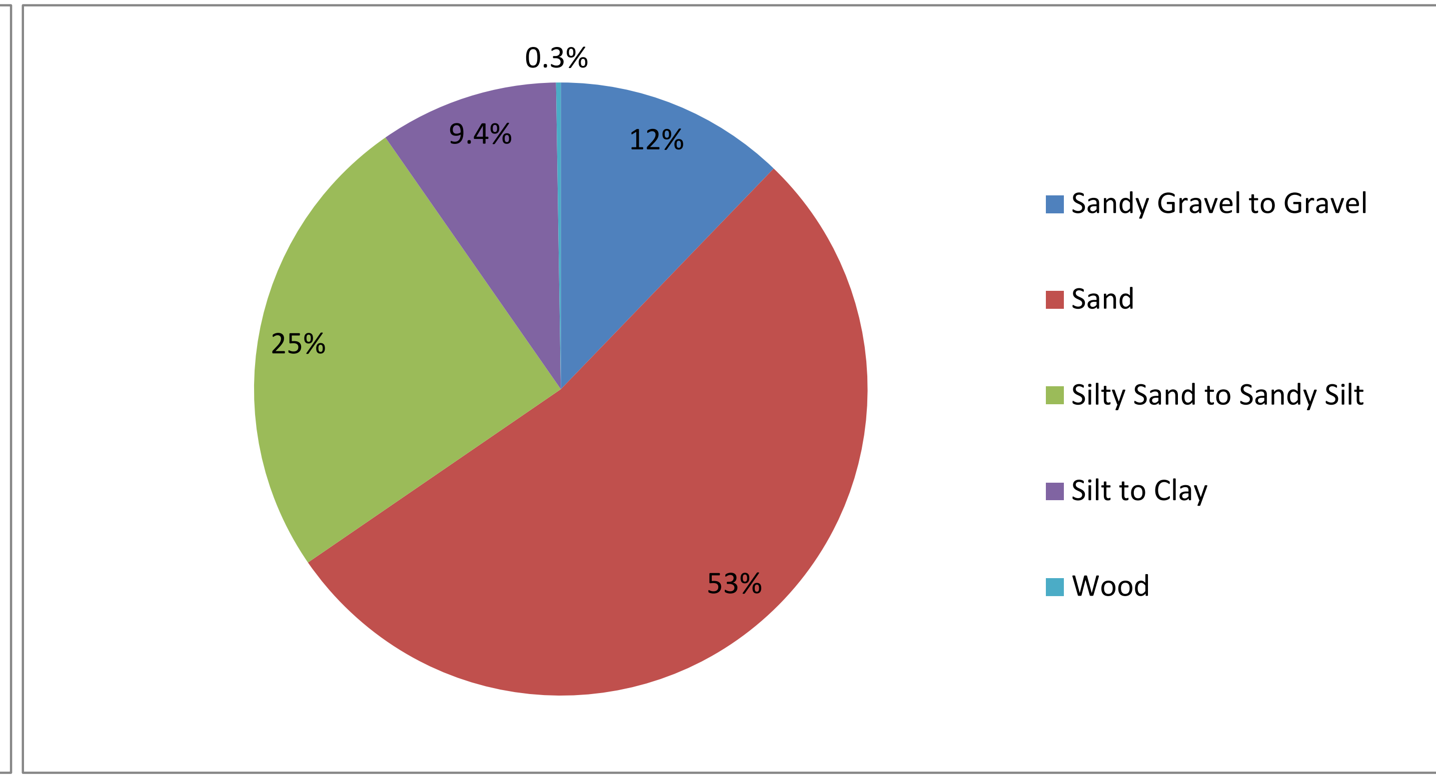
0 50 100 200 Feet

Figure 1-6
Former Process Area Remedial Action Target Zones
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

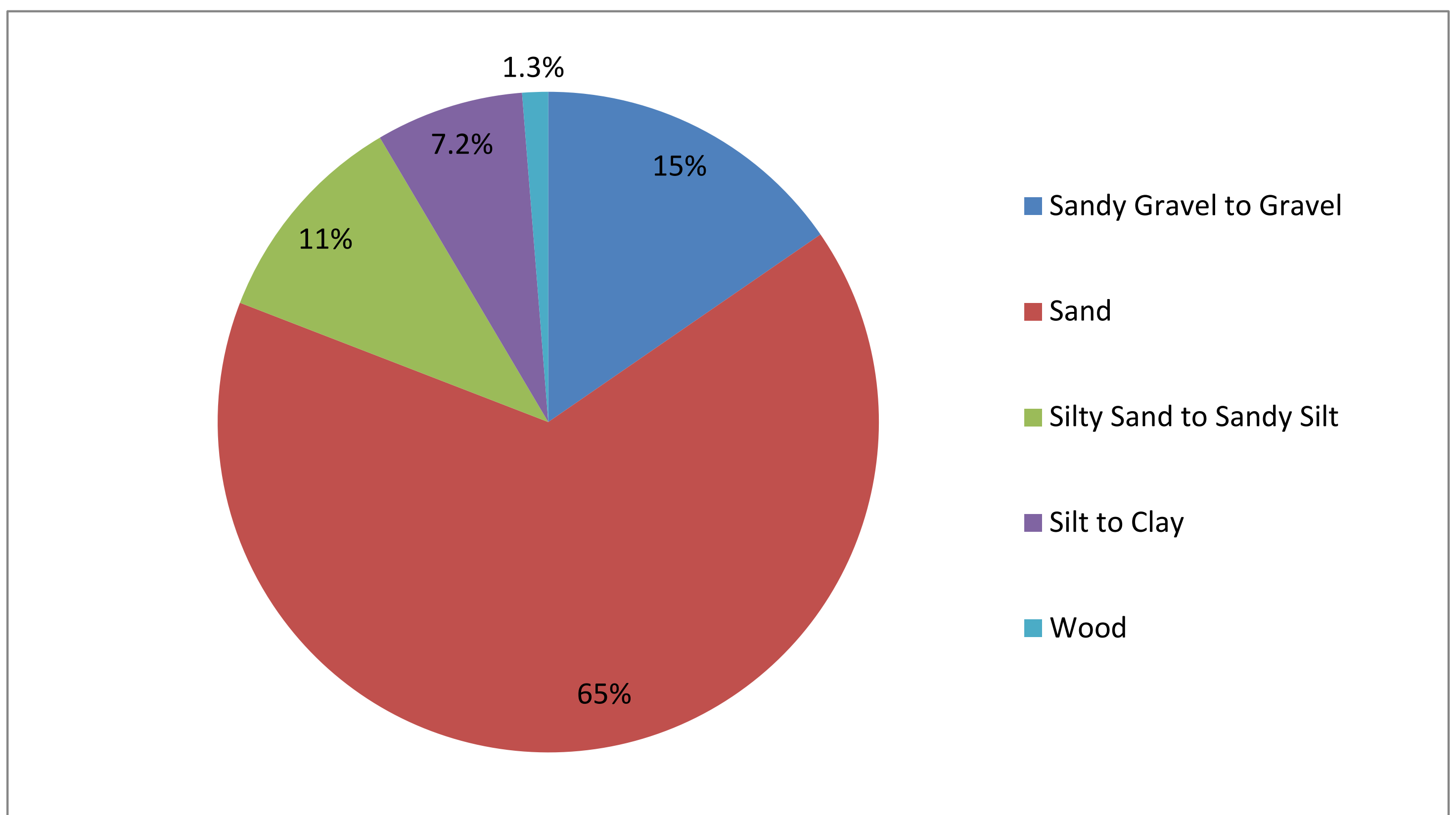
C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-6_RATARGETAREA.MXD GGEE 9/18/2014 1:54:12 PM



Summary of Lithology and NAPL Absence/Presence by feet



Summary of Lithology by Percentage of Confirmation Boring Footage



Summary of NAPL Presence in Lithology by Total Observed NAPL

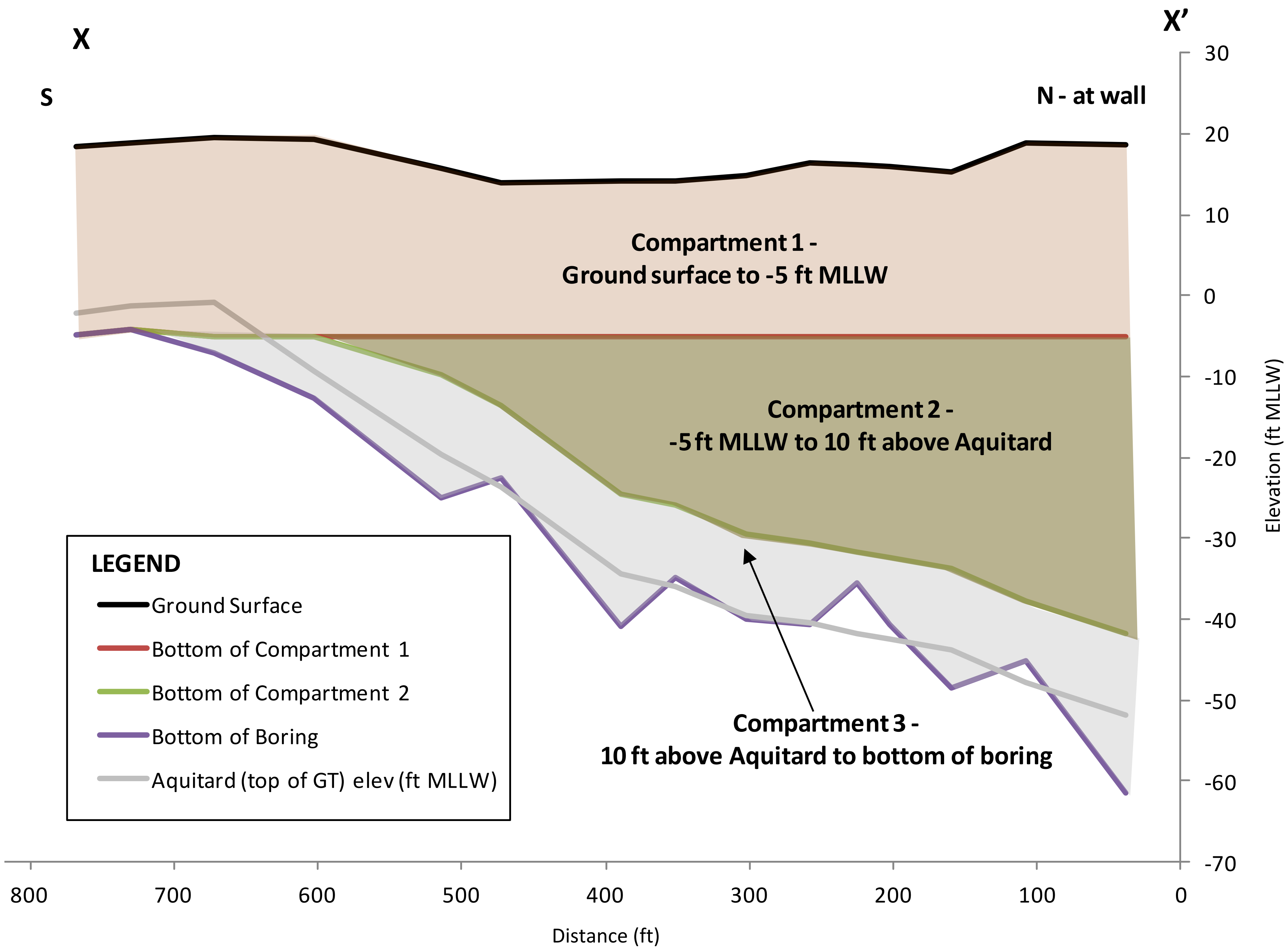
Data Table

Lithology	Sampled Length (feet)	NAPL Absent (feet)	NAPL Present (feet)
Sandy Gravel to Gravel	73	55	18
Sand	318	240	78
Silty Sand to Sandy Silt	149	136	13
Silt to Clay	56	48	8.6
Wood	1.5	0.0	1.5
Grand Total	**598**	**479**	**119**

Figure 1-7
Confirmation Boring Lithology and NAPL Observations
by Selected USCS Soil Classes

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA



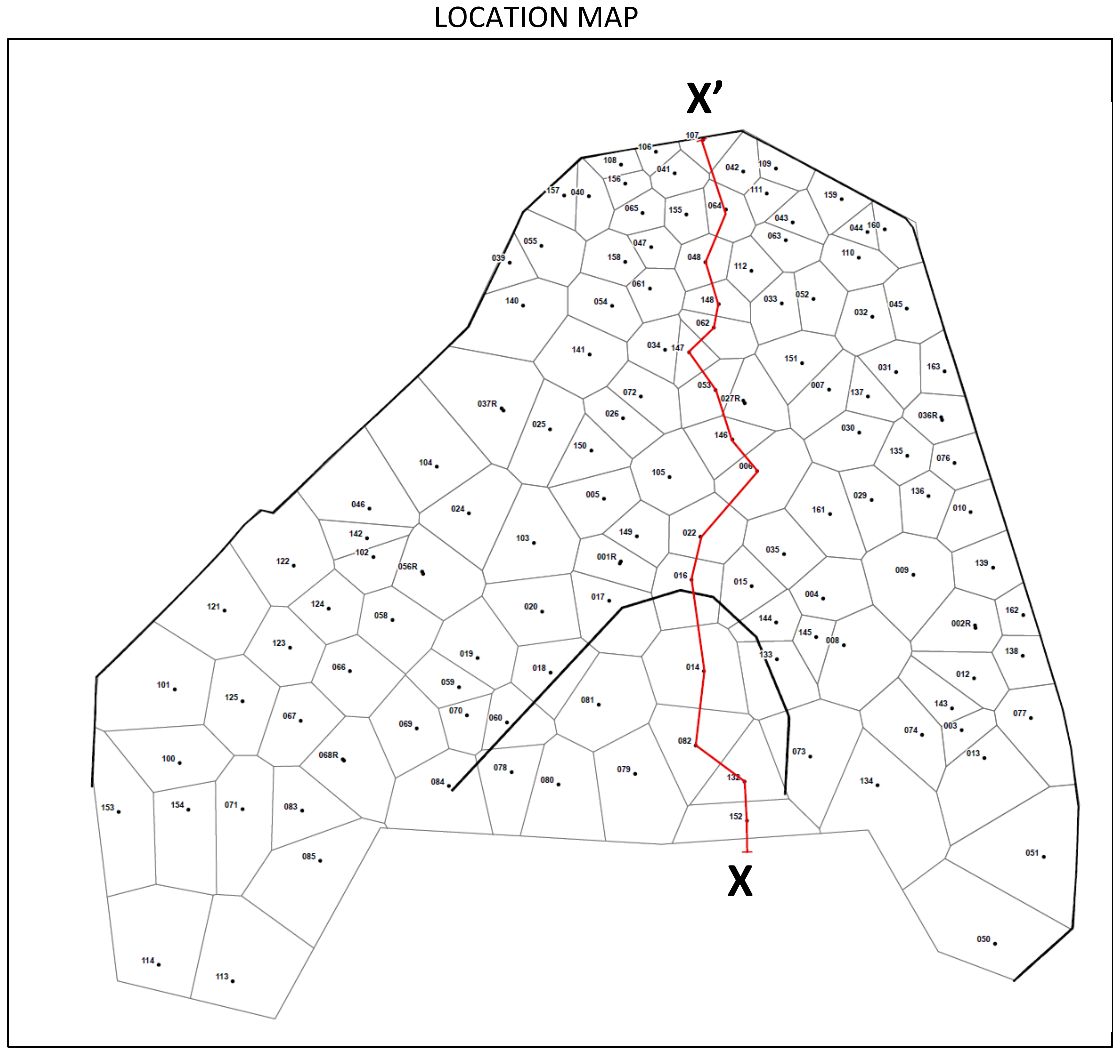


Figure 1-8
Fence Diagram Illustrating Compartment Thicknesses
Upland Dataset
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

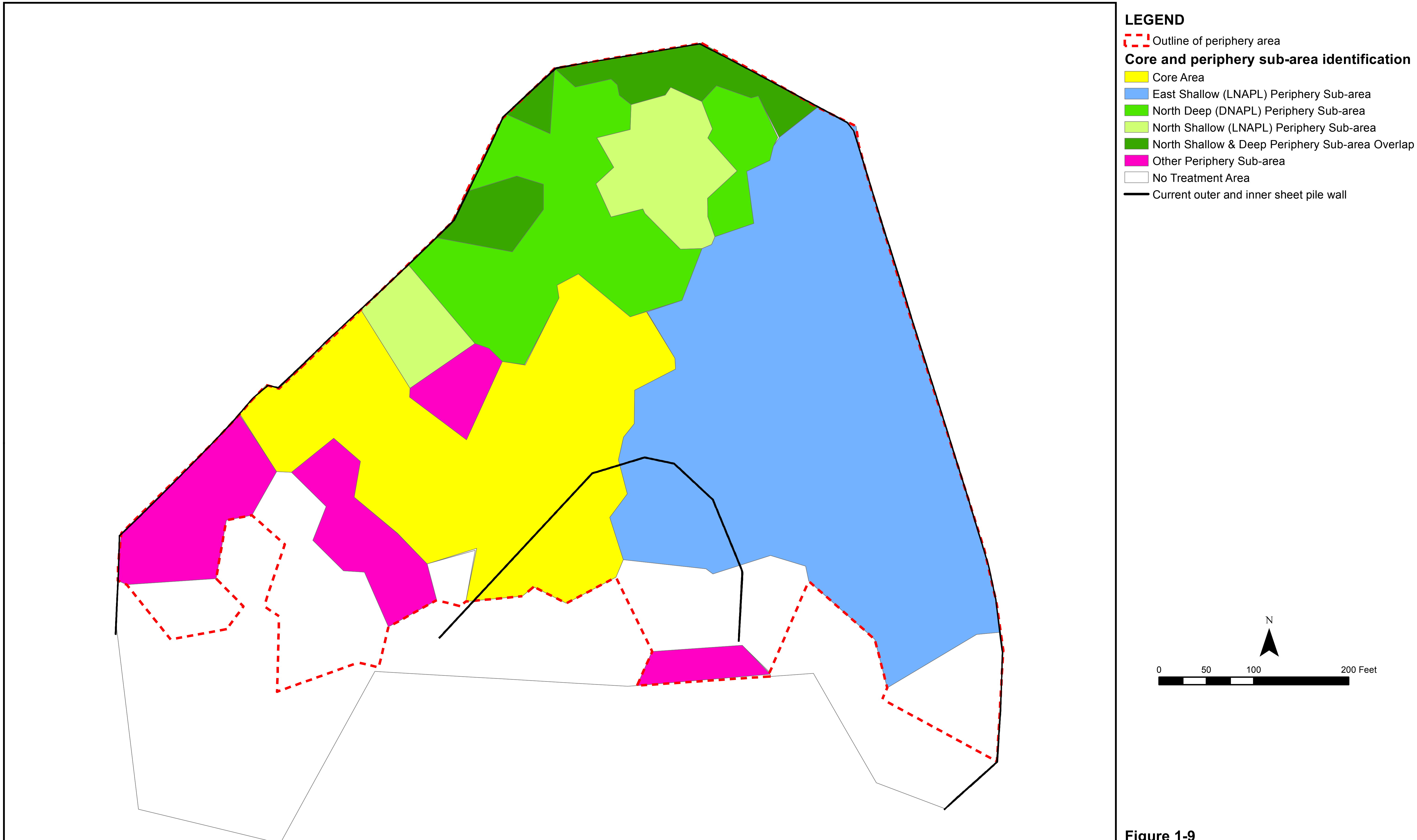
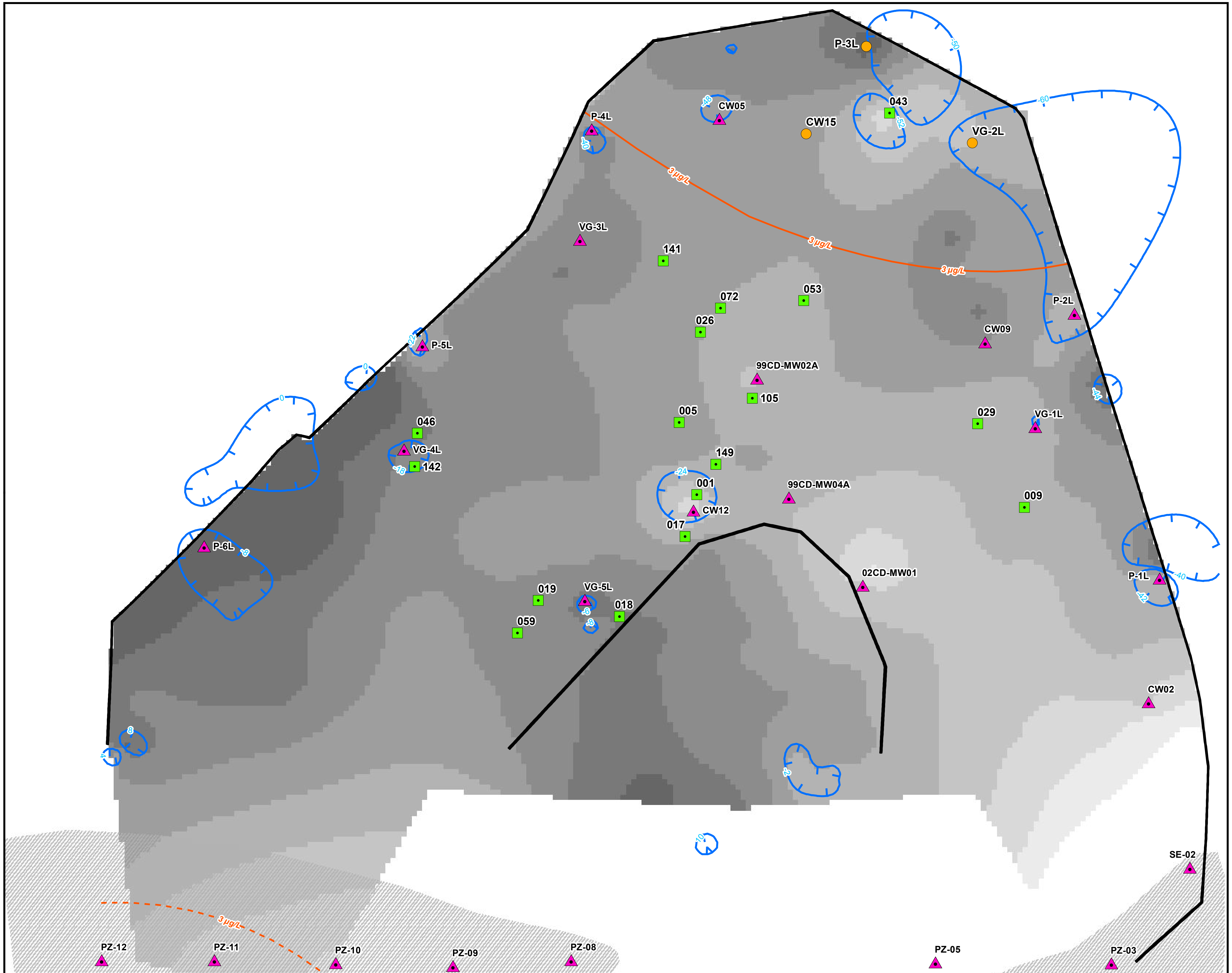


Figure 1-9
NAPL Remedial Action Target Zones
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-9_COREVPERIPHERYSUBAREASREV.MXD GGEE 9/18/2014 1:59:17 PM



LEGEND

- TarGOST location where NAPL pool height at aquitard > 9.4 feet
- Lower Aquifer well with observed NAPL presence
- Lower Aquifer well
- Acenaphthene isopleth (3 µg/L)
- Inferred acenaphthene isopleth (3 µg/L)
- Aquitard surface depressions

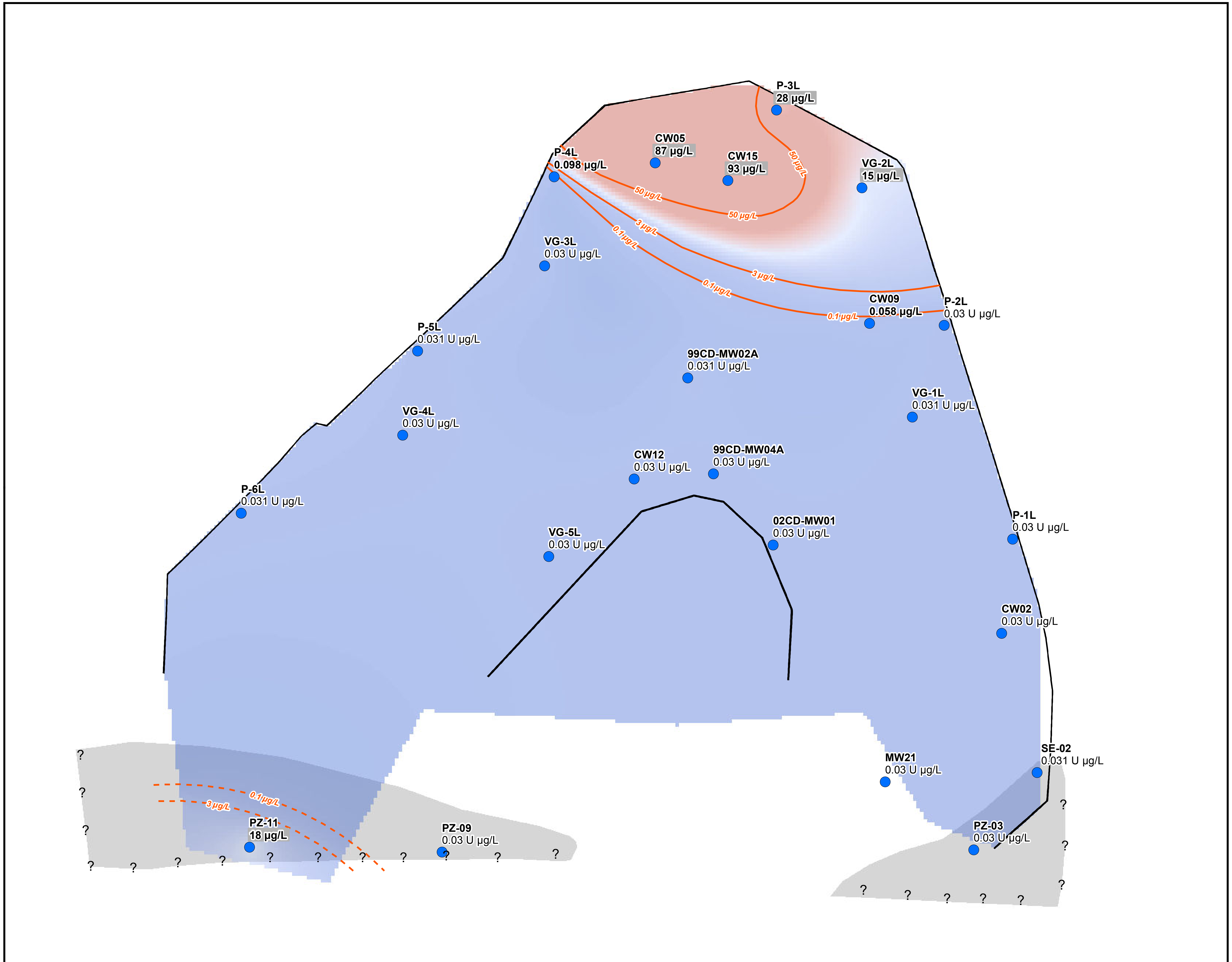
Aquitard thickness (ft MLLW)

- <0
- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- >35
- Aquitard thin (<4 ft) to absent

Notes:
Acenaphthene groundwater cleanup level of 3.0 µg/L established in the Wyckoff ROD 2/2000.
µg/L = micrograms per Liter
ft MLLW = feet mean low low water

Figure 1-10
Aquitard Observations for Assessing Potential for NAPL Migration to Lower Aquifer
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-10_AQUITARD.MXD GGEE 9/18/2014 2:03:00 PM



LEGEND

- Acenaphthene measured May 2013 (µg/L)
- Acenaphthene isopleth (0.1, 3, and 50 µg/L)
- Inferred acenaphthene isopleth
- Current sheet pile wall
- Aquitard thin (<4 ft) to absent

Interpolated acenaphthene concentration (µg/L)

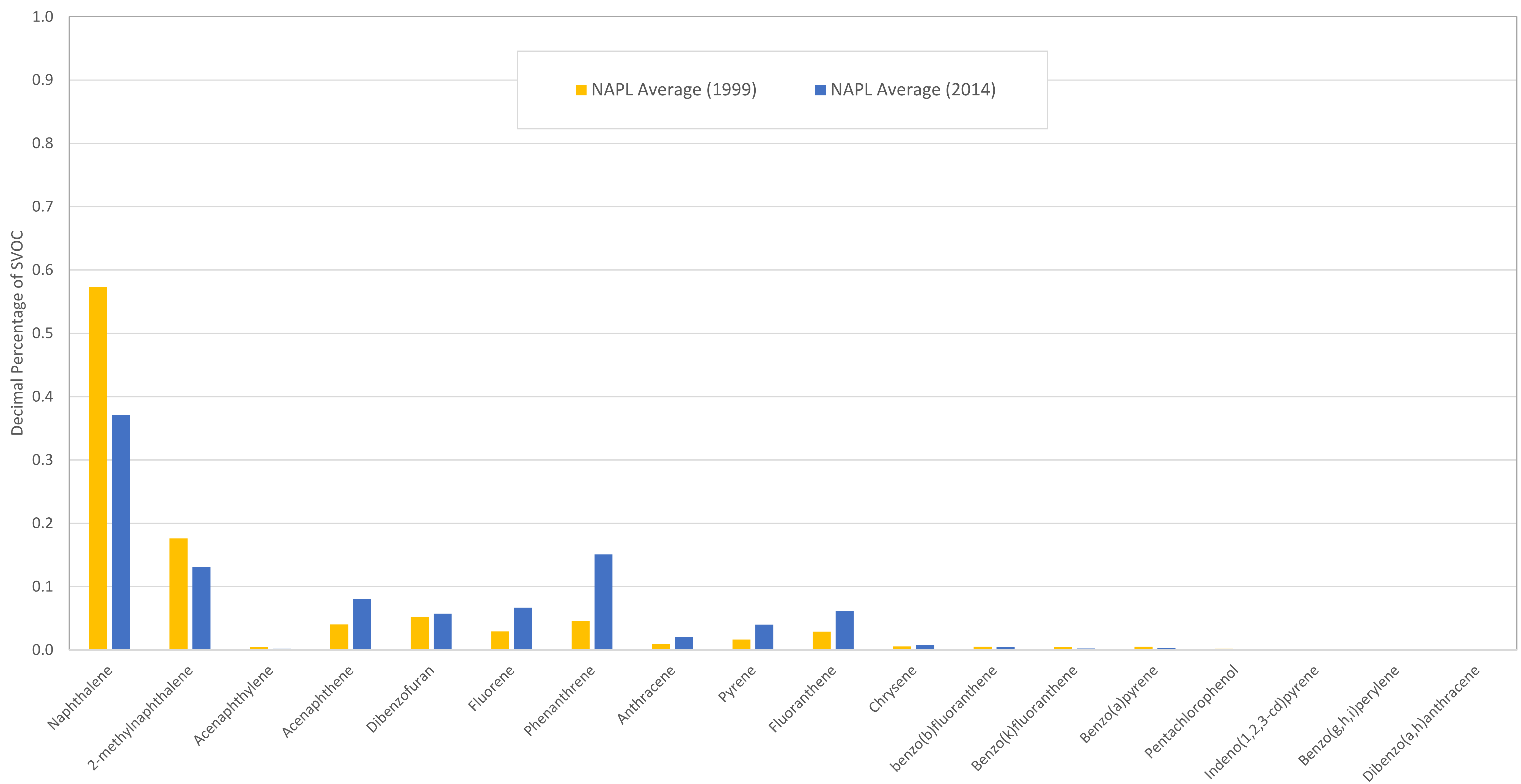
High : 90

Low : 0

Notes:
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.
µg/L = micrograms per Liter

Figure 1-11
Acenaphthene Concentration Isopleths
Measured May 2013
Soil and Groundwater OUs (OU2/OU4) NAPL FFS
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-11_ACENAPHTHENE.MXD GGEE 9/18/2014 2:06:07 PM



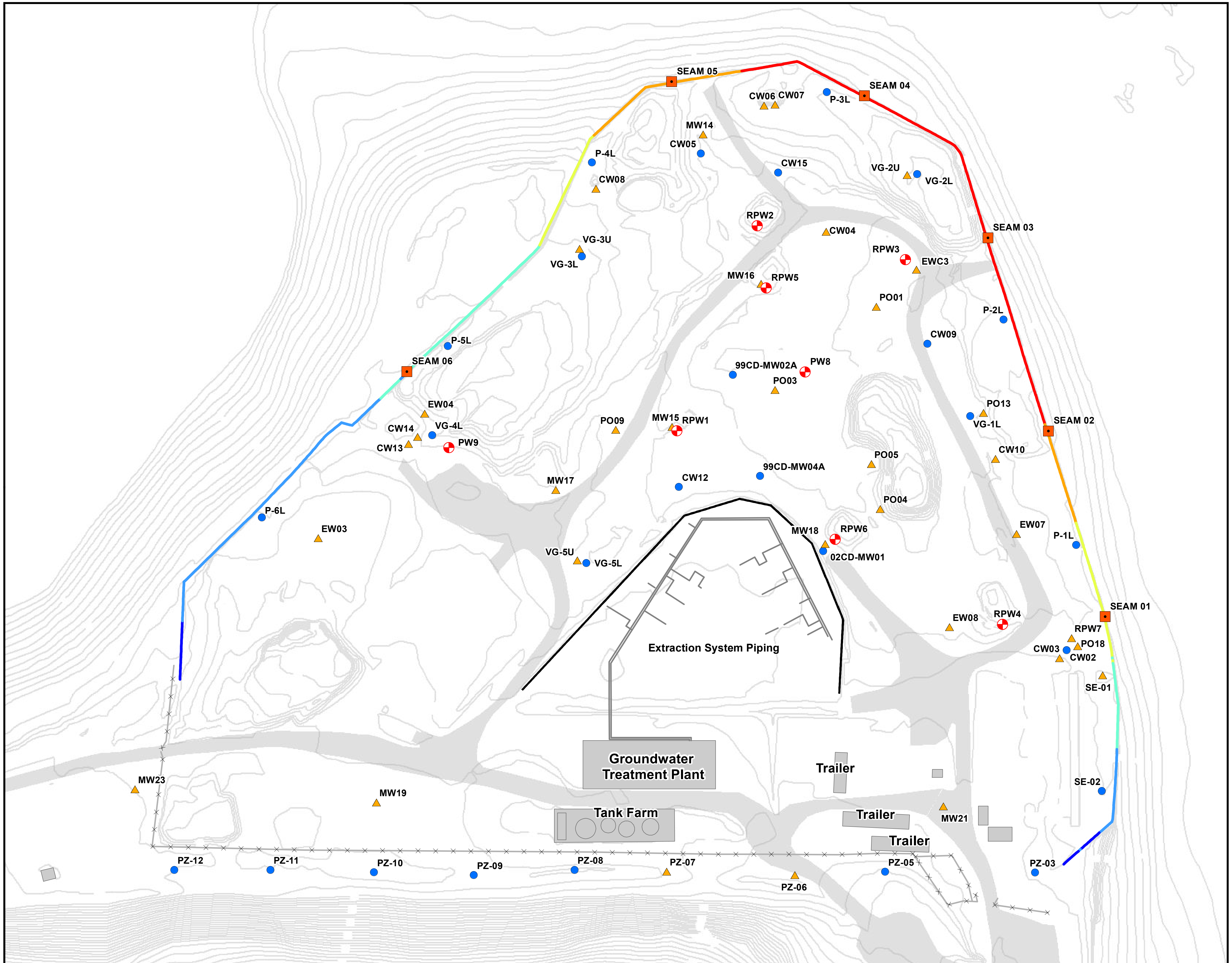
Notes: 1999 upland NAPL samples were collected as part of the USACE 2000 field exploration activities (USACE, 2000).
Datasets were evaluated using the EPA Fingerprint Analysis of Leachate Contaminants (FALCON, EPA 2004) analysis to identify the chemical signature of the NAPL samples.

Figure 1-12

NAPL Fingerprint Comparison between 1999 and 2014 Average Data

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA



LEGEND

Well locations

- Monitoring well, Upper Aquifer
- Monitoring well, Lower Aquifer
- Extraction well, Upper Aquifer
- Sheet pile wall seams

Sheet pile wall

(color coded by driven elevation ft MLLW)

- -79 - -65
- -64 - -55
- -54 - -45
- -44 - -35
- -34 - -25
- -24 - -15

Existing site features

- Current structures
- Current buildings
- Current roads
- Fence
- Pipelines
- Pilot study containment wall
- Sheet pile wall
- Ground surface contours (ft MLLW)

N

0 50 100 200 Feet

Figure 1-14

Site Map with Sheet Pile Wall, Seam, and Well Locations

Soil and Groundwater OUs (OU2/OU4) NAPL FFS

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, WA

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2014\SOIL AND GROUNDWATER OU NAPL - FFS\FIGURE1-14_SITEMAP.MXD GGEE 9/18/2014 2:13:59 PM

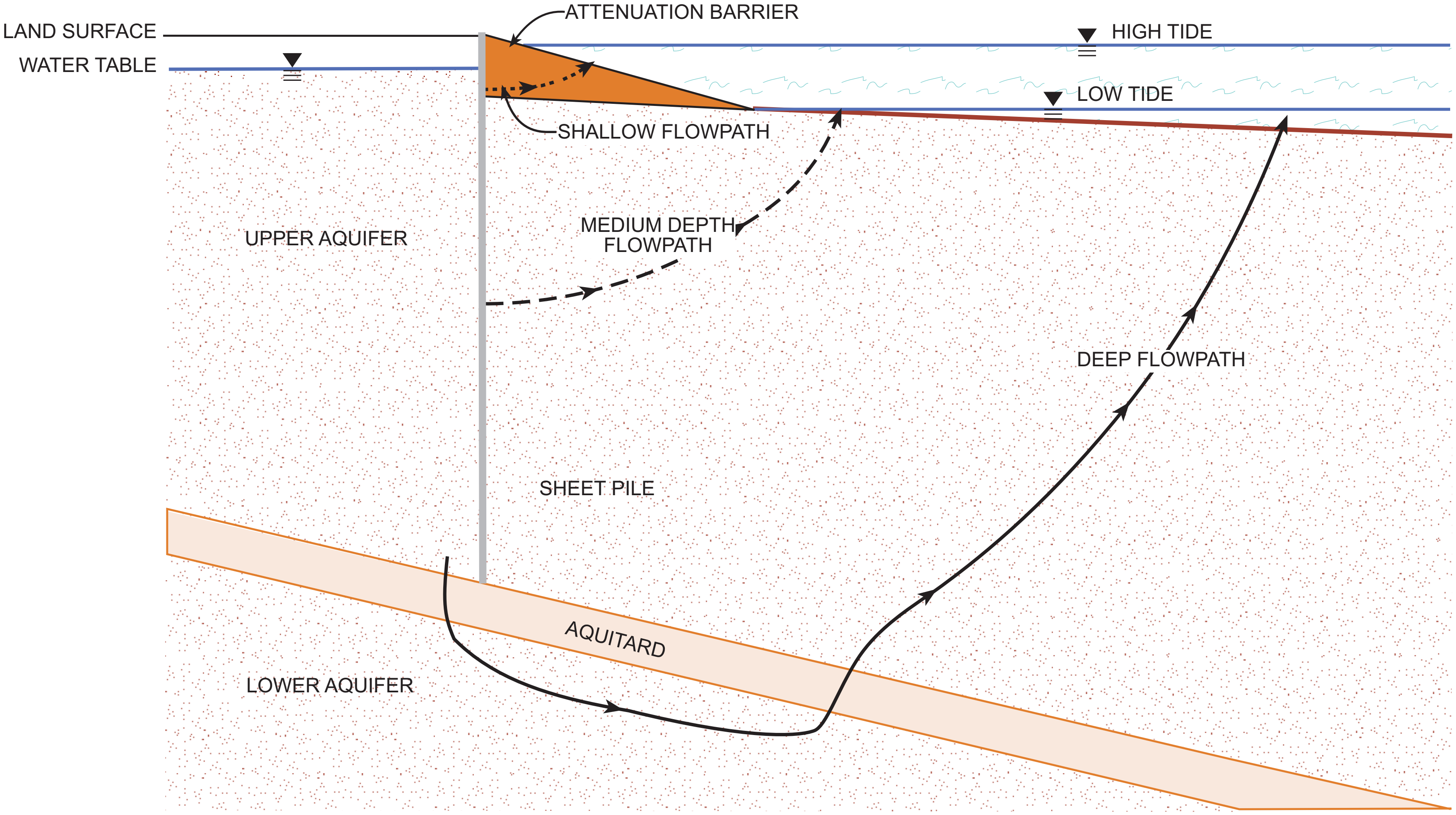


FIGURE 2-1

SCHEMATIC SECTION SHOWING TYPICAL FLOW PATHS

MODELING GROUNDWATER FLOW AND CONTAMINANT TRANSPORT
WYCKOFF/EAGLE HARBOR SUPERFUND SITE

180776-004.FH9

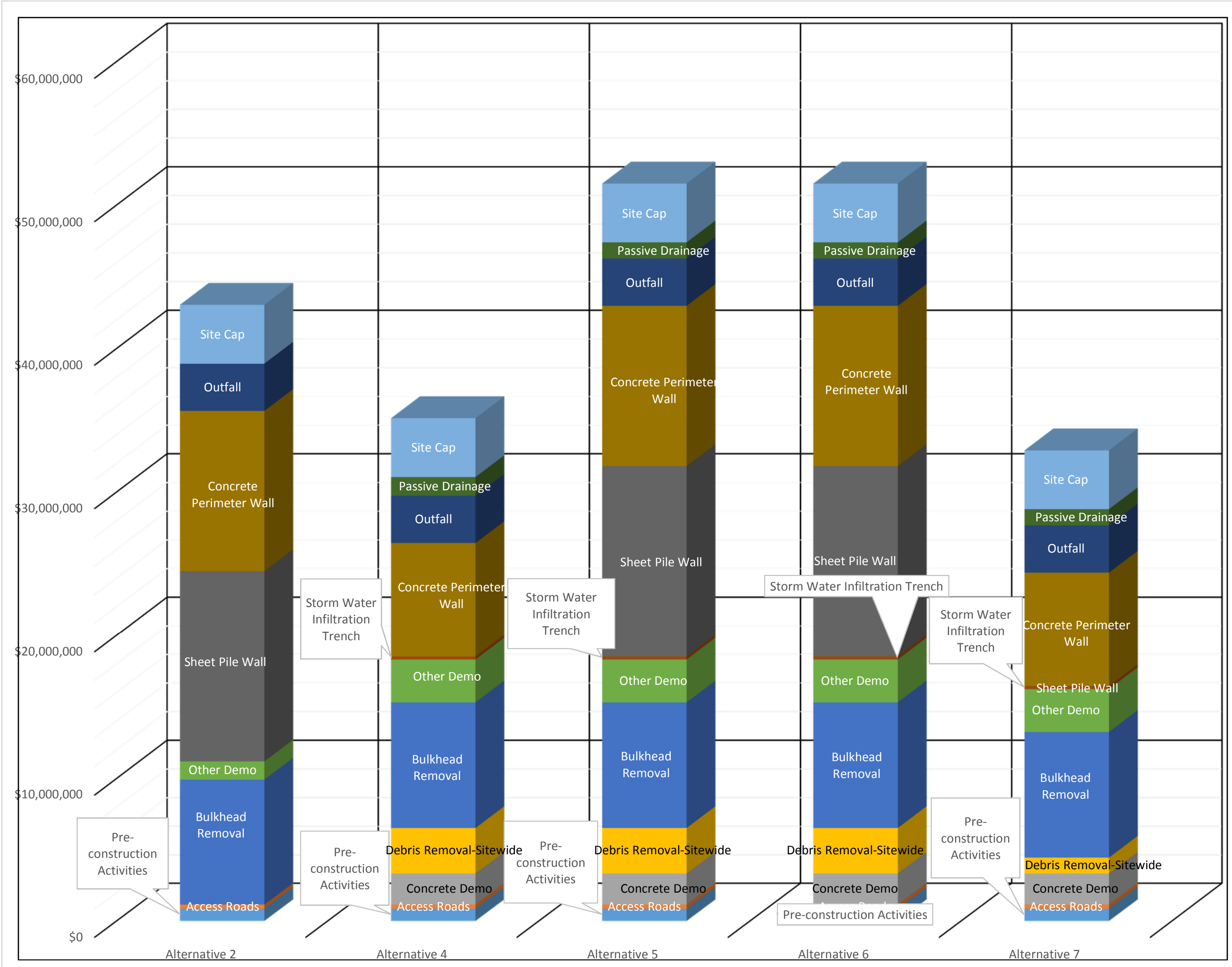


FIGURE 3-1

Common Element Cost Distribution

Wyckoff Soil and Groundwater OU FFS

Bainbridge Island, WA

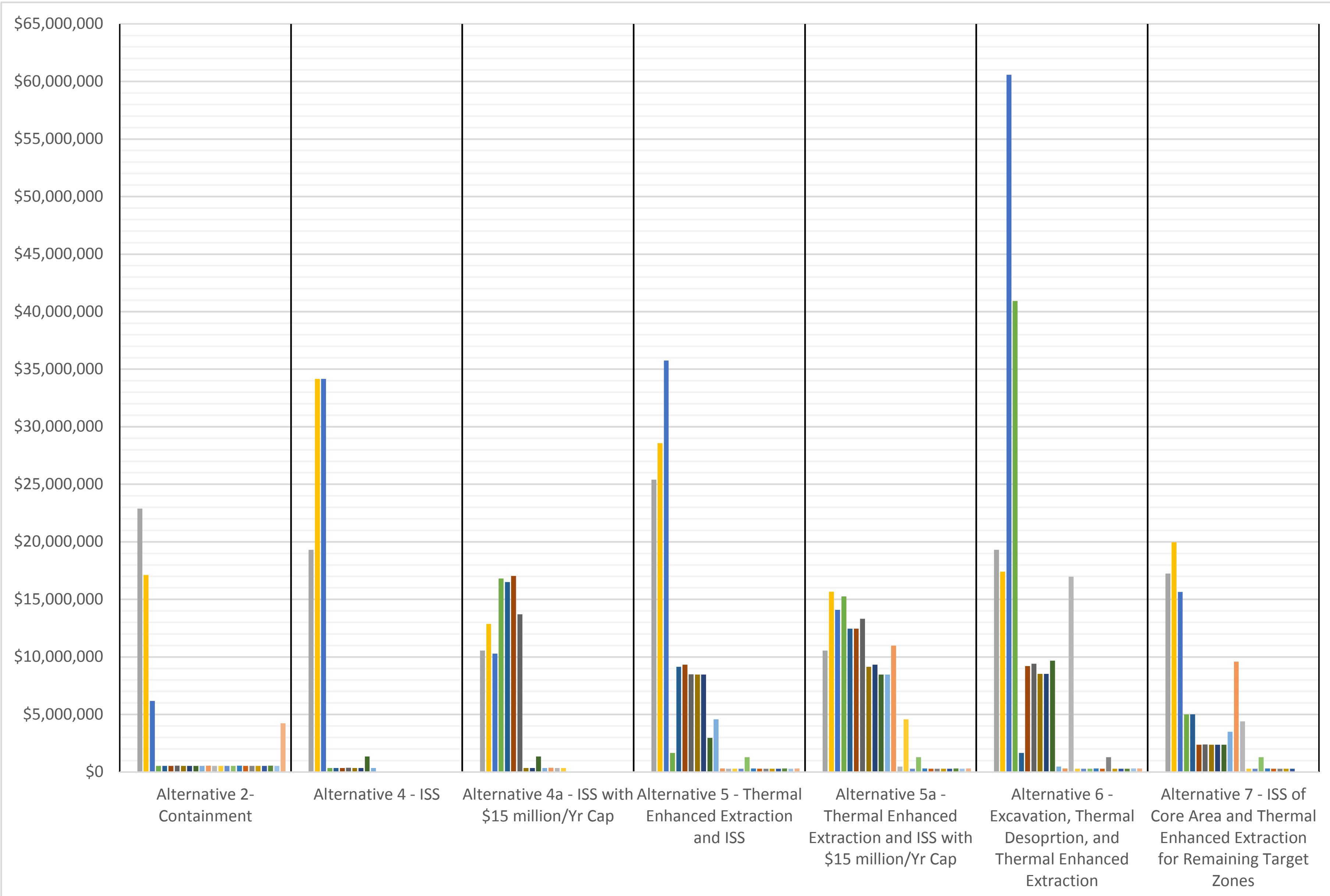


FIGURE 4-1

Remedial Action Alternative 25-Year Cash Flow Projections

Soil and Groundwater OU FFS

Wyckoff/Eagle Harbor, Bainbridge Island, WA

Appendix A
Soil and Groundwater Operable Unit Applicable or Relevant and Appropriate Requirements

Wyckoff/Eagle Harbor Soil and Groundwater Operable Units Applicable or Relevant and Appropriate Requirements

PREPARED FOR:	File
COPY TO:	Ken Scheffler/CH2M HILL Scott McKinley/CH2M HILL Carolyn Kossik/CH2M HILL
PREPARED BY:	Nahide Gulensoy/CH2M HILL
DATE:	August 7, 2014
PROJECT NUMBER:	438527.FS.27

This memorandum identifies the substantive standards of the applicable or relevant and appropriate requirements (ARARs) pertaining to Comprehensive Environmental Response Compensation and Liability Act (CERCLA) response actions. The ARAR identification process was conducted in accordance with "Cleanup Standards", "Degree of Cleanup" (CERCLA [Section 121(d)]) and CERCLA RI/FS Guidance (EPA/540/G-89/004); *CERCLA Compliance with Other Laws Manual: Interim Final* [EPA/540/G-89/006]; and *CERCLA Compliance with Other Laws Manual: Part II* [EPA/540/G-89/009]). Section 121(d) requires, with exceptions, that any promulgated substantive ARAR standard, requirement, criterion, or limitation under any federal environmental law, or any more stringent state requirement pursuant to a state environmental statute, or facility siting law be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain onsite after completion of remedial action. Additionally, the NCP ("Remedial Design/Remedial Action, Operation and Maintenance" [40 CFR 300.435(b)(2)]) requires that ARARs be attained (unless waived) during the remedial action. Identifying ARARs is part of the Soil and Groundwater Operable Units (OU) FFS process.

NAPL-contaminated soil and groundwater in the upland portion of the Wyckoff Site will be remediated under a CERCLA decision document (the 2000 ROD). The general areas identified for remedial action in the Draft CSM Update Report (CH2M HILL, 2013) included the Upper Aquifer, Lower Aquifer, and Aquitard. The Upper Aquifer represents the primary remedial action target area for the FFS, which is the subsurface portion of the Former Process Area (FPA) with a Tar-Specific Green Optical Scanning Tool (TarGOST) response of 10 percent reference emitter (%RE) or greater. Any remedial action(s) implemented will be required to meet ARARs. In many cases, the ARARs form the basis for the preliminary remedial goals (PRGs) to which the contaminants of concern (COCs) must be remediated to protect human health and the environment (HHE). ARARs also define or restrict how specific requirements of a remedial alternative can be implemented based on the nature of the activity or the location of the site.

A.1 ARARs Evaluation Process

The ARARs evaluation for this FFS was conducted in accordance with the National Contingency Plan (NCP) ("Remedial Investigation/Feasibility Study and Selection of Remedy" [40 CFR 300.430(f)(1)(ii)(B)(2)]). A distinction and clarification related to ARARs involves onsite and offsite actions. Onsite actions are defined to be "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action" (NCP [400 CFR 300]). Onsite actions must comply with ARARs but need only comply with the substantive parts of those requirements. Offsite actions must comply with both the substantive and administrative requirements. For onsite activities, a requirement under federal and state environmental laws may be either applicable or relevant and appropriate, but not both.

The identification of ARARs is a two-step process. First, it must be determined whether the law or regulation is applicable. If not applicable, it must be determined if the law or regulation is both relevant and appropriate. The terms “applicable” and “relevant and appropriate” are defined in the NCP (“Definitions” [40 CFR 300.5]) as follows:

- “Applicable requirements” are substantive standards that specifically address the situation at a CERCLA site and would legally apply to remedial actions in the absence of CERCLA authority. All jurisdictional prerequisites of the requirement must be met in order for the requirement to be applicable, including specific application to federal agencies (e.g., through a waiver of federal sovereign immunity).
- “Relevant and appropriate” are environmental requirements such as cleanup standards that address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site (NCP “General” [40 CFR 300.400(g)(2)]). A requirement that is relevant and appropriate may not meet one or more jurisdictional prerequisites for applicability but still makes sense at the site, given the circumstances of the site and the release.

In evaluating the relevance and appropriateness of a requirement, the eight comparison factors in the NCP (“General” [40 CFR 300.400(g)(2)]) are considered:

1. The purpose of the requirement and the purpose of the CERCLA action.
2. The medium regulated or affected by the requirement, and the medium contaminated or affected at the CERCLA site.
3. The substances regulated by the requirement, and the substances found at the CERCLA site.
4. The actions or activities regulated by the requirement, and the remedial action contemplated at the CERCLA site.
5. Any variances, waivers, or exemptions of the requirement, and their availability for the circumstances at the CERCLA site.
6. The type of place regulated, and the type of place affected by the release or CERCLA action.
7. The type and size of structure or facility regulated, and the type and size of structure or facility affected by the release or contemplated by the CERCLA action.
8. Any consideration of use or potential use of affected resources in the requirement, and the use or potential use of the affected resource at the CERCLA site.

To be considered (TBC) information represents another category of non-promulgated advisories or guidance issued by federal or state governments that is not legally binding and does not have the status of ARARs. In some circumstances, TBC information will be evaluated, along with ARARs, in determining the remedial action necessary to protect HHE. TBC information complements ARARs in determining protectiveness at a CERCLA site or in assessing implementation of certain actions. For example, because cleanup standards do not exist for all COCs, health advisories, which would be TBC information, may be helpful in defining cleanup levels. Potential ARARs for the Upper Aquifer were reviewed to determine if they fall into one of three categories: chemical-specific, location-specific, or action-specific requirements. These categories are defined as follows:

- Chemical-specific requirements are usually health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of public and worker safety levels and site cleanup levels.
- Location-specific requirements are restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas.

- Action-specific requirements are usually technology- or activity-based requirements or limitations triggered by remedial actions performed at the site.

A.2 Waivers from ARARs

The CERCLA lead agency delegated authority under Section 121 may waive ARARs, with EPA's concurrence, and select a remedial action that does not attain the same level of cleanup as that identified by the ARARs. CERCLA provides for a possible waiver of an ARAR under the following six circumstances::

- The remedial action selected is only a part of a total remedial action (e.g., an interim action), and the final remedy will attain the ARAR upon its completion.
- Compliance with the ARAR will result in a greater risk to HHE than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial action will attain an equivalent standard of performance using another method or approach.
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.
- For Superfund-financed remedial actions, compliance with the ARARs will not provide a balance between protecting HHE and the availability of Superfund money for responses at other site.

ARAR waivers can be established in the ROD or through a ROD modification.

A.3 Potential ARARs Identified

Table A-1 presents potential federal, Washington State, and local ARARs and TBCs. When the final remedy selection is documented in the CERCLA decision document, all federal and state ARARs with which the final remedy must comply are also finalized. Key potential ARARs are identified in the following discussion.

A.3.1 Potential Chemical-Specific ARARs

The chemical-specific ARARs and TBCs that may affect the Upper Aquifer remedial actions are the elements of the *Washington Administrative Code* regulations that implement MTCA (WAC 173-340). Within this branch of the *Washington Administrative Code*, there are detailed regulations with developing standards for remedial actions involving MTCA soil cleanup standards ("Unrestricted Land Use Soil Cleanup Standards" [WAC 173-340-740]) and groundwater cleanup standards (MTCA, "Groundwater Cleanup Standards" [WAC 173-340-720]).

These standards are in the form of risk-based concentrations that help establish soil, groundwater, and air cleanup standards for chemical compounds. Following is a list of additional Washington State, federal, and local regulations:

- Substantive portions of MTCA ("Selection of Cleanup Actions" [WAC 173-340-360] and MTCA "Overview of Cleanup Standards" [WAC 173-340-700] through MTCA "Priority Contaminants of Ecological Concern" [WAC 173-340-7494], and also includes "Cleanup Standards to Protect Air Quality" [WAC 173-340-750], "Sediment Cleanup Standards" [WAC 173-340-760] and "Sediment Management Standards" [WAC 173-204].
- Nonzero MCL goals and MCLs promulgated under the SDWA, "National Primary Drinking Water Regulations" (40 CFR 141) and/or by the State of Washington ("Group A Public Water Supplies" [WAC 246-290]) as they apply to primary MCL constituents.
- AWQC and state water quality standards at the groundwater/surface water interface developed under the CWA (Section 304) and/or promulgated by the state of Washington ("Water Quality Standards for Groundwaters of the State of Washington" [WAC 173-200] and "Water Quality Standards for Surface

Waters of the State of Washington" [WAC 173-201A]), "National Pollutant Discharge Elimination System [NPDES] Permit Program" [WAC 173-220], and "Wastewater Discharge Standards and Effluent Limitations" [WAC 173-221A].

- *Toxic Substances Control Act of 1976* (TSCA) (implemented via "Polychlorinated Biphenyls [PCBs] Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" [40 CFR 761])
- "National Primary and Secondary Ambient Air Quality Standards" (40 CFR 50)
- "National Emission Standards for Hazardous Air Pollutants" (40 CFR 61)

A.3.2 Potential Location-Specific ARARs

Potential location-specific ARARs that have been identified for the Upper Aquifer include those that protect cultural, historic, and Native American sites and artifacts under the *Native American Graves Protection and Repatriation Act of 1990*, *Archeological and Historic Preservation Act of 1974*, and *National Historic Preservation Act of 1966* (NHPA) and those that protect listed endangered and threatened species or their critical habitat under the *Endangered Species Act of 1973* and the *Fish and Wildlife Coordination Act*. The *Migratory Bird Treaty Act of 1918* has been identified as a substantive standard for DOE compliance in executive orders and *Memorandum of Understanding Between the United States Department of Energy and the United States Fish and Wildlife Service Regarding Implementation of Executive Order 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds"* (DOE and USFWS, 2006), and is pertinent for CERCLA response actions when there is potential for adverse effects on protected bird species. The other major category of location-specific ARARs includes the coastal zone and shoreline management regulations (Coastal Zone Management Act, State Master Program Approval/Amendment Procedures and Master Program Guidelines [WAC 173-26]; Shoreline Management Permit and Enforcement Procedures [WAC 173-27]; Kitsap County Shoreline Master Program; and City of Bainbridge Island Shoreline Management Master Program).

A.3.3 Potential Action-Specific ARARs

Action-specific ARARs that could be pertinent to possible remediation activities at the Upper Aquifer relate to waste management activities; solid and dangerous waste regulations (for management of characterization and remediation wastes, and performance standards for waste left in place or for treated soil used for onsite backfill); and waste transportation for offsite treatment and/or disposal. The other major category of action-specific ARARs concerns standards for controlling emissions to the environment including "General Regulations for Air Pollution Sources" [WAC 173-400], "Controls for New Sources of Toxic Air Pollutants" [WAC 173-460], and the Puget Sound Clean Air Agency Regulations (I, II, and III).

The other categories of action-specific ARARs are related to:

- *The Water Well Construction Act*, "Minimum Standards for Construction and Maintenance of Wells" (WAC 173-160) and "Regulation and Licensing of Well Contractors and Operators" (WAC 173-162),
- "Water Pollution Control" (RCW 90.48, as amended), "Underground Injection Control Program" (WAC 173-218),
- "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" (40 CFR Part 264 and 265),
- *Transportation – Hazardous Materials Regulations (49 CFR Parts 171 through 180),*
- "Oil Pollution Prevention" (40 CFR Part 112), "Facilities Transferring Oil or Hazardous Material in Bulk" (33 CFR Part 154), "Facility Oil Handling Standards" (WAC 173-180), and
- The Occupational Safety and Health Agency (OSHA) Regulations (29 CFR 1910).

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Groundwater					
Safe Drinking Water Act of 1974 **(Public Law 93-523, as amended; 42 USC 300f, et seq.); "National Primary Drinking Water Regulations" (40 CFR 141); "National Secondary Drinking Water Regulations" (40 CFR 143); Washington State Drinking Water Regulations [WAC 246-290]**					
"Maximum Contaminant Levels for Organic Contaminants" (40 CFR 141.61) "Maximum Contaminant Level Goals for Organic Contaminants" (40 CFR 141.50)	Chemical	Establishes MCLs and nonzero MCLGs as criteria for groundwater and surface water that are or may be used for drinking water. The standards/goals are designed to protect human health from adverse effects of organic contaminants in the drinking water.	NAPL source material present in the Upper Aquifer contains contaminants that require remediation. Groundwater is not currently used for drinking water, and institutional controls will remain in place to permanently prohibit withdrawal of groundwater from the Upper Aquifer for drinking water, irrigation or other beneficial uses. However, groundwater in the southwest portion of the Lower Aquifer is a potential source for drinking water, irrigation or other beneficial uses after the restoration is complete.	ARAR	NAPL source and Lower Aquifer groundwater remediation and management activities (e.g., groundwater treatment, discharge of treated groundwater, in situ remediation of groundwater, and MNA).
"Secondary Maximum Contaminant Levels" (40 CFR 143.3) "Monitoring" (40 CFR 143.4)	Chemical	Establishes secondary maximum contaminant levels for public water systems. These levels represent reasonable goals for drinking water quality. The States may establish higher or lower levels which may be appropriate dependent upon local conditions such as unavailability of alternate source waters or other compelling factors, provided that public health and welfare are not adversely affected.	NAPL source material present in the Upper Aquifer contains contaminants that require remediation to protect marine and Lower Aquifer water quality. Upper Aquifer groundwater is not currently used for drinking water, and institutional controls will remain in place to permanently prohibit withdrawal of groundwater from the Upper Aquifer for drinking water, irrigation or other beneficial	ARAR	NAPL source and Lower Aquifer groundwater remediation and management activities (e.g., groundwater treatment, discharge of treated groundwater, in situ remediation of groundwater, and MNA).

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
			uses. However, groundwater in the southwest portion of the Lower Aquifer is a potential source for drinking water, irrigation or other beneficial uses after the restoration is complete.		
"Group A public water supplies - Water Quality: Maximum contaminant levels (MCLs) and maximum residual disinfectant levels (MRDLs), Organic Chemicals" (WAC 246-290-310[7])	Chemical	Establishes MCLs and MRDLs for Group A public water supplies to protect human health from adverse effects of organic contaminants in the drinking water.	NAPL source material present in the Upper Aquifer contains contaminants that require remediation to protect marine and Lower Aquifer water quality. Upper Aquifer groundwater is not currently used for drinking water, and institutional controls will remain in place to permanently prohibit withdrawal of groundwater from the Upper Aquifer for drinking water, irrigation or other beneficial uses. However, groundwater in the southwest portion of the Lower Aquifer is a potential source for drinking water, irrigation or other beneficial uses after the restoration is complete.	ARAR	NAPL source and Lower Aquifer groundwater remediation and management activities (e.g., groundwater treatment, discharge of treated groundwater, in situ remediation of groundwater, and MNA).
"Maximum Contaminant Levels for Inorganic Contaminants" (40 CFR 141.62) "Maximum Contaminant Level Goals for Inorganic Contaminants" (40 CFR 141.51)		Establishes MCLs and nonzero MCLGs as criteria for groundwater and surface water that are or may be used for drinking water. The standards/goals are designed to protect human health from adverse effects of inorganic contaminants in the drinking water.	NAPL source material present in the Upper Aquifer contains contaminants that require remediation to protect marine and Lower Aquifer water quality. Upper Aquifer groundwater is not currently used for drinking water, and institutional controls will remain in place to	ARAR	NAPL source and Lower Aquifer groundwater remediation and management activities (e.g., groundwater treatment, discharge of treated groundwater, in situ remediation of groundwater, and MNA).

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
			permanently prohibit withdrawal of groundwater from the Upper Aquifer for drinking water, irrigation or other beneficial uses. However, groundwater in the southwest portion of the Lower Aquifer is a potential source for drinking water, irrigation or other beneficial uses after the restoration is complete.		
"Water Quality Standards for Groundwaters of the State of Washington" (WAC 173-200)					
"Water Quality Standards for Groundwaters of the State of Washington" (WAC 173-200)	Chemical	Establishes groundwater quality standards which, together with the State of Washington's technology-based treatment requirements, provide for the protection of the environment and human health and protection of existing and future beneficial uses of groundwaters.	NAPL source material present in the Upper Aquifer contains contaminants that require remediation to protect marine and Lower Aquifer water quality. Upper Aquifer groundwater is not currently used for drinking water, and institutional controls will remain in place to permanently prohibit withdrawal of groundwater from the Upper Aquifer for drinking water, irrigation or other beneficial uses. However, groundwater in the southwest portion of the Lower Aquifer is a potential source for drinking water, irrigation or other beneficial uses after the restoration is complete.	ARAR	NAPL source and Lower Aquifer groundwater remediation and management activities (e.g., groundwater treatment, discharge of treated groundwater, in situ remediation of groundwater, and MNA).
"Water Pollution Control" (RCW 90.48, as amended); "Underground Injection Control Program" (WAC 173-218)					
"UIC Well Classification Including Allowed and Prohibited Wells, Class V Injection Well" (WAC 173-218-040[5])	Action	Establishes criteria and standards for an underground injection control program for Class V injection wells.	NAPL source material, groundwater and soil in the Upper Aquifer contains contaminants that require remediation; treated groundwater from the GWTP, steam, oxidants such as hydrogen peroxide and permanganate, catalysts such as ozone, air, and jet grouting (Portland	ARAR	NAPL source material, groundwater and soil remedial activities involve underground injection (treated groundwater from the GWTP, steam injection for thermal enhanced extraction, injection of oxidants such as hydrogen peroxide, permanganate, and catalysts such as ozone for ISCO

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
			cement and bentonite) may be injected through vertical/horizontal wells or direct push wells.		treatment, air injection for enhanced aerobic biodegradation, and Portland cement and bentonite injection for ISS).
"Hazardous Waste Cleanup—Model Toxics Control Act" (RCW 70.105D, as amended); "Model Toxics Control Act—Cleanup" (WAC 173-340)					
"Groundwater Cleanup Standards" (WAC 173-340-720) "Method B Cleanup Levels for Potable Ground Water" (WAC 173-340-720[4][b][i-iii][A]&[B]) "Adjustments to Cleanup Levels" (WAC 173-340-720[7])	Chemical	Groundwater cleanup levels are based on estimates of the highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions. Method B equations (720-1 and 720-2) are used to calculate groundwater cleanup levels for noncarcinogens and carcinogens, respectively, only if "sufficiently protective, health-based criteria or standards have not been established under applicable state and federal laws. Groundwater cleanup levels are established at concentrations that do not directly or indirectly cause violations of surface water, sediment, soil, or air cleanup standards.	NAPL source material present in the Upper Aquifer contains contaminants that require remediation to protect marine and Lower Aquifer water quality. Upper Aquifer groundwater is not currently used for drinking water, and institutional controls will remain in place to permanently prohibit withdrawal of groundwater from the Upper Aquifer for drinking water, irrigation or other beneficial uses. However, groundwater in the southwest portion of the Lower Aquifer is a potential source for drinking water, irrigation or other beneficial uses after the restoration is complete.	ARAR	NAPL source and Lower Aquifer groundwater remediation and management activities (e.g., groundwater treatment, discharge of treated groundwater, in situ remediation of groundwater, and MNA).
"Water Well Construction" (RCW 18.104, as amended); "Minimum Standards for Construction and Maintenance of Wells" (WAC 173-160); "Regulation and Licensing of Well Contractors and Operators" (WAC 173-162)					
"How Shall Each Water Well Be Planned and Constructed?" (WAC 173-160-161)	Action	Identifies well planning and construction requirements.	New groundwater wells may be installed after removal of existing groundwater wells as part of the remedial action. Groundwater extraction, containment, monitoring, injection, biosparging, dewatering, and treatment wells and borings occur in the Upper Aquifer.	ARAR	Remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Are the Requirements for the Location of the Well Site and Access to the Well?" (WAC 173-160-171)	Action	Identifies the requirements for locating a well.	New groundwater wells may be installed in the Lower Aquifer after removal of existing groundwater wells as part of the remedial action. Groundwater extraction, containment, monitoring, injection,	ARAR	Remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
			biosparging, dewatering, and treatment wells and borings occur in the Upper Aquifer.		
"What Are the Requirements for Preserving the Natural Barriers to Groundwater Movement Between Aquifers?" (WAC 173-160-181)	Action	Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.	New groundwater wells may be installed Lower Aquifer after removal of existing groundwater wells as part of the remedial action. Groundwater extraction, containment, monitoring, injection, biosparging, dewatering, and treatment wells and borings occur in the Upper Aquifer.	ARAR	Remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?" (WAC 173-160-400)	Action	Identifies the minimum standards for resource protection wells and geotechnical soil borings.	New groundwater wells may be installed Lower Aquifer after removal of existing groundwater wells as part of the remedial action. Groundwater extraction, containment, monitoring, injection, biosparging, dewatering, and treatment wells and borings occur in the Upper Aquifer.	ARAR	Remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Are the General Construction Requirements for Resource Protection Wells?" (WAC 173-160-420)	Action	Identifies the general construction requirements for resource protection wells.	New groundwater wells may be installed Lower Aquifer after removal of existing groundwater wells as part of the remedial action. Groundwater extraction, containment, monitoring, injection, biosparging, dewatering, and treatment wells and borings occur in the Upper Aquifer.	ARAR	Remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Are the Minimum Casing Standards?" (WAC 173-160-430)	Action	Identifies the minimum casing standards.	New groundwater wells may be installed Lower Aquifer after removal of existing groundwater wells as part of the remedial action. Groundwater extraction, containment, monitoring, injection, biosparging, dewatering, and treatment wells and borings occur in the Upper Aquifer.	ARAR	Remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Are the Equipment Cleaning Standards?" (WAC 173-160-440)	Action	Identifies the equipment cleaning standards.	New groundwater wells may be installed Lower Aquifer after removal of existing groundwater wells as part	ARAR	Remediation activities that require siting, installation, construction,

TABLE A-1
Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered
Former Process Area, Soil and Groundwater OUs
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
			of the remedial action. Groundwater extraction, containment, monitoring, injection, biosparging, dewatering, and treatment wells and borings occur in the Upper Aquifer.		operation, maintenance, and decommissioning of wells and borings.
"What Are the Well Sealing Requirements?" (WAC 173-160-450)	Action	Identifies the well sealing requirements.	New groundwater wells may be installed Lower Aquifer after removal of existing groundwater wells as part of the remedial action. Groundwater extraction, containment, monitoring, injection, biosparging, dewatering, and treatment wells and borings occur in the Upper Aquifer.	ARAR	Remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Is the Decommissioning Process for Resource Protection Wells?" (WAC 173-160-460)	Action	Identifies the decommissioning process for resource protection wells.	New groundwater wells may be installed Lower Aquifer after removal of existing groundwater wells as part of the remedial action. Groundwater extraction, containment, monitoring, injection, biosparging, dewatering, and treatment wells and borings occur in the Upper Aquifer.	ARAR	Remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"Regulation and Licensing of Well Contractors and Operators" (WAC 173-162)	Action	Identifies the requirements for the licensing of well contractors and operators.	New groundwater wells may be installed Lower Aquifer after removal of existing groundwater wells as part of the remedial action. Groundwater extraction, containment, monitoring, injection, biosparging, dewatering, and treatment wells and borings occur in the Upper Aquifer.	ARAR	Remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites **(OSWER Directive 9200.4-17P)**					
Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (OSWER Directive 9200.4-17P)	Action	Provides the framework and appropriateness for using MNA as a remedy component for organic and inorganic contaminants.	Groundwater in the Upper and Lower Aquifers contains contaminants that require remediation. The use of MNA as a remedy may be appropriate.	TBC	Groundwater remediation activities, including MNA.
Surface Water					
Clean Water Act of 1972 **(Public Law 107-303, as amended; 33 USC 1251, et seq.), Section 303c; "Water Quality Standards" (40 CFR 131)**					

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B)" (40 CFR 131.36[b][1])	Chemical	Establishes numeric water quality criteria for the protection of human health and aquatic organisms. Toxic criteria for the protection of aquatic life is provided in the water quality criteria regulations "Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B)" (40 CFR 131.36[b][1]), "EPA's Section 304(a), Criteria for Priority Toxic Pollutants," supersede criteria adopted by the state, except where the state criteria are more stringent than the federal criteria.	NAPL source material, groundwater and soil in the Upper Aquifer contains contaminants that require remediation to protect surface waters in Eagle Harbor and Puget Sound. Passive Upper Aquifer groundwater treatment may also discharge treated water to Eagle Harbor and Puget Sound. The final end use of the Site is planned as a park with open areas. To reduce surface water infiltration and to prevent exposure to potential, low-level residual contaminants, a surface cover with an impervious bottom liner, will be installed. Following completion of remedial action, storm water will be collected and discharged to surface waters in Eagle Harbor using best management practices typical of vegetated areas.	ARAR	Groundwater and soil remediation activities that affect surface water (e.g., discharge of treated groundwater, in situ remediation of groundwater, run-off/run-on from excavated soil stockpiles, dewatering for soil excavation below the groundwater table, fluids pumping from horizontal and vertical wells for enhanced NAPL recovery, passive groundwater treatment, and MNA), and storm water management practices that affect surface water.
"Hazardous Waste Cleanup—Model Toxics Control Act" (RCW 70.105D, as amended); "Model Toxics Control Act—Cleanup" (WAC 173-340)					
"Surface Water Cleanup Standards" (WAC 173-340-730)	Chemical	Surface water cleanup levels are based on estimates of the highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions.	Groundwater and soil in the Upper Aquifer contains contaminants that require remediation and discharges to surface waters in Eagle Harbor and Puget Sound. The final end use of the Site is planned as a park with open areas. To reduce surface water infiltration and to prevent exposure to potential, low-level residual contaminants, a surface cover with an impervious bottom liner,uch as a multi-layer cover or some form of ET cover, will be installed. Storm water would be collected and discharged to surface waters in Eagle Harbor and	ARAR	Groundwater and soil remediation activities that affect surface water (e.g., discharge of treated groundwater, in-situ remediation of groundwater, run-off/run-on from excavated soil stockpiles, dewatering for soil excavation below the groundwater table, fluids pumping from horizontal and vertical wells for enhanced NAPL recovery, and MNA), and storm water management practices that affect surface water.

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
			Puget Sound using best management practices typical of vegetated areas.		
"Water Pollution Control" (RCW 90.48, as amended); "Water Quality Standards for Surface Waters of the State of Washington" (WAC 173-201A); "National Pollutant Discharge Elimination System (NPDES)" (40 CFR 122); "National Pollutant Discharge Elimination System Permit Program" (WAC 173-220, WAC 173-221A); "Determination of Reportable Quantities for Hazardous Substances" (40 CFR 117)					
"Toxic Substances" (WAC 173-201A-240[3])	Chemical	Establishes water quality standards for surface waters of the State of Washington consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife.	Groundwater and soil in the Upper Aquifer contains contaminants that require remediation and discharges to surface waters in Eagle Harbor and Puget Sound. The use designations for Eagle Harbor and Puget Sound include aquatic life use (spawning and rearing), primary contact recreation, water supply (drinking, irrigation, and agriculture), and miscellaneous uses (wildlife habitat, harvesting, commerce, boating, and aesthetics).	ARAR	Groundwater and soil remediation activities that affect surface water (e.g., discharge of treated groundwater, in situ remediation of groundwater, run-off/run-on from excavated soil stockpiles, dewatering for soil excavation below the groundwater table, fluids pumping from horizontal and vertical wells for enhanced NAPL recovery, and MNA), and storm water management practices that affect surface water.
"National Pollutant Discharge Elimination System Permit Program" (WAC 173-220)	Chemical	Establishes a state individual permit program, applicable to the discharge of pollutants and other wastes and materials to the surface waters of the state, operating under state law as a part of the National Pollutant Discharge Elimination System (NPDES).	Groundwater and soil in the Upper Aquifer contains contaminants that require remediation and discharges to surface waters in Eagle Harbor and Puget Sound,	ARAR	Groundwater and soil remediation activities that affect surface water (e.g., discharge of treated groundwater, in situ remediation of groundwater, run-off/run-on from excavated soil stockpiles, dewatering for soil excavation below the groundwater table, fluids pumping from horizontal and vertical wells for enhanced NAPL recovery, and MNA), and storm water management practices that affect surface water. Only the substantive requirements are applicable.
"Wastewater Discharge Standards and Effluent Limitations" (WAC 173-221A)	Chemical	Establishes minimum discharge standards which represent "known, available, and reasonable methods" of prevention, control, and treatment for industrial wastewater facilities that discharge to waters of the state.	Groundwater and soil in the Upper Aquifer contains contaminants that require remediation and discharges to surface waters in Eagle Harbor and Puget Sound.	ARAR	Groundwater and soil remediation activities that affect surface water (e.g., discharge of treated groundwater, in situ remediation of groundwater, run-off/run-on from excavated soil stockpiles, dewatering for soil excavation below the

TABLE A-1
Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered
Former Process Area, Soil and Groundwater OUs
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
					groundwater table, fluids pumping from horizontal and vertical wells for enhanced NAPL recovery, and MNA), and storm water management practices that affect surface water.
"Determination of Reportable Quantities for Hazardous Substances" (40 CFR 117)	Chemical	Establishes a determination of the reportable quantities for substances designated as hazardous, and addresses reporting requirements, penalties, and liabilities for discharge of designated substances, in equal to or greater than reportable quantities, to the navigable waters.	Groundwater and soil in the Upper Aquifer contains contaminants that require remediation and discharges to surface waters in Eagle Harbor and Puget Sound,	ARAR	Groundwater and soil remediation activities that affect surface water (e.g., discharge of treated groundwater, in situ remediation of groundwater, run-off/run-on from excavated soil stockpiles, dewatering for soil excavation below the groundwater table, fluids pumping from horizontal and vertical wells for enhanced NAPL recovery, and MNA), and storm water management practices that affect surface water.
Oil Pollution Act of 1990 **(33 USC 2701, et seq.); "Oil Pollution Prevention" (40 CFR Part 112); "Facilities Transferring Oil or Hazardous Material in Bulk" (33 CFR Part 154);** ***Oil Spill Prevention and Response Act of 1991*** **(RCW 90.56); "Facility Oil Handling Standards" (WAC 173-180)**					
"General Requirements for Spill Prevention, Control, and Countermeasure (SPCC) Plans" (40 CFR Part 112.7)	Action	Establishes requirements for non-transportation related onshore and offshore facility owners and operators to outline procedures to prevent the discharge of oil into navigable waters	Groundwater and soil in the Upper Aquifer contains contaminants that require remediation. The Site is an operator of non-transportation related onshore facility engaging in transferring (from a tank or transmission pipeline), storing, handling, and consuming oil in bulk during remediation activities.	ARAR	Groundwater remediation activities (e.g., discharge of treated groundwater, in situ remediation of groundwater, run-off/run-on from excavated soil stockpiles, dewatering for soil excavation below the groundwater table, fluids pumping from horizontal and vertical wells for enhanced NAPL recovery, and MNA). NAPL from enhanced NAPL recovery process may be stored and used as a fuel supplement for other treatment processes.
"Facilities Transferring Oil or Hazardous Material in Bulk" (33 CFR Part 154)	Action	Applies to a facility that is capable of transferring oil or hazardous materials, in bulk, to or from a vessel, where the vessel has a total capacity, from a combination of all bulk products carried, of 39.75 cubic meters (250 barrels) or more. Establishes requirements for the facility operators to prepare	Groundwater and soil in the Upper Aquifer contains contaminants that require remediation. The Site is an operator of non-transportation related onshore facility engaging in transferring (from a tank or	ARAR	Groundwater remediation activities (e.g., discharge of treated groundwater, in situ remediation of groundwater, run-off/run-on from excavated soil stockpiles, dewatering for soil excavation below the

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
		and maintain operations manuals, and to comply with equipment, facility operation standards, vapor control system, and response plan standards and requirements.	transmission pipeline), storing, handling, and consuming oil in bulk during remediation activities.		groundwater table, fluids pumping from horizontal and vertical wells for enhanced NAPL recovery, and MNA). NAPL from enhanced NAPL recovery process may be stored and used as a fuel supplement for other treatment processes.
"Facility Oil Handling Standards" (WAC 173-180, Part A through Part H)	Action	Establishes a set of regulations that are designed to protect the State of Washington's environment and public health and safety through a comprehensive spill prevention, preparedness, and response program. These regulations include oil transfer requirements, design standards for facilities, operations manual requirements, training and certification requirements, prevention plan requirements, oil transfer response plan and contingency plan requirements, and drill program requirements.	Groundwater and soil in the Upper Aquifer contains contaminants that require remediation. The Site is an operator of non-transportation related onshore facility engaging in transferring (from a tank or transmission pipeline), storing, handling, and consuming oil in bulk during remediation activities.	ARAR	Groundwater remediation activities (e.g., discharge of treated groundwater, in situ remediation of groundwater, run-off/run-on from excavated soil stockpiles, dewatering for soil excavation below the groundwater table, fluids pumping from horizontal and vertical wells for enhanced NAPL recovery, and MNA). NAPL from enhanced NAPL recovery process may be stored and used as a fuel supplement for other treatment processes.
Soil and Vadose Zone					
"Hazardous Waste Cleanup—Model Toxics Control Act" (RCW 70.105D, as amended); "Model Toxics Control Act—Cleanup" (WAC 173-340)					
"Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740) "Method B Soil Cleanup Levels for Unrestricted Land Use" (WAC 173-340-740[3]) "Adjustments to Cleanup Levels" (WAC 173-340-740[5]) "Point of Compliance" (WAC 173-340-740[6]) "Compliance Monitoring" (WAC 173-340-740[7])	Chemical	Establishes soil cleanup levels where residential land use represents the reasonable maximum exposure under both current and future site use conditions. Cleanup standards require specification of the following: • Hazardous substance concentrations that protect HHE (cleanup levels) • Location of the site where cleanup levels must be attained ("points of compliance") • Other regulatory requirements that apply to the cleanup action because of the type of action or location of the site These requirements are generally established in conjunction with the selection of a specific cleanup action.	Soil in the Upper Aquifer contains contaminants that require remediation. The requirements corresponding to Method B soil cleanup levels may be used to calculate cleanup levels based on an unrestricted land use (the planned final end use of the Wyckoff Site is a park with open areas).	ARAR	Soil cleanup actions where concentration of hazardous substances in the soil exceeds Method B cleanup levels using "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740[3][b] and [c]).

TABLE A-1
Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered
Former Process Area, Soil and Groundwater OUs
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745)	Chemical	Establishes soil cleanup levels if it has been determined that industrial land use represents the reasonable maximum exposure.	Soil in the Upper Aquifer contains contaminants that require remediation. The requirements corresponding to industrial properties may be used to calculate cleanup levels.	ARAR	Soil cleanup actions where concentration of hazardous substances in the soil exceeds cleanup levels using "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745).
"Deriving Soil Concentrations for Groundwater Protection" (WAC 173-340-747[3] through [8])	Chemical	Establishes soil concentrations that will not cause contamination of groundwater at levels that exceed the groundwater cleanup levels established under "Groundwater Cleanup Standards" (WAC 173-340-720). Provides an overview of the methods for deriving these soil concentrations to meet relevant criteria. Certain methods are tailored for particular types of hazardous substances or sites and certain methods are more complex than others and/or require the use of site-specific data.	Soil in the Upper Aquifer contains contaminants that require remediation. The requirements corresponding to soil cleanup levels may be used to calculate cleanup levels to ensure protection of groundwater. Groundwater is not currently used for drinking water, and institutional controls will remain in place to permanently prohibit withdrawal of groundwater from the Upper Aquifer for drinking water, irrigation or other beneficial uses. However, groundwater from the Lower Aquifer is a potential source for drinking water, irrigation or other beneficial uses after the restoration is complete.	ARAR	Soil cleanup actions where concentration of hazardous substances in the soil exceeds soil concentration for protection of groundwater. As allowed, "Deriving Soil Concentrations for Groundwater Protection" (WAC 173-340-747[8]), Alternative fate and transport models, one of the seven allowable methods under "Deriving Soil Concentrations for Groundwater Protection" (WAC 173-340-747) will be used to determine appropriate cleanup levels.
Guidance for Developing Ecological Soil Screening Levels (OSWER Directive 9285.7-55)	Chemical	Provides a set of risk-based soil screening levels (EcoSSLs) for several soil contaminants that are of ecological concern for terrestrial plants and animals at hazardous waste sites. Also describes the process used to derive these levels and provides guidance for their use.	Soil in the Upper Aquifer contains contaminants that require remediation. Comparison to SSLs may be appropriate for defining potential COPCs or to default to an EcoSSL for COPCs that lack corresponding published state cleanup criteria.	TBC	Soil cleanup actions to protect ecological receptors.
"Terrestrial Ecological Evaluation Procedures" (WAC 173-340-7490) "Site-Specific Terrestrial Ecological Evaluation Procedures" (WAC 173-340-7493)	Chemical	Defines goals and procedures for determining whether a release of hazardous substances to soil may pose a threat to the terrestrial environment. Characterizes existing or potential threats to terrestrial plants or animals exposed to hazardous substances in soil; establishes site-specific cleanup	Soil in the Upper Aquifer contains contaminants that require evaluation to determine if ecological exposures have the potential to cause significant adverse effects.	TBC	Soil remediation activities including containment (surface/subsurface barrier and hydraulic containment), removal (excavation and extraction), ex situ treatment (onsite thermal desorption), in situ treatment (thermal enhanced extraction, ISS, ISCO,

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Priority Contaminants of Ecological Concern" (WAC 173-340-7494)		standards for the protection of terrestrial plants and animals. "Priority Contaminants of Ecological Concern" (WAC 173-340-7494) provides for numeric concentrations of hazardous substances determined to persist, bioaccumulate, or be highly toxic to terrestrial ecological receptors.			enhanced aerobic biodegradation, and MNA), and onsite disposal (reuse treated soil for backfill or to recontour the site topography). After using the generic screening levels available in Table 749-3, site-specific terrestrial ecological cleanup levels have been developed using "Site-Specific Terrestrial Ecological Evaluation Procedures" (WAC 173-340-7493).
Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (OSWER Directive 9200.4-17P)	Action	Provides the framework and appropriateness for using MNA as a remedy component for organic and inorganic contaminants.	Soil in the Upper Aquifer contains contaminants that require remediation. The use of MNA as a remedy may be appropriate.	TBC	Soil remediation activities, including MNA.
Hazardous Material Transportation Act of 1975 (49 USC 5102 et seq.); Hazardous Materials Transportation Uniform Safety Act of 1990; Transportation – Hazardous Materials Regulations (49 CFR Parts 171 through 180)					
Hazardous Material Transportation Act of 1975 (HMTA) (49 CFR Parts 171 through 180)	Action	HMTA establishes regulations to provide adequate protection against the risks to life and property inherent in the transportation of hazardous material in commerce by improving the regulatory and enforcement authority of the Secretary of Transportation. A hazardous material is defined as any "particular quantity or form" of a material that "may pose an unreasonable risk to health and safety or property." 49 CFR Parts 171 through 180 establish regulations for material designations, packaging and shipping requirements, and operational rules.	The Soil and Groundwater OU contains contaminated media, structures, underground utilities, and buried debris. Soil in the Upper Aquifer contains contaminants that may require transport offsite to a permitted facility for disposal. Waste materials that contain dioxins may require incineration prior to offsite landfill disposal.	ARAR	The Soil and Groundwater OU contains contaminated media, structures, underground utilities, and buried debris. Soil in the Upper Aquifer contains contaminants that may require transport offsite to a permitted facility for disposal. Waste materials that contain dioxins may require incineration prior to offsite landfill disposal.
Air					
"National Primary and Secondary Ambient Air Quality Standards" (40 CFR 50); "Washington Clean Air Act" (Chapter 70.94 RCW, as amended); "General Regulations for Air Pollution Sources" (WAC 173-400); "The Puget Sound Clean Air Agency Regulations"					
"General Regulations for Air Pollution Sources" (WAC 173-400)	Action	Defines methods of control to be employed to minimize the release of air contaminants associated with fugitive emissions resulting from materials handling, construction, demolition, or other operations. Emissions are to be minimized through application of best available control technology.	Soil and/or groundwater remedial actions implemented in the Upper Aquifer have the potential to emit emissions subject to these standards because soil and groundwater hazardous contaminants detected in	ARAR	Actions performed at the Upper Aquifer that result in the emission of hazardous air pollutants, including decontamination, demolition, and excavation activities implemented during a remedial action that have the

TABLE A-1
Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered
Former Process Area, Soil and Groundwater OUs
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
			the Upper Aquifer include covered hazardous air pollutants.		potential to emit visible, particulate, fugitive, and hazardous air emissions and odors.
"General Standards for Maximum Emissions" (WAC 173-400-040)	Action	All sources and emission units are required to meet the general emission standards unless a specific source standard is available. General standards apply to visible emissions, particulate fallout, fugitive emissions, odors, emissions detrimental to health and property, sulfur dioxide, and fugitive dust.	Soil and/or groundwater remedial actions implemented in the Upper Aquifer have the potential to emit emissions subject to these standards because hazardous contaminants detected in the Upper Aquifer include covered regulated hazardous air pollutants.	ARAR	Remedial actions that have the potential to release hazardous air emissions, including demolition, excavation, onsite thermal desorption, and thermal enhanced extraction.
"Emission Standards for Combustion and Incineration Units" (WAC 173-400-050)	Action	Establishes emission standards for combustion and incineration units.	Soil and/or groundwater remedial actions implemented in the Upper Aquifer have the potential to emit emissions subject to these standards because hazardous contaminants detected in the Upper Aquifer include covered regulated hazardous air pollutants.	ARAR	Remedial actions that have the potential to release hazardous air emissions. As part of the thermal desorption treatment process, excavated soil would be treated through a propane-fired thermal desorption unit that includes a rotary desorber for soil treatment, a baghouse for dust collection, and a thermal oxidizer to destroy organic vapors.
"Emission Standards for Sources Emitting Hazardous Air Pollutants" (WAC 173-400-075)	Action	Establishes national emission standards for hazardous air pollutants. Adopts, by reference, "National Emission Standards for Hazardous Air Pollutants" (NESHAP [40 CFR 61]) and appendices.	Soil and/or groundwater hazardous contaminants detected in the Upper Aquifer include covered regulated hazardous air pollutants.	ARAR	Actions performed at the Upper Aquifer that result in the emission of hazardous air pollutants, including decontamination, demolition, excavation, onsite thermal desorption (dust collection and vapor recovery/destruction), and thermal enhanced extraction (vapor recovery/destruction) activities implemented during the remedial action that have the potential to emit visible, particulate, fugitive, and hazardous air emissions and odors.
"Regulation I of the Puget Sound Clean Air Agency"	Action	Establishes standards and rules that are generally applicable to the control and/or prevention of the emission of air contaminants from all sources within the jurisdiction of the Agency, for the uniform	Soil and/or groundwater remedial actions implemented in the Upper Aquifer have the potential to emit emissions subject to these standards.	ARAR	Actions performed at the Upper Aquifer that result in the emission of hazardous air pollutants, including decontamination, demolition,

TABLE A-1
Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered
Former Process Area, Soil and Groundwater OUs
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
		administration and enforcement of this regulation, and for implementation of the requirements and purposes of the Washington Clean Air Act and the Federal Clean Air Act.			excavation, onsite thermal desorption (dust collection and vapor recovery/destruction), and thermal enhanced extraction (vapor recovery/destruction) activities implemented during the remedial action that have the potential to emit visible, particulate, fugitive, and hazardous air emissions and odors.
"Regulation II of the Puget Sound Clean Air Agency"	Action	Establishes a special regulation to reduce ozone concentrations as required by the Federal Clean Air Act as amended and to provide for control of photochemically reactive volatile organic compounds (VOC), which are precursors to ozone, to meet the National Ambient Air Quality Standard for ozone.	Soil and/or groundwater remedial actions implemented in the Upper Aquifer have the potential to emit emissions subject to these standards.	ARAR	Actions performed at the Upper Aquifer that result in the emission of hazardous air pollutants, including decontamination, demolition, excavation, onsite thermal desorption (dust collection and vapor recovery/destruction), and thermal enhanced extraction (vapor recovery/destruction) activities implemented during the remedial action that have the potential to emit visible, particulate, fugitive, and hazardous air emissions and odors. As part of the ISCO treatment process, oxidants (such as hydrogen peroxide) will be used for NAPL oxidation. To increase its oxidizing strength, aqueous iron, heat, and ozone may be used to catalyze hydrogen peroxide.
"Regulation III of the Puget Sound Clean Air Agency"	Action	Establishes standards to reduce the ambient concentrations of toxic air contaminants in the Puget Sound region and thereby prevent air pollution. The major requirements of this regulation are implementation of Best Available Control Technology (BACT) for sources of toxics air contaminants, quantification of toxic air pollutant emissions from new and existing sources by comparing modeled or measured concentrations with the Acceptable Source Impact Levels (ASILs), and demonstration of health and safety protection.	Soil and/or groundwater remedial actions implemented in the Upper Aquifer have the potential to emit emissions subject to these standards.	ARAR	Groundwater and soil remediation activities, such as the Upper Aquifer treatment systems with the potential to emit hazardous air emissions would be considered a new source.
"Washington Clean Air Act" (Chapter 70.94 RCW, as amended); "Controls for New Sources of Toxic Air Pollutants" (WAC 173-460)					

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Purpose" (WAC 173-460-010) "Applicability" (WAC 173-460-030) "Control Technology Requirements" (WAC 173-460-060) "Ambient Impact Requirement" (WAC 173-460-070) "First Tier Review" (WAC 173-460-080) "Table of ASIL, SQER and de Minimis Emission Values" (WAC 173-460-150)	Action	Establishes control of new sources emitting toxic air pollutants to prevent air pollution, reduce emissions to the extent reasonably possible, and maintain such levels of air quality as will protect human health and safety. Toxic air pollutants include carcinogens and noncarcinogens listed in "Table of ASIL, SQER and de Minimis Emission Values" (WAC 173-460-150). Three major requirements of this regulation are implementation of best available control technology for toxics, quantification of toxic air pollutant emissions, and demonstration of health and safety protection.	Hazardous contaminants detected in soil and/or groundwater in the Upper Aquifer include constituents that would constitute toxic air pollutants if released to the air.	ARAR	Groundwater and soil remediation activities, such as the Upper Aquifer treatment systems with the potential to emit hazardous air emissions would be considered a new source.
"Hazardous Waste Cleanup—Model Toxics Control Act" (RCW 70.105D, as amended); "Model Toxics Control Act—Cleanup" (WAC 173-340)					
"Cleanup Standards to Protect Air Quality" (WAC 173-340-750) "Method B Air Cleanup Levels" (WAC 173-340-750[3]) "Adjustments to Air Cleanup Levels" (WAC 173-340-750[5]) "Point of Compliance" (WAC 173-340-750[6]) "Compliance Monitoring" (WAC 173-340-750[7])	Chemical	Establishes air cleanup standards to determine if air emissions at a site pose a threat to human health or the environment. Cleanup standards require specification of the following: • Hazardous substance concentrations that protect HHE (cleanup levels) • Location of the site where cleanup levels must be attained ("points of compliance") • Other regulatory requirements that apply to the cleanup action because of the type of action or location of the site These requirements are generally established in conjunction with the selection of a specific cleanup action.	Hazardous contaminants detected in soil and/or groundwater in the Upper Aquifer include constituents that would constitute toxic air pollutants if released to the air. The requirements corresponding to Method B air cleanup levels may be used to calculate cleanup levels.	ARAR	Groundwater and soil remediation activities, such as containment (surface/subsurface barrier and hydraulic containment), removal (excavation and extraction), ex situ treatment (onsite thermal desorption), in situ treatment (thermal enhanced extraction, ISS, ISCO, enhanced aerobic biodegradation, and MNA), and onsite disposal (reuse treated soil for backfill or to recontour the site topography), with the potential to emit hazardous air emissions, where Method B cleanup levels are exceeded using "Cleanup Standards to Protect Air Quality" (WAC 173-340-750[3]).
***The Resource Conservation and Recovery Act*; "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" (40 CFR Part 264); "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" (40 CFR Part 265)**					
"Air Emissions Standards for Equipment Leaks" (40 CFR Part 264, Subpart BB)	Action	Establishes standards for owners and operators of facilities that treat, store, or dispose of hazardous wastes, with equipment that contains or contacts hazardous wastes with organic concentrations of at least 10 percent by weight. Requires equipment to	Hazardous contaminants detected in soil and/or groundwater in the Upper Aquifer include VOCs and SVOCs that would constitute toxic air	ARAR	Remedial actions that have the potential to release hazardous air emissions include ex situ treatment of excavated soil using onsite thermal desorption process (dust collection

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
		be designed to prevent organic emissions from leaking to the atmosphere. Requires control devices to be monitored and inspected to ensure proper maintenance and operation.	pollutants if released to the air via equipment leaks.		and vapor recovery/destruction), and in situ treatment using thermal enhanced extraction process (vapor recovery/destruction).
"Air Emissions Standards for Tanks, Surface Impoundments and Containers" (40 CFR Part 264, Subpart CC) (40 CFR Part 265, Subpart CC)	Action	Establishes standards for owners and operators of interim status or permitted TSD facilities that manage volatile hazardous waste with average VO concentration of 500 ppmw or more, which treat, store, or dispose of hazardous wastes in tanks, surface impoundments, containers, or miscellaneous unit and large quantity generators that accumulate volatile hazardous waste in 90-day tanks and containers. Requires specific analytical waste determinations for waste management units that are exempt, and specific emission requirements for nonexempt waste management units.	Hazardous contaminants detected in soil and/or groundwater in the Upper Aquifer include VOCs and SVOCs that would constitute toxic air pollutants if released to the air from tanks, surface impoundment, and containers.	ARAR	Remedial actions that have the potential to release hazardous air emissions include ex situ treatment of excavated soil using onsite thermal desorption process (VOCs and SVOCs from excavated soil may be contained for treatment) and in situ treatment using thermal enhanced extraction process (VOCs and SVOCs may be recovered via vapor extraction and contained for ex situ treatment).
"Standards of Performance for New Stationary Sources" (40 CFR Part 60)					
"Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units" (40 CFR Part 60, Subpart Dc)	Action	Establishes standards of performance for small industrial-commercial-institutional steam generating units. This regulation provides limitations for particulate matter and sulfur dioxide emissions, and requirements for performance testing and monitoring.	Soil and/or groundwater remedial actions implemented in the Upper Aquifer have the potential to emit emissions subject to these standards because hazardous contaminants detected in the Upper Aquifer include covered regulated hazardous air pollutants.	ARAR	Remedial actions that have the potential to release hazardous air emissions. As part of the thermal enhanced extraction process, steam injection will be utilized through installed process wells. The steam would be produced in a propane-fired steam generator. Liquids and vapors will be co-extracted from process wells, during and after steam injection, and contaminants removed via treatment. NAPL will be separated and contaminated water treated in the existing GWTP. Vapors will be routed through a thermal oxidizer for destruction.
Clean Air Act of 1990 **and amendments; "National Emission Standard for Asbestos" (40 CFR Part 61, Subpart M),**					
"Applicability" (40 CFR 61.140) "Standard for Demolition and Renovation" (40 CFR 61.145)	Action	Defines regulated ACM and regulated removal and handling requirements. Specifies sampling, inspection, handling, and disposal requirements for regulated sources having	Encountering ACM on pipelines or buried asbestos within the Upper Aquifer is possible during the demolition and removal of existing	ARAR	Site preparation for remedial action implementation that include demolition and removal of existing structures, underground utilities, and

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
		the potential to emit asbestos. Specifically, no visible emissions are allowed during handling, packaging, and transport of ACM.	structures, underground utilities, and buried debris.		buried debris, and associated handling, packaging, and transportation of ACM, including IDW management and disposal.
Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation, and Spraying Operations (40 CFR 61.150)	Action	Identifies requirements for the removal and disposal of asbestos from demolition and renovation activities.	Encountering ACM on pipelines or buried asbestos within the Upper Aquifer is possible during the demolition and removal of existing structures, underground utilities, and buried debris.	ARAR	Site preparation for remedial action implementation that include demolition and removal of existing structures, underground utilities, and buried debris, and associated handling, packaging, and transportation of ACM including IDW management and disposal.
Solid Wastes					
Toxic Substances Control Act of 1976 **(Public Law 107-377, as amended; 15 USC Section 2605, et seq.); "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" (40 CFR Part 761)**					
"Applicability," "PCB Waste" (40 CFR 761.50[b]1, 2, 3, 4 and 7) "Applicability," "Storage for Disposal" (40 CFR 761.50[c])	Action	Establishes general PCB disposal requirements for the storage and disposal of PCB wastes including liquid PCB wastes, PCB items, PCB remediation waste, PCB bulk product wastes, and PCB/radioactive wastes at concentrations greater than 50 ppm.	PCB wastes encountered and or generated during the remediation of the Upper Aquifer.	ARAR	Soil excavation and remediation, equipment and debris handling and disposal, and IDW management and disposal.
"Disposal Requirements," "PCB Liquids" (40 CFR 761.60[a]) "Disposal Requirements," "PCB Articles" (40 CFR 761.60[b]) "Disposal Requirements," "PCB Containers" (40 CFR 761.60[c])	Action	Establishes requirements applicable to the handling and disposal of PCB liquids, PCB articles, and PCB containers.	PCB liquids, articles, and/or containers encountered and/or generated during the remedial actions for the Upper Aquifer.	ARAR	Equipment and debris handling, storage, and disposal; IDW management and disposal.
"PCB Remediation Waste" (40 CFR 761.61)	Action	Provides cleanup and disposal options for PCB remediation waste based on the concentration at which the PCBs are found.	PCB remediation wastes encountered and/or generated during the remedial actions for the Upper Aquifer.	ARAR	Soil remediation, RTD, and IDW management and disposal.
"Hazardous Waste Management" (RCW 70.105, as amended); "Dangerous Waste Regulations" (WAC 173-303); ***The Resource Conservation and Recovery Act*** **(RCRA) (40 CFR Parts 260 through 280)**					

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Identifying Solid Waste" (WAC 173-303-016) "Recycling Processes Involving Solid Waste" (WAC 173-303-017)	Action	Establishes criteria for solid and recycled solid wastes.	Solid wastes and/or recycled solid wastes will be generated during the Upper Aquifer remedial actions.	ARAR	Site preparation (demolition and removal of existing structures, underground utilities, and buried debris) for remedial action implementation, and remediation activities treated soil after excavation, decontaminated materials from demolition and excavation activities).
"Designation of Dangerous Waste" (WAC 173-303-070)	Action	Establishes the method for determining if a solid waste is a dangerous waste (or an extremely hazardous waste).	Dangerous/hazardous waste will be generated during the Upper Aquifer remedial actions.	ARAR	Site preparation (demolition and removal of existing structures, underground utilities, and buried debris) for remedial action implementation, and remediation activities (soil excavation, and ex situ treatment [onsite thermal desorption with onsite reuse or offsite incineration]) that generate wastes (e.g., demolition waste, drums, barrels, tanks, containers, bulk wastes, debris, and contaminated soil).
"Conditional Exclusion of Special Wastes" (WAC 173-303-073)	Action	Establishes the conditional exclusion and the management requirements of special wastes, as defined in "Definitions" (WAC 173-303-040).	Special wastes have the potential to be generated during the Upper Aquifer remedial actions.	ARAR	Remediation activities (demolition, disposal, storage, recycling, and onsite treatment) that manage special wastes consistent with the requirements of the *Washington Administrative Code*.
"Requirements for Universal Waste" (WAC 173-303-077)	Action	Identifies those wastes exempted from regulation under "Land Disposal Restrictions" (WAC 173-303-140) and "Requirements for Generators of Dangerous Waste" (WAC 173-303-170) through "Reserved" (WAC 173-303-9907) (excluding, "Special Powers and Authorities of the Department" [WAC 173-303-960]). These wastes are subject to regulation under "Standards for Universal Waste Management" (WAC 173-303-573).	Universal wastes have the potential to be generated during the Upper Aquifer remedial actions.	ARAR	Remediation activities (demolition, disposal, storage, recycling, and onsite treatment) that manage universal wastes consistent with the requirements of the *Washington Administrative Code*.
"State-Specific Dangerous Waste Numbers" (WAC 173-303-104)	Action	Establishes the dangerous waste number for each of the dangerous waste criteria designations and for listed and characteristic waste codes that are unique	State-specific dangerous wastes have the potential to be generated during the Upper Aquifer remedial actions.	ARAR	Remediation activities (demolition, disposal, storage, recycling, and onsite treatment) that manage State-specific

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
		to Washington State. In addition to the classification of wastes stipulated by RCRA ("Identification and Listing of Hazardous Waste" [40 CFR Part 261]), wastes must be classified according to the State system. The additional types of dangerous waste are defined as WT01 (Toxic DW, determined from bioassay data or by literature designation) and WP01 (Persistent DW, based on concentrations of HHs or PAHs).			dangerous wastes consistent with the requirements of the *Washington Administrative Code*.
"Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120) "Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120[3]) "Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120[5])	Action	Defines the requirements for the recycling of materials that are solid and dangerous waste. Specifically, "Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120[3]) provides for the management of certain recyclable materials, including spent refrigerants, antifreeze, and lead acid batteries. "Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120[5]) provides for the recycling of used oil.	Recycled, reclaimed, and recovered wastes have the potential to be generated during the Upper Aquifer remedial actions.	ARAR	Remediation recycling activities consistent with the requirements of the *Washington Administrative Code* and not otherwise subject to CERCLA as hazardous substances. For example, as part of the enhanced NAPL recovery process, NAPL would be separated and transferred to a storage tank for offsite treatment, or if possible, the recovered NAPL could be used as a fuel supplement for onsite treatment processes.
"Land Disposal Restrictions" (WAC 173-303-140)	Action	Establishes treatment requirements and disposal prohibitions for land disposal of dangerous waste and incorporates by reference "Land Disposal Restrictions" (WAC 173-303-140[2][a]), and the federal land disposal restrictions of "Land Disposal Restrictions" (40 CFR 268) that are applicable to solid waste that is a dangerous or mixed waste in accordance with "Designation of Dangerous Waste" (WAC 173-303-070[3]).	Land disposal restrictions may apply to excavated soil that has been treated with the thermal desorption process and is designated to be reused onsite as backfill, or is transported offsite to a permitted disposal facility for treatment/disposal.	ARAR	Remedial action waste materials (e.g., excavated soil, and/or debris) destined for onsite land disposal or transported offsite to a permitted disposal facility for treatment/disposal.
"Requirements for Generators of Dangerous Waste" (WAC 173-303-170)	Action	Establishes the requirements for dangerous waste generators. "Requirements for Generators of Dangerous Waste" (WAC 173-303-170[3]) includes the substantive provisions of "Accumulating Dangerous Waste On-Site" (WAC 173-303-200) by reference. "Accumulating Dangerous Waste On-Site" (WAC 173-303-200) further includes certain substantive standards from "Use and Management of Containers" (WAC 173-303-630) and "Tank Systems"	Dangerous wastes will be generated from the remedial actions in the Upper Aquifer.	ARAR	Remediation wastes (demolition and removal of existing structures, underground utilities, and buried debris, contaminated soil and groundwater, personnel protective gear, treatment chemicals).

TABLE A-1
Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered
Former Process Area, Soil and Groundwater OUs
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
		(WAC 173-303-640) by reference. Specifically, the substantive standards for management of dangerous/ mixed waste are applicable to the management of dangerous waste that will be generated during the remedial action.			
“Manifest” (WAC 173-303-180) “Preparing Dangerous Waste for Transport” (WAC 173-303-190)	Action	Establishes manifest procedures for a generator who transports, or offers for transport a dangerous waste for off-site treatment, storage, or disposal, or a treatment, storage, and disposal facility who offers for transport a rejected dangerous waste load. Establishes requirements for packaging, labeling, marking, and placarding. (Federal requirements: “Standards Applicable to Generators of Hazardous Waste – Pre-Transport Requirements” [40 CFR Part 262 Subpart C]).	Dangerous wastes will be generated from the remedial actions in the Upper Aquifer that may be transported for offsite disposal.	ARAR	Remediation wastes (demolition and removal of existing structures, underground utilities, and buried debris, contaminated soil and groundwater, personnel protective gear, treatment chemicals).
“Accumulating Dangerous Waste On-Site” (WAC 173-303-200)	Action	Establishes the requirements for accumulating wastes onsite. “Accumulating Dangerous Waste On-Site” (WAC 173-303-200) further includes certain substantive standards from “Use and Management of Containers (WAC 173-303-630) and “Tank Systems” (WAC 173-303-640) by reference.	Dangerous waste will be generated from the remedial actions in the Upper Aquifer.	ARAR	Management of dangerous waste during site preparation and remedial actions.
“Generator Recordkeeping” (WAC 173-303-210) “Generator Reporting” (WAC 173-303-220) “Special Conditions” (WAC 173-303-230)	Action	Establishes requirements for generator recordkeeping and reporting.	Dangerous wastes will be generated from the remedial actions in the Upper Aquifer that may be stored onsite until treatment or transport to offsite facility for treatment and/or disposal.	ARAR	Remediation wastes (demolition and removal of existing structures, underground utilities, and buried debris, contaminated soil and groundwater, personnel protective gear, treatment chemicals).
“Requirements” (WAC 173-303-64620[4])	Action	Establishes the standards for implementing corrective action for releases of dangerous waste and constituents under the HWMA. Requires corrective action to be “consistent with” specified sections of “Model Toxics Control Act—Cleanup” (WAC 173-340) and “Dangerous Waste Regulations,” “Requirements” (WAC 173-303-64620[4]).	Corrective action applies to all releases of dangerous waste and dangerous constituents during the Soil and Groundwater OU remedial actions as stated in “Requirements” (WAC 173-303-64620[1]). CERCLA may be the authority being used to clean up the release; the cleanup must be “consistent with” corrective action. The substantive portions of “Model Toxics Control Act—Cleanup”	ARAR	Corrective action applies to environmental media at the Wyckoff/Eagle Harbor site where dangerous waste and dangerous constituents have been placed, whether intentional or unintentional, during Wyckoff operations.

TABLE A-1
Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered
Former Process Area, Soil and Groundwater OUs
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
			(WAC 173-340) establish minimum requirements for HWMA corrective action.		
"Miscellaneous Units" [40 CFR Part 264 Subpart X]	Action	Establishes standards for owners and operators of facilities that treat, store, or dispose of hazardous wastes in miscellaneous units. Requires the units to be located, designed, constructed, operated, maintained, and closed in a manner that will ensure protection of human health and the environment. Requires monitoring, testing, analytical data, inspections, response, and reporting procedures.	Miscellaneous remedial action units will be used for in situ and ex situ treatment of contaminated soil and groundwater in the Upper Aquifer.	ARAR	Miscellaneous remedial action units may include thermal desorber and thermal oxidizer (ex situ treatment of excavated soil using onsite thermal desorption process), boiler/steam generator (in situ treatment using thermal enhanced extraction process), and propane vaporizer to fuel onsite treatment units.
"Chemical, Physical, and Biological Treatment" [40 CFR Part 265 Subpart Q]	Action	Establishes standards for owners and operators of facilities, which treat hazardous wastes by chemical, physical, or biological methods in other than tanks, surface impoundments, and land treatment facilities. Requires that hazardous wastes or treatment reagents not be placed in the treatment process or equipment if they could cause the treatment process or equipment to rupture, leak, corrode, or otherwise fail before the end of its intended life. If hazardous waste is continuously fed into a treatment process or equipment, the process or equipment must be equipped with a means to stop this inflow. Establishes inspection requirements and closure procedures.	Chemical, physical, and biological treatment processes will be used for in situ and ex situ treatment of contaminated soil and groundwater in the Upper Aquifer	ARAR	Chemical, physical, and biological treatment processes may include containment (surface/subsurface barrier, hydraulic containment), removal (excavation, extraction), ex situ treatment (onsite thermal desorption), and in situ treatment (thermal enhanced extraction, ISS, ISCO, enhanced aerobic biodegradation, and MNA), and onsite disposal (reuse treated soil for backfill or to recontour the site topography).
"Incinerators" [40 CFR Part 264 Subpart O] [40 CFR Part 265 Subpart O]	Action	Establishes minimum national standards for owners and operators of hazardous waste incinerators.	Waste materials will be transported offsite to a permitted treatment facility for incineration prior to offsite landfill disposal.	ARAR	As part of the ex situ treatment (onsite thermal desorption) of contaminated soil in the Upper Aquifer, dioxin-contaminated waste materials (e.g., excavated soil and/or debris) exceeding LDR treatment standards will be transported offsite to a permitted treatment facility for incineration prior to offsite landfill disposal.
"Hazardous Waste Management System", [40 CFR Parts 260 through 280]	Action			ARAR	Hazardous demolition debris (from removal of existing structures, underground utilities, and buried

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
					debris for site preparation) that cannot be decontaminated or reused onsite will be transported to a RCRA Subtitle C facility for disposal.
"Criteria for Municipal Solid Waste Landfills" [40 CFR Part 258]	Action			ARAR	Decontaminated demolition waste (concrete, buried utilities, and debris) and other nonhazardous solid waste from remedial activities that cannot be reused onsite will be transported to a RCRA Subtitle D facility for disposal.
"Solid Waste Management—Reduction and Recycling" (RCW 70.95, as amended); "Solid Waste Handling Standards" (WAC 173-350)					
"Owner Responsibilities for Solid Waste (WAC 173-350-025) "Performance Standards" (WAC 173-350-040) "On-Site Storage, Collection and Transportation Standards" (WAC 173-350-300) "Remedial Action" (WAC 173-350-900)	Action	Establishes minimum functional performance standards for the proper handling and disposal of solid waste. Details requirements for the proper handling of solid waste materials originating from residences, commercial, agricultural and industrial operations, and other sources, and identifies those functions necessary to ensure effective solid waste handling programs at both the state and local level.	Solid, nondangerous waste will be generated during implementation of the Upper Aquifer remedial actions.	ARAR	Site preparation and remedial actions that generate solid, nondangerous waste.
Hazardous Material Transportation Act of 1975 (49 USC 5102 et seq.); Hazardous Materials Transportation Uniform Safety Act of 1990; Transportation – Hazardous Materials Regulations (49 CFR Parts 171 through 180)					
Hazardous Material Transportation Act of 1975 (HMTA) (49 CFR Parts 171 through 180)	Action	HMTA establishes regulations to provide adequate protection against the risks to life and property inherent in the transportation of hazardous material in commerce by improving the regulatory and enforcement authority of the Secretary of Transportation. A hazardous material is defined as any "particular quantity or form" of a material that "may pose an unreasonable risk to health and safety or property." 49 CFR Parts 171 through 180 establish regulations for material designations, packaging and shipping requirements, and operational rules.	The Soil and Groundwater OU contains contaminated media, structures, underground utilities, and buried debris. Any hazardous demolition debris generated during site preparation that cannot be decontaminated or reused onsite will be transported to a RCRA Subtitle C TSD facility for disposal.	ARAR	Hazardous demolition debris (from removal of existing structures, underground utilities, and buried debris for site preparation) that cannot be decontaminated or reused onsite will be transported to a RCRA Subtitle C TSD facility for disposal.
Sediments					

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Hazardous Waste Cleanup—Model Toxics Control Act" (RCW 70.105D, as amended); "Model Toxics Control Act—Cleanup" (WAC 173-340); "Sediment Management Standards" (WAC 173-204)					
"Sediment Cleanup Standards" (WAC 173-340-760) "Sediment Management Standards" (WAC 173-204) "Sediment Quality Standards" (WAC 173-204-300) "Sediment Source Control" (WAC 173-204-400) "Sediment Cleanup Standards" (WAC 173-204-500)	Chemical	Establishes requirements for identifying, investigating, and cleaning up a release or threatened release of a contaminant to sediment that may pose a threat to human health or the environment.	Intertidal areas may be present following implementation of remedial action in the Soil and Groundwater OU. The requirements corresponding to sediment management standards would be used to ensure that surface soils within intertidal areas meet sediment cleanup standards protective of aquatic and human health. The cleanup standards will address the following pathways: - Protection of benthic toxicity based on promulgated numeric criteria or bioassay evaluation. - Protection of human health via seafood consumption, direct contact, or incidental ingestion.	ARAR	Surface soils within intertidal areas following implementation of remedial action in the Soil and Groundwater OU, where concentration of hazardous substances exceeds sediment cleanup standards.
Historical and Archeological Resources					
***National Historic Preservation Act of 1966* (Public Law 89-665, as amended, 16 USC 470, et seq.)**					
"Protection of Historic Properties" (36 CFR 800)	Location	Legislation intended to preserve historical and archaeological sites in the United States of America. Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation, mitigation processes, and consultation with interested parties.		ARAR	Investigation and remediation activities that occur in areas near cultural or historic sites.
***Protection and Enhancement of the Cultural Environment* (Executive Order 11593)**					
"National Historic Landmarks Program" (36 CFR 65) "National Register of Historic Places" (36 CFR 60)	Location	Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation, mitigation processes, and consultation with interested parties.		ARAR	Investigation and remediation activities that occur in areas near cultural or historic sites.
***Native American Graves Protection and Repatriation Act of 1990* (Public Law 101-601, as amended, 25 USC 3001, et seq.); "Native American Graves Protection and Repatriation Regulations" (43 CFR 10)**					

TABLE A-1
Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered
Former Process Area, Soil and Groundwater OUs
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Native American Graves Protection and Repatriation Regulations" (43 CFR 10)	Location	Establishes federal agency responsibility for discovery of human remains, associated and unassociated funerary objects, sacred objects, and items of cultural patrimony. Requires Native American Tribal consultation in the event of discovery.		ARAR	Investigations and remedial activities that affect Native American archaeological, cultural areas and historic sites that contain associated remains and objects.
Archeological and Historic Preservation Act of 1974 **(Public Law 93-291, as amended; 16 USC 469a-1 through 469a-2(d))**					
"Applicant Requirements" 16 USC 469a-1 through 469a-2(d)	Location	Requires that remedial actions do not cause the loss of any archaeological or historic data. This act mandates preservation of the data; it does not require protection of the actual waste site or facility.		ARAR	Investigation and remediation activities that occur in areas near archeological or historic sites.
Natural and Ecological Resources					
Coastal Zone Management Act **(16 USC 1451, et seq.);** ***Washington State Shoreline Management Act of 1971*** **(RCW 90.58); State Master Program Approval/Amendment Procedures and Master Program Guidelines (WAC 173-26); Shoreline Management Permit and Enforcement Procedures (WAC 173-27); Kitsap County Shoreline Master Program; City of Bainbridge Island Shoreline Management Master Program**					
State Master Program Approval/Amendment Procedures and Master Program Guidelines (WAC 173-26)	Location	Establishes guidelines to implement the requirements of Chapter 90.58 RCW, the Shoreline Management Act of 1971.	Eagle Harbor is bounded by a shoreline of statewide interest, and remedial actions within or adjacent to the Soil and Groundwater OU could involve activities regulated by this program.	ARAR	Remedial actions will occur at or adjacent to the coastal zone/shoreline.
Shoreline Management Permit and Enforcement Procedures (WAC 173-27)	Location	Requires local governments to establish a program, consistent with rules adopted by Ecology, for the administration and enforcement of the permit system for shoreline management. Requires the local program to be integrated with other local government systems for administration and enforcement of land use regulations and to provide minimum procedural requirements as necessary to comply with statutory requirements while providing latitude for local government to establish procedural systems based on local needs and circumstances.	Eagle Harbor is bounded by a shoreline of statewide interest, and remedial actions within or adjacent to the Soil and Groundwater OU could involve activities regulated by this program.	ARAR	Remedial actions will occur at or adjacent to the coastal zone/shoreline.
Kitsap County Shoreline Master Program (locally adapted draft, January 30, 2013)	Location	Establishes regulations to guide the future development of the shorelines in Kitsap County in a manner consistent with the Shoreline Management	Eagle Harbor is bounded by a shoreline of statewide interest, and remedial actions within or adjacent to the Soil and Groundwater OU	ARAR	Remedial actions will occur at or adjacent to the coastal zone/shoreline.

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
		Act of 1971, and is adopted pursuant to RCW 90.58, and WAC 173-26.	could involve activities regulated by this program.		
City of Bainbridge Island Shoreline Management Master Program (officially adapted November 26, 1996; response to public comments is pending for the proposed comprehensive update in July 2013)	Location	Establishes policies and regulations for the shorelines of Bainbridge Island.	Eagle Harbor is bounded by a shoreline of statewide interest, and remedial actions within or adjacent to the Soil and Groundwater OU could involve activities regulated by this program.	ARAR	Remedial actions will occur at or adjacent to the coastal zone/shoreline.
Endangered Species Act of 1973 **(Public Law 93-205, as amended; 7 USC Section 136; 16 USC Ch. 1531, et seq.)**					
"Interagency Cooperation—Endangered Species Act of 1973, as Amended" (50 CFR 402)	Location	Prohibits actions by federal agencies that are likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of habitat critical to them. Mitigation measures must be applied to actions that occur within critical habitats or surrounding buffer zones of listed species, in order to protect the resource.	Federal endangered and/or threatened species including fish, plants, and animals are found within or adjacent to the Soil and Groundwater OU. In 1999, the Endangered Species Act (ESA) listed the Chinook salmon, summer chum and bull trout in the Puget Sound.	ARAR	Remediation actions and investigation activities that occur within critical habitats or designated buffer zones of federal listed species.
Migratory Bird Treaty Act of 1918 **(16 USC 703-712; Ch. 128; July 13, 1918; 40 Stat. 755), as amended**					
Migratory Bird Treaty Act of 1918 (16 USC 703-712)	Location	Protects all migratory bird species and prevents "take" of protected migratory birds, their young, or their eggs."		ARAR	Remedial actions that require mitigation measures to deter nesting by migratory birds on, around, or within remedial action site and methods to identify and protect occupied bird nests.
"Powers and Duties," "Habitat Buffer Zone for Bald Eagles—Rules" (RCW 77.12.655); "Permanent Regulations," "Bald Eagle Protection Rules" (WAC 232-12-292)					
"Permanent Regulations," "Bald Eagle Protection Rules" (WAC 232-12-292)	Location	Protects eagle habitat to maintain eagle populations so the species is not classified as threatened, endangered, or sensitive in Washington State.		ARAR	Investigative and remediation activities that affect bald eagle habitat.
Fish and Wildlife Conservation Act of 1980 **(Public Law 96-366, as amended; 16 USC 2901-2911)**					
"Rules Implementing the Fish and Wildlife Conservation Act of 1980" (50 CFR 83)	Location	Preserve and promote conservation of non-game fish and wildlife and their habitats.	Wildlife and their habitats have the potential to occur in or adjacent to the Soil and Groundwater OU.	ARAR	Remedial action that affect non-game fish, and wildlife and/or their habitats.
Land Use and Exposure Scenarios					

TABLE A-1
Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered
Former Process Area, Soil and Groundwater OUs
Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
	Location	Establishes the future land-use projections for the Wyckoff Site which includes the Upper Aquifer in the Soil and Groundwater OU.		TBC	
Occupational Safety And Health					
***Occupational Safety And Health Act* (29 USC 651, et seq.); *Washington State Industrial Safety And Health Act* (RCW 49.17); "Occupational Safety and Health Agency (OSHA) Regulations" (29 CFR 1910); "Hazardous Waste Operations" (WAC 296-843); "Emergency Response" (WAC 296-824)**					
"Hazardous Waste Operations Regulations" (WAC 296-843)	Action	Establishes the minimum requirements for employees working in operations involving hazardous waste at a treatment, storage, and disposal (TSD) facility, employees conducting initial investigations of government-identified sites before determining whether hazardous substances are present, employees conducting corrective actions, involving clean-up operations, at sites covered by the Resource Conservation and Recovery Act of 1976 (RCRA) as amended (42 U.S.C. 6901 et seq.) or chapter 70.105 RCW, Hazardous waste management; and employees performing clean-up operations at an uncontrolled hazardous waste site.	Employees will be performing clean-up operations at an uncontrolled hazardous waste site that is on EPA's National Priority Site List (NPL).	ARAR	Remediation and management activities.
"Emergency Response Regulations" (WAC 296-824)	Action	Establishes the minimum requirements that help protect the safety and health of the employees during a response to a hazardous substance release in a workplace or any other location.	Potential for a hazardous substance release exists during the clean-up operations.	ARAR	Remediation and management activities.

Note: Complete reference citations are provided in Chapter 11.

ACM = asbestos-containing material
ALARA = as low as reasonably achievable
ARAR = applicable or relevant and appropriate requirement
ASILs = Acceptable Source Impact Levels
BACT = Best Available Control Technology
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COPC = contaminant of potential concern
DW = dangerous waste
ET = evapotranspiration
EcoSSL = ecological soil screening level
EPA = U.S. Environmental Protection Agency
GWTP = Groundwater Treatment Plant
HH = halogenated hydrocarbons
HHE = human health and the environment
HWMA = Hazardous Waste Management Act
IDW = investigation-derived waste
ISCO = in situ chemical oxidation
ISS = in situ solidification/stabilization
LDR = land disposal restrictions
MCL = maximum contaminant level
MCLG = maximum contaminant level goal
MNA = monitored natural attenuation
NAPL = non-aqueous phase liquid
NPL = National Priority Site List
PAHs = polynuclear aromatic hydrocarbons
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
RTD = removal, treatment, and disposal
SVOC = semi-volatile organic compounds
TBC = to be considered
TSD = treatment, storage, and disposal

TABLE A-1

Potential Federal, Washington State, and Local Applicable or Relevant and Appropriate Requirements and To Be Considered

Former Process Area, Soil and Groundwater OUs

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application

VOC = volatile organic compounds

Appendix B
Remedial Action Alternative Drawings

Wyckoff- DRAWING INDEX

Sht. no.	Dwg no.	Drawing Title	DESCRIPTION	TARGET DATE	Designed By	Drawn By	Checked By	Approved By	Stamped By
		GENERAL - 100							
1	100-G-001	COVER SHEET - LOCATION AND VICINITY MAPS		8-May-14	BT	BT	MD	KS	
2	100-G-002	INDEX TO DRAWINGS - 1		8-May-14	BT	BT	MD	KS	
3	100-G-003	GENERAL LEGEND SHEET AND ABBREVIATIONS		8-May-14	BT	BT	MD	KS	
4	100-G-005	ALTERNATIVES PLAN OVERALL		8-May-14	BT	BT	MD	KS	
5	100-G-006	CIVIL NOTES AND LEGEND		8-May-14	BT	BT	MD	KS	
		COMMON ELEMENTS - 101							
6	101-CE-100	ENTRANCE ROAD IMPROVEMENTS - PLAN	PLAN LOCATION AND TYPICAL CROSS SECTION	8-May-14	BT	BT	MD	KS	
7	101-CE-101	ENTRANCE ROAD IMPROVEMENTS - PROFILE	PLAN LOCATION AND TYPICAL CROSS SECTION	8-May-14	BT	BT	MD	KS	
8	101-CE-102	OVERALL DEMOLITION PLAN	FOUNDATIONS, EXCAVATION LIMITS, SHEET PILE WALL EXCAVATION, ETC.	25-Apr-14	BT	BT	VR	KS	
9	101-CE-103	OUTFALL PLAN		8-May-14	BT	BT	MD	KS	
10	101-CE-104	OUTFALL PROFILE		8-May-14	BT	BT	MD	KS	
11	101-CE-105	PASSIVE GROUNDWATER TREATMENT SYSTEM ALTS 5, 6	PASSIVE SYSTEM SIM FOR ALTS 5, 6	18-Apr-14	BT	BT	KS	KS	
12	101-CE-300	EXISTING SHEET PILE MODIFICATION	SECTION SHOWING EXCAVATION AND NEW WALL CONSTRUCTION	18-Apr-14	BT	BT	KS	KS	
13	101-CE-301	PASSIVE GROUNDWATER TREATMENT DETAILS	DETAILS	18-Apr-14	BT	BT	KS	KS	
		ALTERNATIVE 2 - CONTAINMENT							
14	200-C-100	SITE PLAN - WELLS AND PIPING	WELLS AND GROUNDWATER EXTRACTION PIPING LAYOUT	11-Apr-14	MD	DS	MR	KS	
15	200-C-101	SITE PLAN - FINAL CAP	SITE CAP AND STORMWATER LAYOUT	4-Apr-14	BT	BT	MR	KS	
16	200-C-301	CAP SECTIONS	TYPICAL COVER SECTIONS	18-Apr-14	BT/MR	BT	MR	KS	
		ALTERNATIVE 4 - ISS							
17	300-C-100	OVERALL SITE PLAN	ISS FACILITIES AND TEMPORARY STORMWATER POND	4-Apr-14	TO	BT	TO	KS	
18	300-C-101	SITE PLAN - ISS TREATMENT		4-Apr-14	TO	JP	TO	KS	
19	300-C-102	SITE PLAN - JET GROUT TREATMENT		4-Apr-14	TO	JP	TO	KS	
20	300-C-103	PASSIVE GROUNDWATER TREATEMENT SYSTEM		11-Apr-14	TO	BT	TO	KS	
21	300-C-300	CROSS SECTIONS ISS/JET GROUT		11-Apr-14	TO	JP	TO	KS	
22	300-C-301	ISS PROGRESSION ISS/JET GROUT		11-Apr-14	TO	JP	TO	KS	
23	300-C-600	ALT 4 PROCESS FLOW DIAGRAM		11-Apr-14	TO	DS	TO	KS	
		ALTERNATIVE 5 -THERMAL ENHANCED EXTRACTION AND INSITU CHEMICAL OXIDATION							
24	400-C-100	SITE PLAN - NAPL EXTRACTION & COVER	Sheet pile locations, DNAPL extraction well locations	11-Apr-14	RH	BT	RH	KS	
25	400-C-101	SITE PLAN - THERMAL WELLS	GW EXTRACTION WELLS AND STEAM INJECTION WELLS, steam plant	4-Apr-14	BS	BT	BS	KS	
26	400-C-102	SITE PLAN - VAPOR REMOVAL FROM AND AIR INJECTION INTO COVER		4-Apr-14	BS	BT	BS	KS	
27	400-C-103	SITE PLAN - ENHANCED AEROBIC	biosparge - biospare + steam injection wells + locations under cap + some horiz	11-Apr-14	RH	BT	RH	KS	
28	400-C-104	PIPING PLAN	GENERAL PIPE ROUTING CORRIDORS AND ELEVATED PIPE RACKS	11-Apr-14	CK	DS	CK	KS	
29	400-C-105	SITE PLAN - ISCO	Shows location of ISCO wells (also applies to Alt 6)	11-Apr-14	BS	BT	BS	KS	
30	400-C-500	WELLHEAD DETAILS	ALSO APPLIES TO ALT 6.	18-Apr-14	CK	DS	CK	KS	
31	400-C-600	ALT 5 PROCESS FLOW DIAGRAM 1	New vapor and groundwater treatment equipment (also applies to Alt 6)	4-Apr-14	CK	DS	CK	KS	
32	400-C-601	ALT 5 PROCESS FLOW DIAGRAM 2	Modifications to existing GWTP (also applies to Alt 6)	4-Apr-14	CK	DS	CK	KS	
33	400-C-602	ALT 5 PROCESS FLOW DIAGRAM 3	Modifications to existing GWTP (also applies to Alt 6)	4-Apr-14	CK	DS	CK	KS	
34	400-M-101	TREATMENT SYSTEM PLAN	BUILDING/MECHANICAL TREATMENT SYSTEM DETAIL (ALSO APPLIES TO AL	4-Apr-14	CK	DS	CK	KS	
		ALTERNATIVE 6 - EXCAVATION, THERMAL DESORPTION, AND THERMAL ENHANCED EXTRACTION							
35	500-C-100	SITE PLAN - MTTD OVERALL PLAN	Sheet pile locations, areas receiving MTTD, well locations	4-Apr-14	AR/BT	BT	AR/BT	KS	
36	500-C-101	SITE PLAN - NAPL EXTRACTION & COVER, THERMAL		18-Apr-14	BS/BT	BT	BS/BT	KS	
37	500-C-102	SITE PLAN - COVER, PIPING, BIOSPARGING, VAPOR REMOVAL AND AIR INJECTION		18-Apr-14	BS	BT	BS	KS	
38	500-C-103	PIPING PLAN	THERMAL GENERAL ROUTING OF PIPE	18-Apr-14	CK	DS	CK	KS	
39	500-C-104	SITE PLAN - ENHANCED AEROBIC PLAN		18-Apr-14	RH	BT	RH	KS	
40	500-C-600	ALT 6 PROCESS FLOW DIAGRAM	Shows the sequence for performing MTTD	4-Apr-14	AR/BS	DS	AR/BS	KS	

NEW ISSUE IN DRAWING SET (yellow)
FINISHED IN DRAWING SET (blue)

GENERAL NOTES

1. CLEAR, GRUB, AND PREPARE SUBGRADE IN NEW ROAD AREA. PROVIDE TEMPORARY EROSION CONTROL AND SILT FENCING.

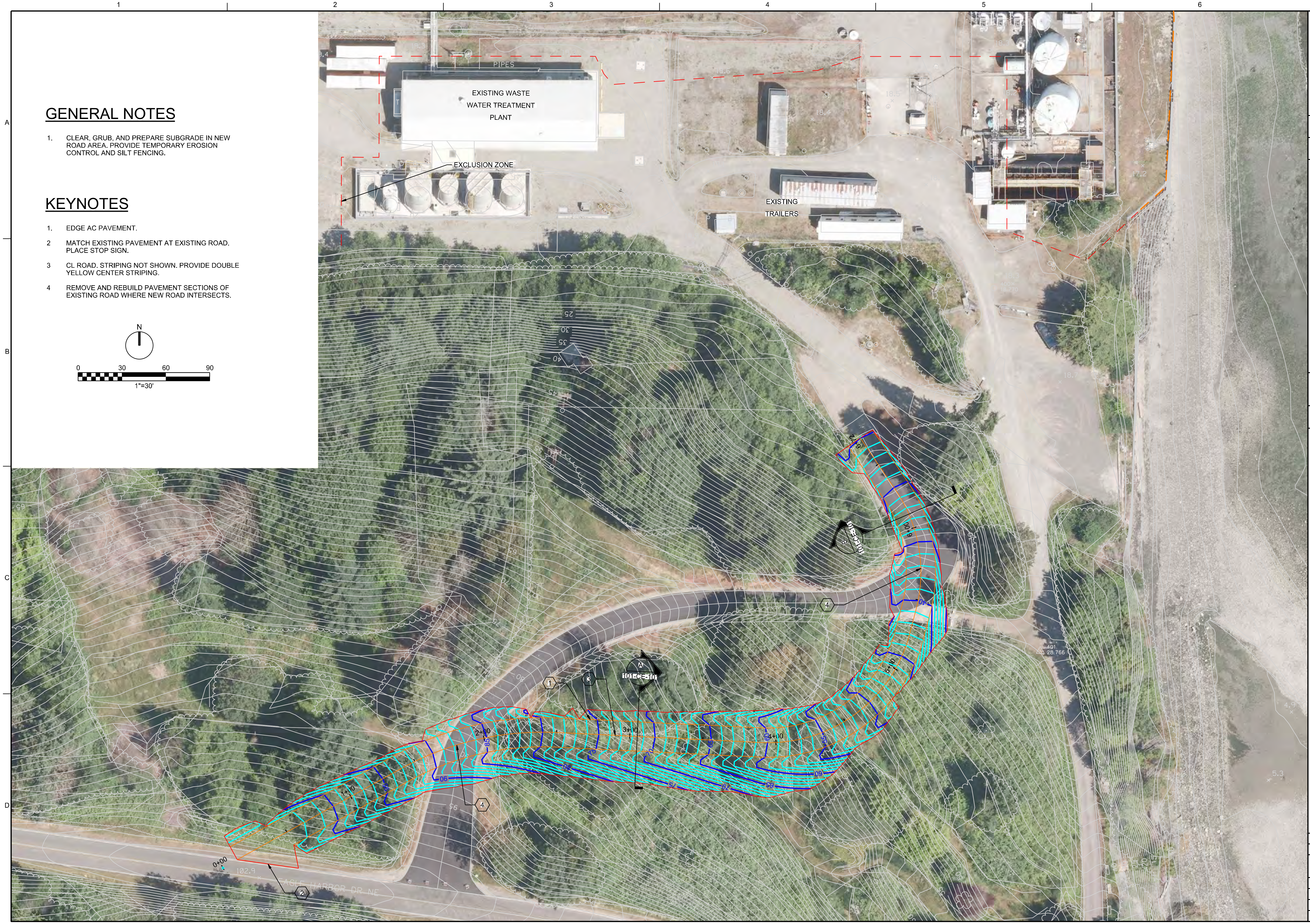
KEYNOTES

1. EDGE AC PAVEMENT.
2. MATCH EXISTING PAVEMENT AT EXISTING ROAD. PLACE STOP SIGN.
3. CL ROAD. STRIPING NOT SHOWN. PROVIDE DOUBLE YELLOW CENTER STRIPING.
4. REMOVE AND REBUILD PAVEMENT SECTIONS OF EXISTING ROAD WHERE NEW ROAD INTERSECTS.

N

0 30 60 90

1"=30'



$PWURL $PWPATH

FILENAME: 101-CE-100_438527.dgn

PLOT DATE: 2014\06\11

PLOT TIME: 4:51:59 PM

NO.	DATE	REVISION	BY	APVD

DSGN BCT | DR BCT | CHK BCT | APVD KTS

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL

COMMON ELEMENTS
ROAD IMPROVEMENTS

1"=40 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	101-CE-100
SHEET	of

REFERENCE DOCUMENTS:

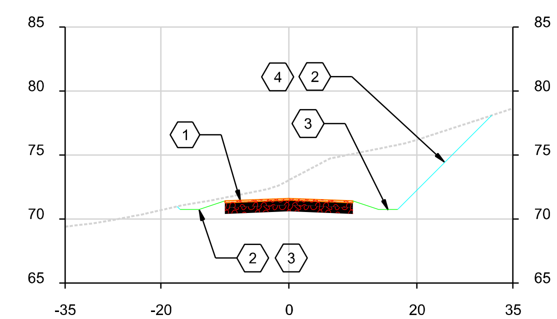
PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

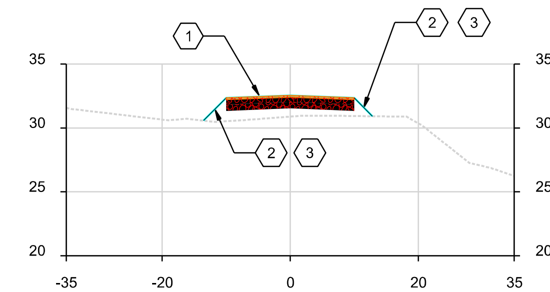
1. CLEAR, GRUB, AND PREPARE SUBGRADE IN NEW ROAD AREA. PROVIDE TEMPORARY EROSION CONTROL AND SILT FENCING.

KEYNOTES

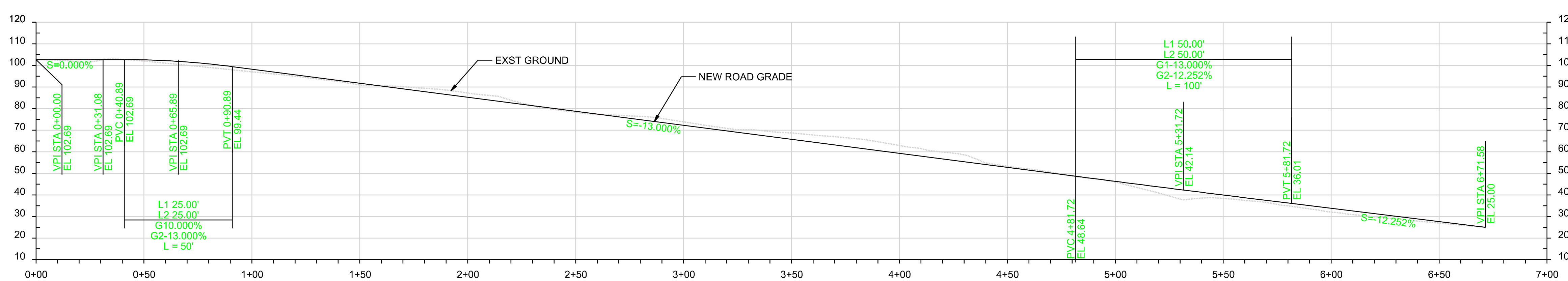
1. 4" ACP OVER 10" BASE COURSE.
2. PROVIDE EROSION CONTROL FOR ALL EXCAVATED SLOPES OR AREAS DISTURBED DURING CONSTRUCTION.
3. PROVIDE HAY BALES EVERY 10 FEET ALONG DRAINAGE FLOW PATHS, BOTH SIDES OF ROAD.
4. 2:1 SLOPE.



A ROAD CROSS SECTION
1"=15'-0" HORIZ 1"=7.5' VERT
101-CE-100



B ROAD CROSS SECTION
1"=15'-0" HORIZ 1"=7.5' VERT
101-CE-100



ROAD PROFILE
1"=30'-0"

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

COMMON ELEMENTS
ROAD IMPROVEMENTS PROFILE

NO.	DATE	REVISION	BY	APVD

DSGN BCT | DR BCT | CHK KTS | APVD

VARIES
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	101-CE-101
SHEET	of

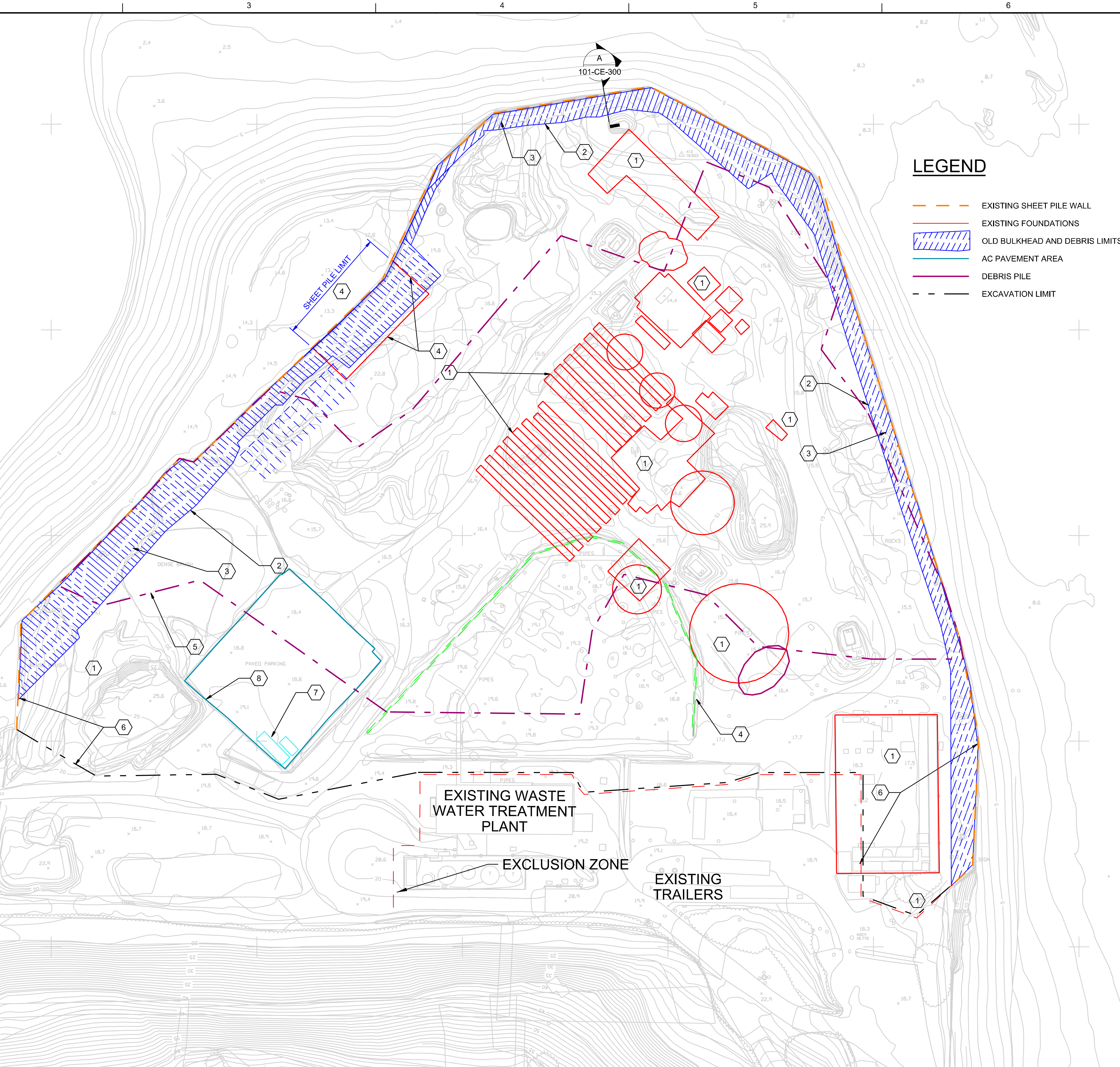
PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE THIS DWG FOR DEMOLITION CHANGES.
2. EXISTING FOUNDATIONS AND DEBRIS LIMITS ARE APPROXIMATE AND OBTAINED FROM VARIOUS HISTORICAL RECORDS. FIELD VERIFY ALL LOCATIONS AND ADJUST REMOVALS TO ACCOUNT FOR ACTUAL LOCATIONS AND FOUNDATIONS OR DEBRIS NOT SHOWN.

KEYNOTES

1. EXCAVATE ALL FOUNDATIONS IN EXCLUSION ZONE, TYPICAL. DECONTAMINATE EXCAVATED CONCRETE. CRUSH CONCRETE AND REMOVE REBAR. PLACE CRUSHED CONCRETE AT EQUAL DEPTH WITHIN VAPOR COVER LIMITS. SEE NOTE 5. PLACE ANY REMAINING CRUSHED CONCRETE TO A UNIFORM DEPTH OUTSIDE VAPOR COVER LIMITS.
2. APPROXIMATE LIMITS OLD WOOD BULKHEAD.
3. DEBRIS AREA BETWEEN OLD BULKHEAD AND EXISTING SHEET PILE WALL. EXCAVATE, DECONTAMINATE, AND CRUSH ROCKS. SEE DWG 101-CE-300 FOR REMOVAL DETAILS. REMOVE AND DISPOSE OF ALL OTHER MATERIALS FROM THE SITE INCLUDING WOOD BULKHEADS, METALS, AND OTHER NON EARTH MATERIALS.
4. REMOVE EXISTING SHEET PILE WALLS AND ABOVE GROUND PIPING CONTAINED WITHIN THE SHEET PILE WALL. DECONTAMINATE AND REMOVE FROM SITE.
5. VAPOR COVER LIMITS. SEE DWG 400-C-102.
6. EXCAVATE ALL AREAS WITHIN THE EXCAVATION ZONE TO A MINIMUM DEPTH OF 5 FT WITHIN THE AREA BOUNDED BY EXCAVATION LIMITS, EXCLUSION ZONE, AND EXISTING WALL.
7. DIESEL STORAGE TANKS SHOWN. PROCESS EQUIPMENT NOT SHOWN THIS AREA. REMOVE AND DISPOSE OF ALL TANKS AND EQUIPMENT AND ASSOCIATED APPURTENANCES.
8. REMOVE EXST AC PAVMENT ESTIMATED THICKNESS 3". DECONTAMINATE, CRUSH, AND PLACE AS DESCRIBED IN NOTE 1.



NO.	DATE	REVISION	BY	APVD

DSGN BCT | DR BCT | CHK MD | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL

COMMON ELEMENTS - DEMOLITION
SITE PLAN - DEMOLITION

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	101-CE-102
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

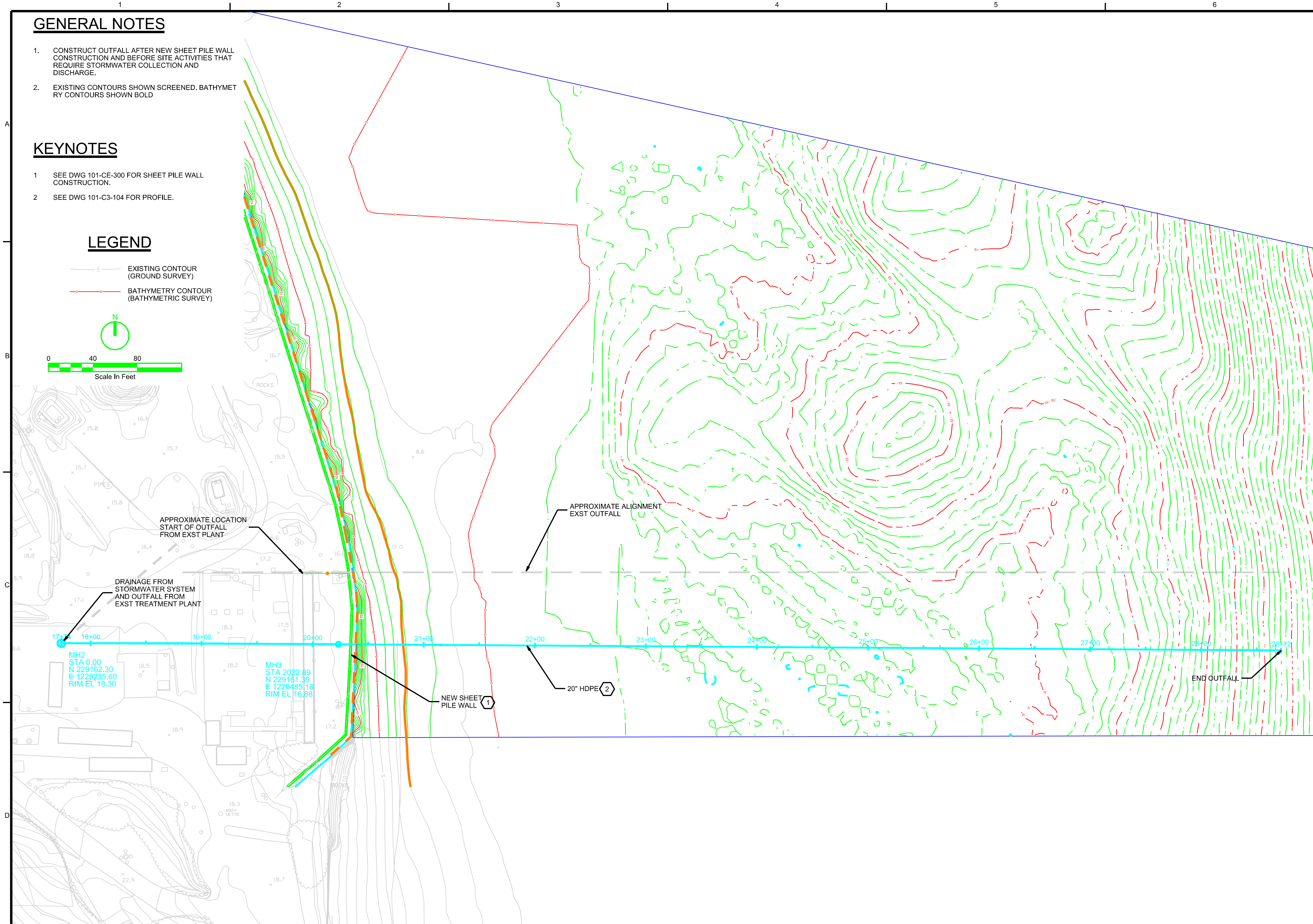
1. CONSTRUCT OUTFALL AFTER NEW SHEET PILE WALL CONSTRUCTION AND BEFORE SITE ACTIVITIES THAT REQUIRE STORMWATER COLLECTION AND DISCHARGE.
2. EXISTING CONTOURS SHOWN SCREENED. BATHYMETRY CONTOURS SHOWN BOLD

KEYNOTES

1 SEE DWG 101-CE-300 FOR SHEET PILE WALL CONSTRUCTION.

2 SEE DWG 101-C3-104 FOR PROFILE.

LEGEND



CH2MHILL®

COMMON ELEMENTS

SITE PLAN - OUTFALL

FOCUSED FEASIBILITY STUDY

WYCKOFF

EPA

NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK | APVD

BCT | BCT | KTS |

1"=40 FT

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.

0 1"

DATE

PROJ 438527

DWG 101-CE-103

SHEET of

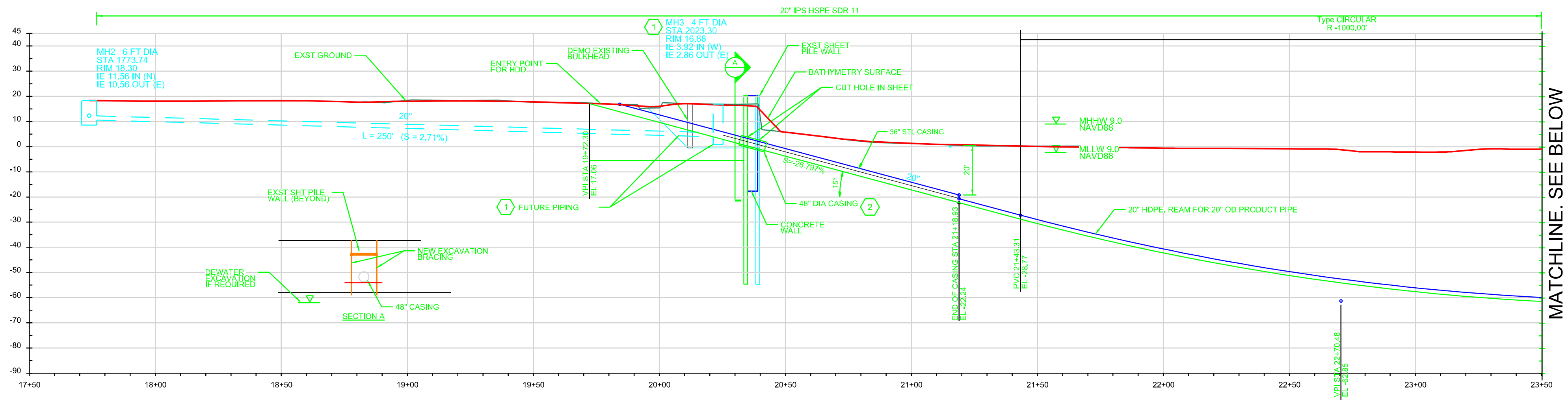
PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

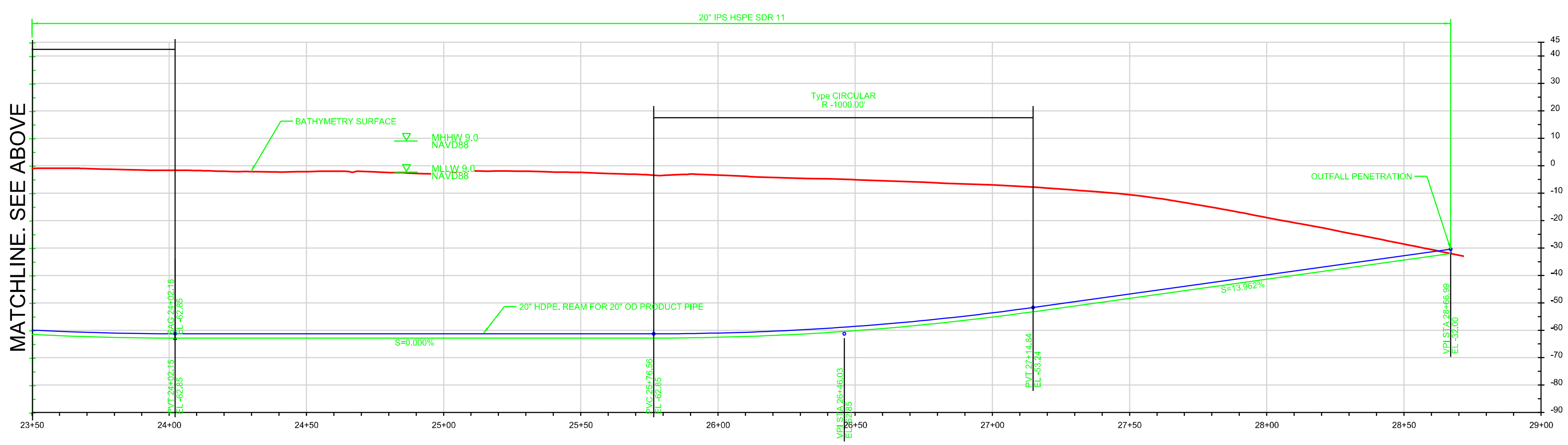
1. SEE DWG 101-CE-103 FOR PLAN VIEW.
2. APPLIES TO ALTERNATIVES 2, 5, 6. SIMILAR WALL AREA CONSTRUCTION FOR ALTERNATIVE 4. SEE DWG 101-CE-300 FOR EXISTING AND NEW WALL DETAILS.

KEYNOTES

1. STORMWATER/DRAIN PIPING AND MANHOLES PLACED AFTER OUTFALL CONSTRUCTION. SEE SCHEDULE FOR TIMING.
2. SEAL ANNULUS AFTER CASING INSTALLATION FOR WATERTIGHT SEAL



OUTFALL PROFILE
1"=30'-0"



OUTFALL PROFILE
1"=30'-0"

NO.	DATE	REVISION	BY	APVD

DSGN | DR BCT | CHK BCT | APVD KTS

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

COMMON ELEMENTS
OUTFALL PROFILE

CH2MHILL®

1"=30 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"

DATE	
PROJ	438527
DWG	101-CE-104
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SCHEMATIC LOCATOINS SHOWN

KEYNOTES

1. GROUNDWATER TREATMENT SYSTEM MANHOLE.
2. FRENCH DRAIN.
3. DRAIN PIPE THROUGH SHEET PILE WALL
4. NEW SHEET PILE WALL
5. EXST SHEET PILE WALL

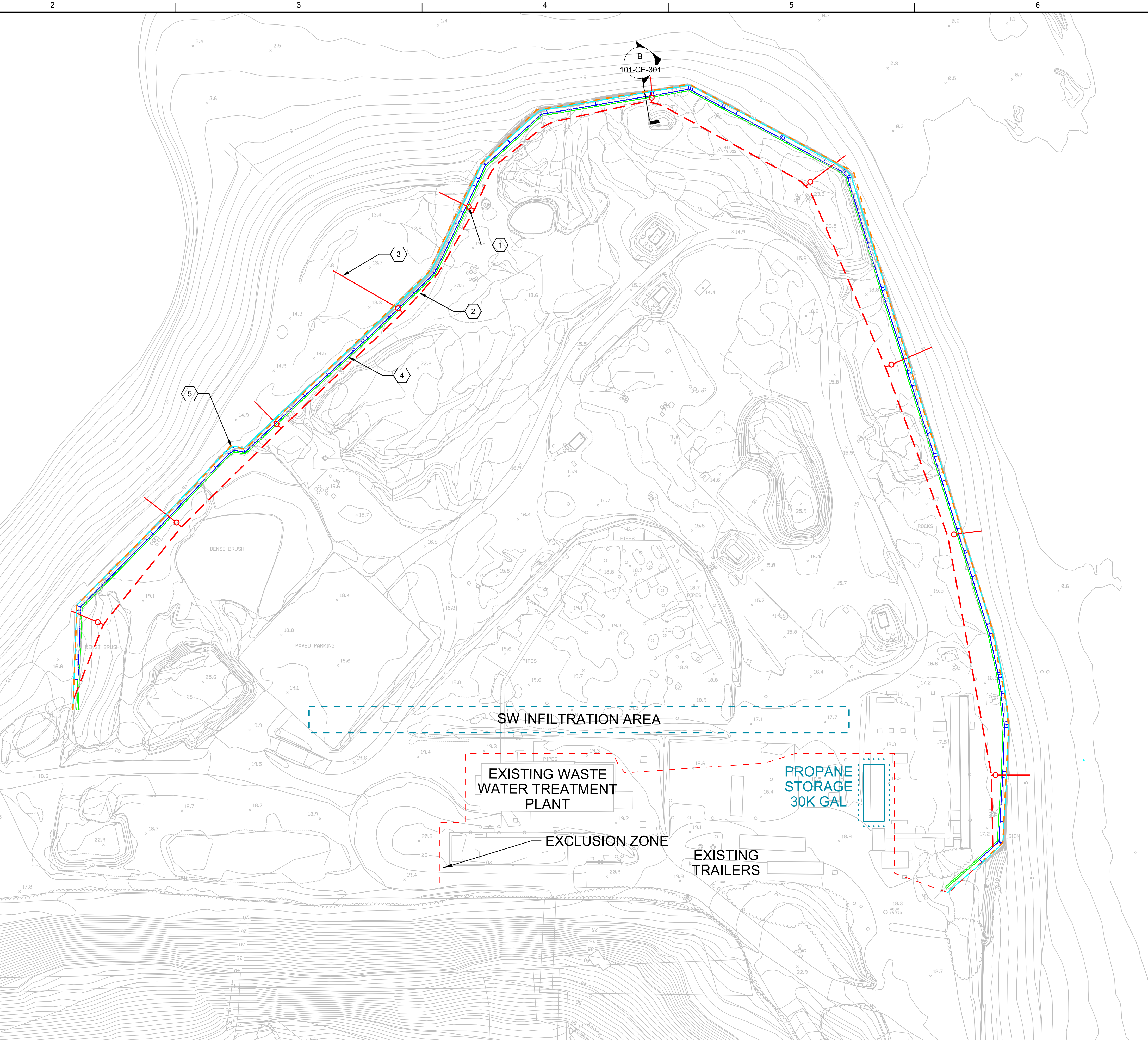
LEGEND

- EXST SHEET PILE WALL
- NEW SHEET PILE WALL (SHEET PILE AND CONCRETE)
- NEW TREATEMENT SYSTEM MANHOLE
- NEW FRENCH DRAIN
- NEW DRAIN PIPE THROUGH WALLS

N

0 50 100 150

1"=50'



NO.	DATE	REVISION	BY	APVD

DSGN SM | DR SM | CHK BCT | APVD SM

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

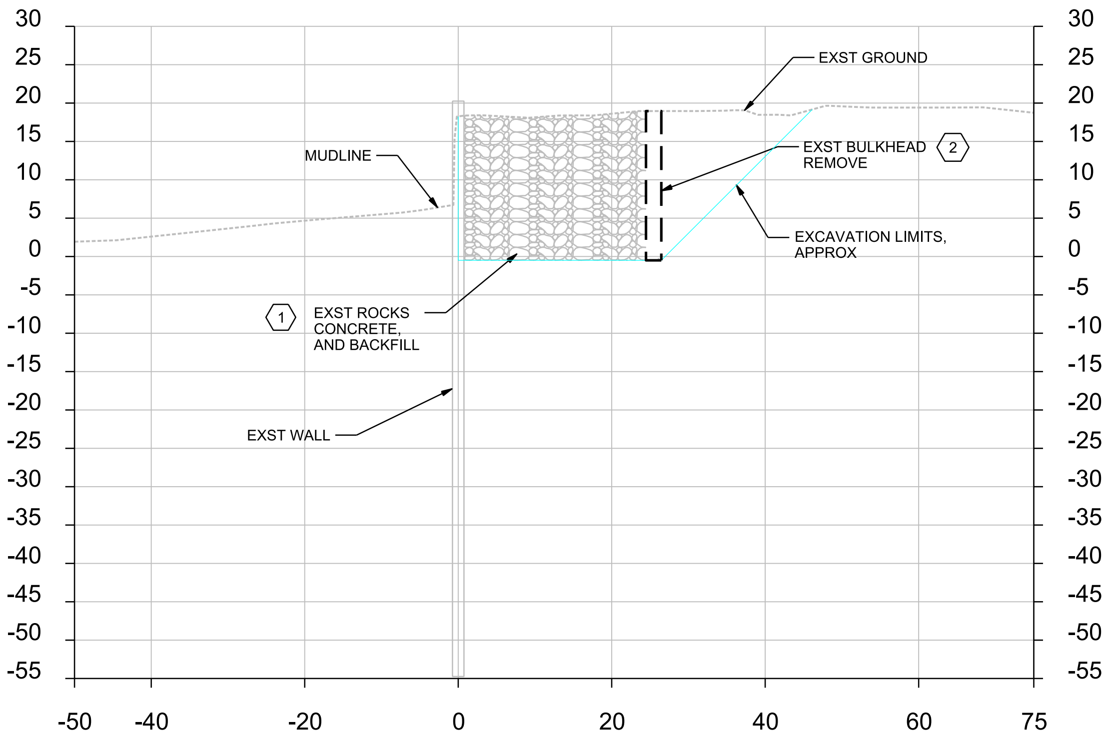
ALTERNATIVES 5, 6
SITE PLAN
PASSIVE GROUNDWATER TREATMENT SYSTEM

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	101-CE-105
SHEET	of

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL.

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION



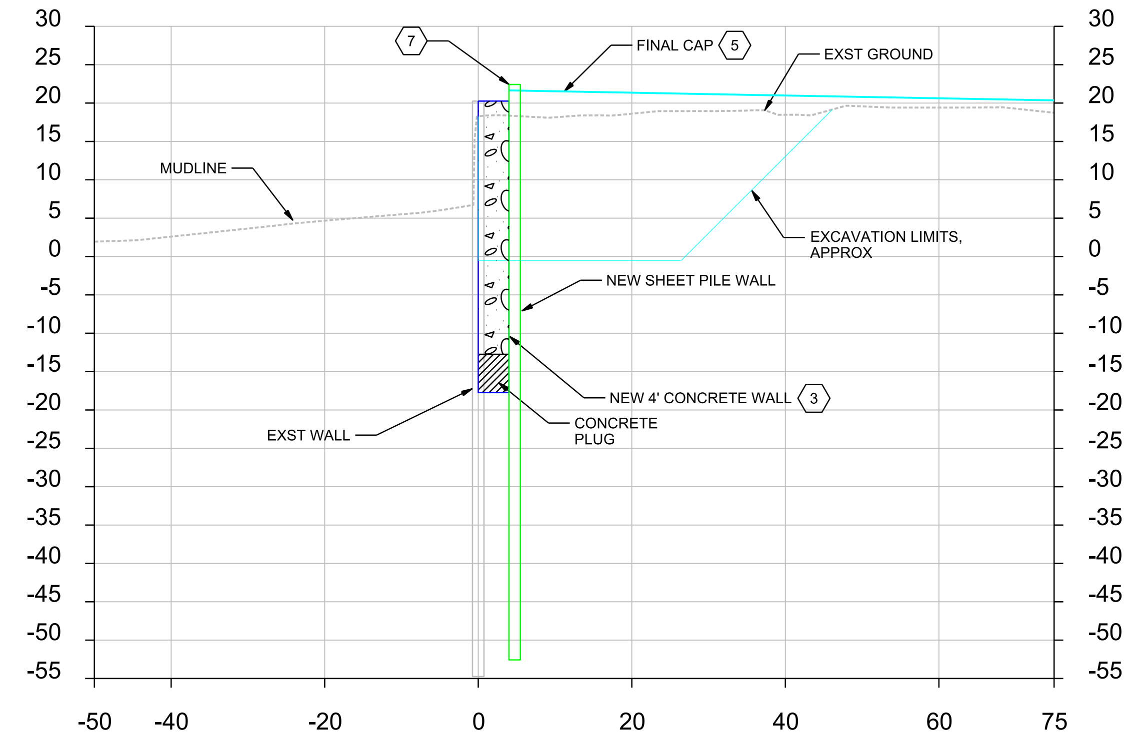
A REMOVALS/DEMOLITION

1"=25'

101-CE-102

CONSTRUCTION SEQUENCE ALTERNATIVE 4

1. REMOVE MATERIALS AS SHOWN IN REMOVALS/DEMOLTION.
2. MAINTAIN WATER LEVEL IN EXCAVATION AREA TO NO MORE THAN 16 FT ABOVE TIDE LEVEL AT ALL TIMES UNTIL BACKFILL IS PLACED
3. PLACE AND COMPACT BACKFILL
4. ISS TREAT SITE
5. EXCAVATE MATERIAL BEHIND EXISTING SHEET PILE WALL.
6. POUR NEW CONCRETE WALL
7. CONSTRUCT FINAL COVER



B NEW WALL CONSTRUCTION ALTERNATIVE 2

1"=25'

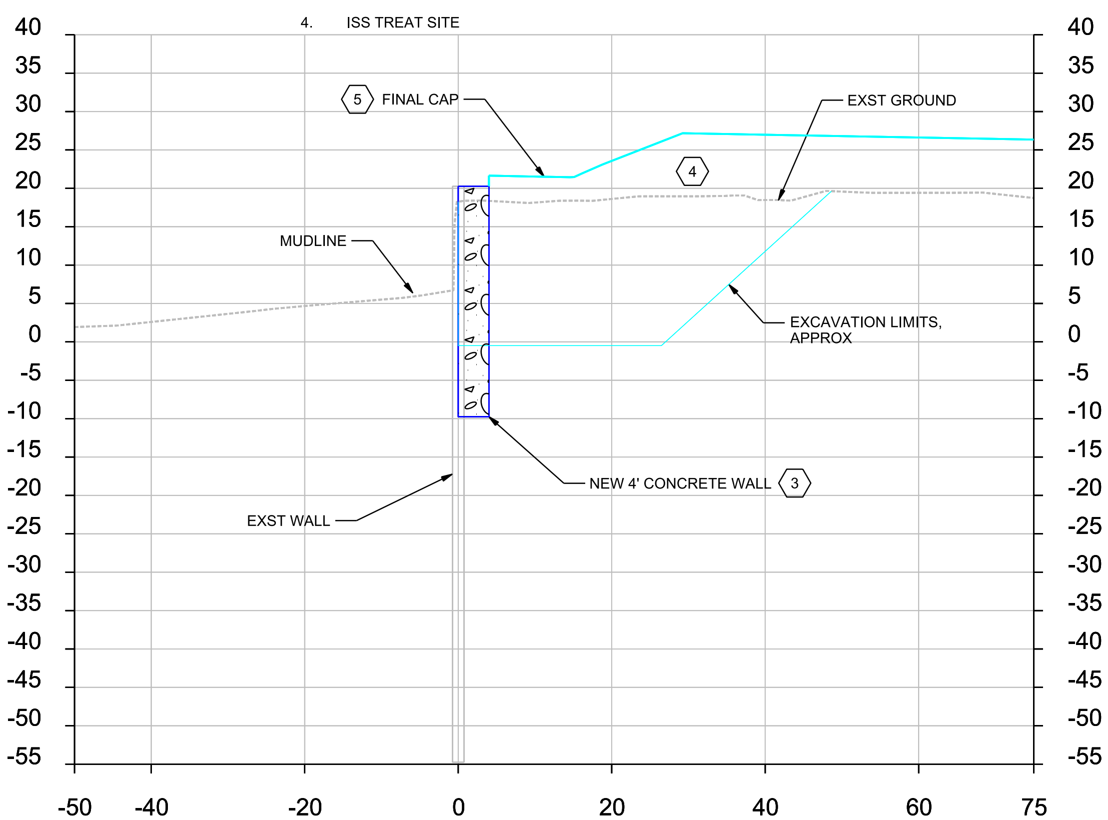
200-C-101

CONSTRUCTION SEQUENCE ALTERNATIVES 2,5,6

1. REMOVE MATERIALS AS SHOWN IN REMOVALS/DEMOLTION.
2. MAINTAIN WATER LEVEL IN EXCAVATION AREA TO NO MORE THAN 16 FT ABOVE TIDE LEVEL AT ALL TIMES UNTIL BACKFILL IS PLACED
3. PLACE AND COMPACT BACKFILL
4. DRIVE NEW SHEET PILE
5. EXCAVATE MATERIAL BETWEEN NEW AND EXISTING SHEET PILE WALL.
6. CONSTRUCT FINAL COVER
7. POUR NEW CONCRETE PLUG AND WALL

KEYNOTES

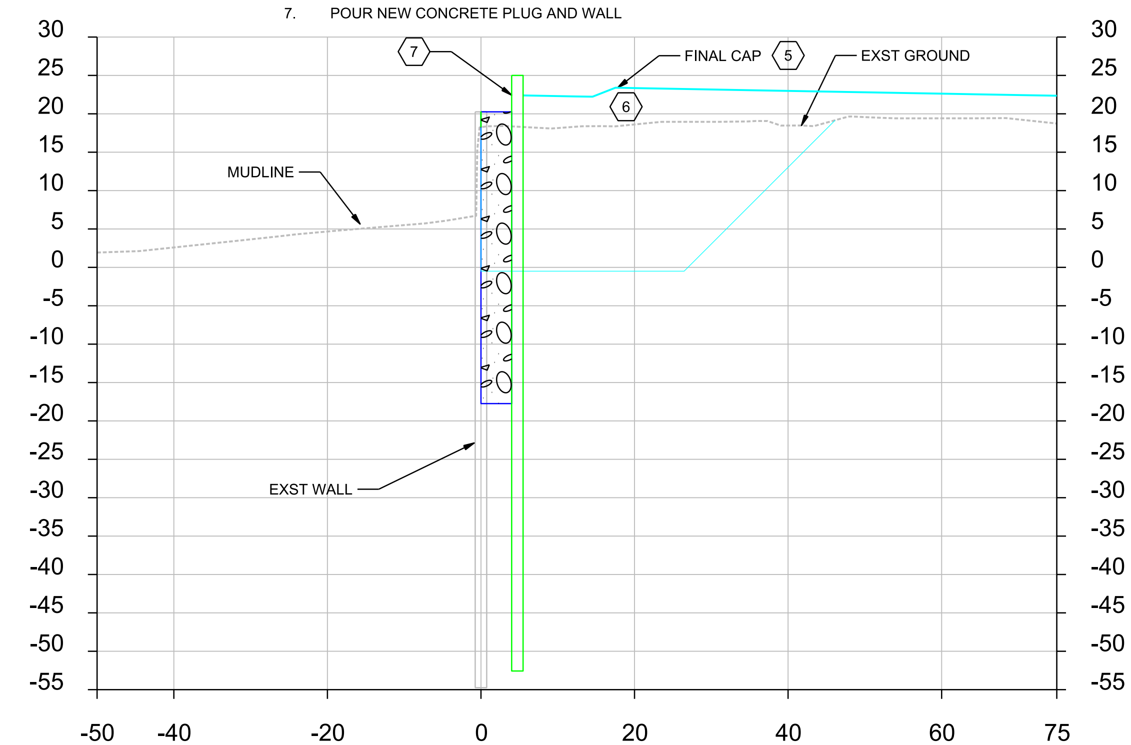
1. REMOVE, DECONTAMINATE, CRUSH TO 2" MINUS SIZE. REMOVE ALL REBAR AND DELETERIOUS MATERIAL.
2. REMOVE BULKHEAD PILING. HEIGHT, WIDTH, AND NUMBER OF PILINGS VARY.
3. REINFORCEMENT #8's, 12" O.C. EW EF.
4. FILL DEPTH VARIES. APPROX. 6 FT OF SWELL WILL BE GRADED TO ACHEIVE MINIMUM 2% SLOPE OF FINAL COVER.
5. FINAL CAP. SEE DET 2 ON 200-C-301.
6. FILL REQUIRED TO ACHIEVE 2% MIN SLOPE OF FINAL CAP.
7. SHEET PILE WALL ELEVATION VARIES. MAXIMUM WALL ELEVATION = 25.0. NEW SHEET PILE WALL WAS DESIGNED FOR MAXIMUM ELEVATION.



C NEW WALL CONSTRUCTION ALTERNATIVE 4

1"=25'

200-C-101, 300-C-100



D NEW WALL CONSTRUCTION ALTERNATIVES 5, 6

1"=25'

200-C-100, 400-C-100, 500-C-100

NO.	DATE	REVISION	BY	APVD

DSGN BT | DR BT | CHK KS | APVD

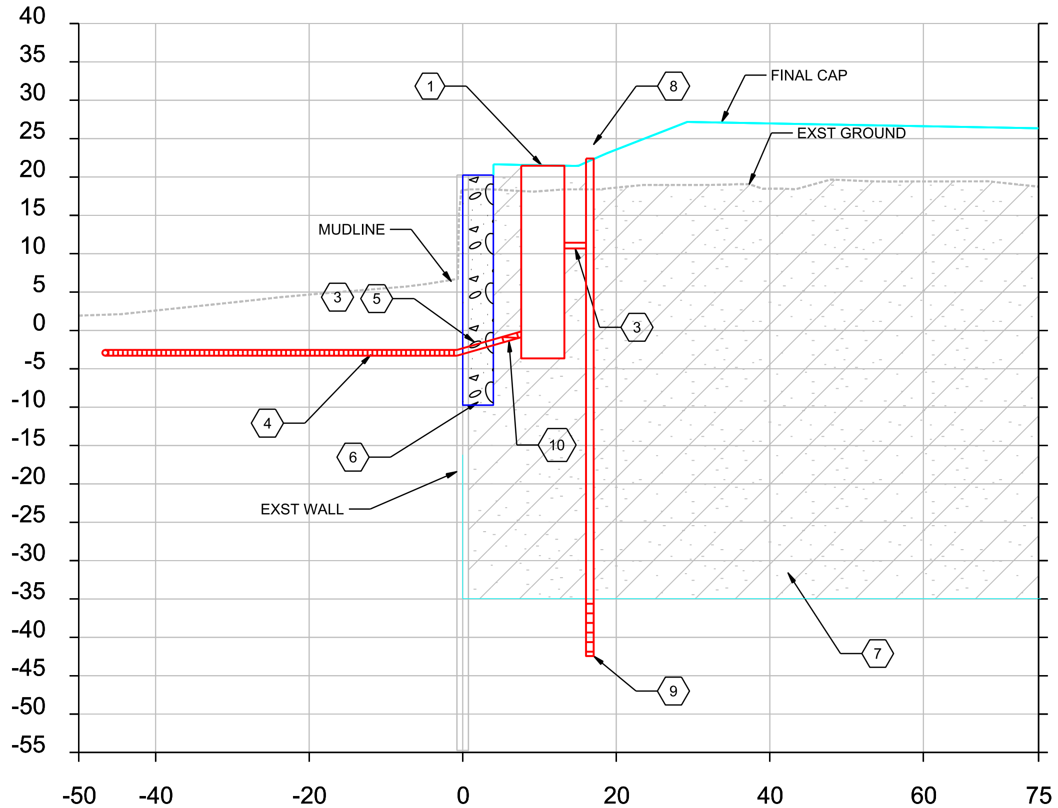
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

COMMON ELEMENTS
DETAILS - REMOVALS AND NEW WALL CONSTRUCTION

VARIES
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

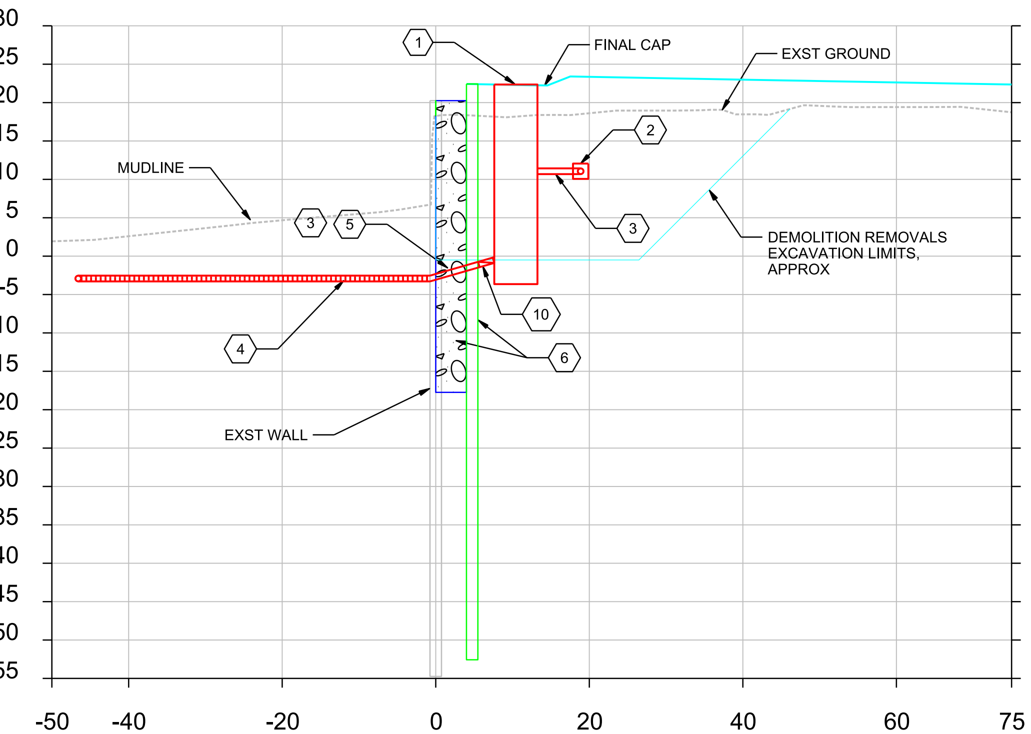
DATE	
PROJ	438527
DWG	101-CE-300
SHEET	of



A GROUNDWATER TREATMENT SECTION ALT 4

1"=25'

300-C-103



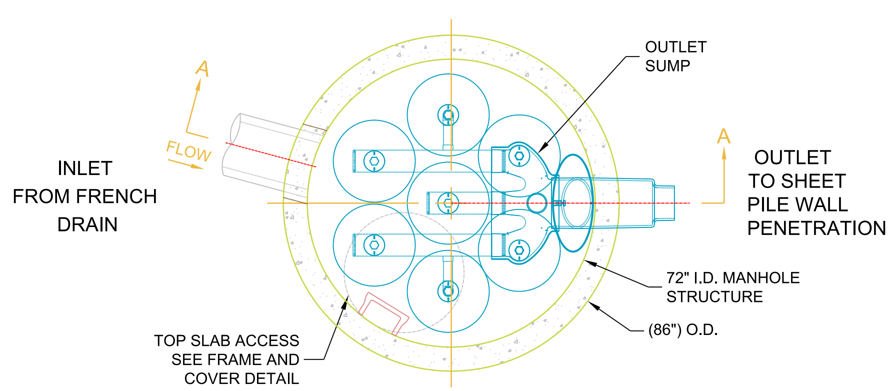
B GROUNDWATER TREATMENT SECTION ALT 5, 6

1"=25'

101-CE-105

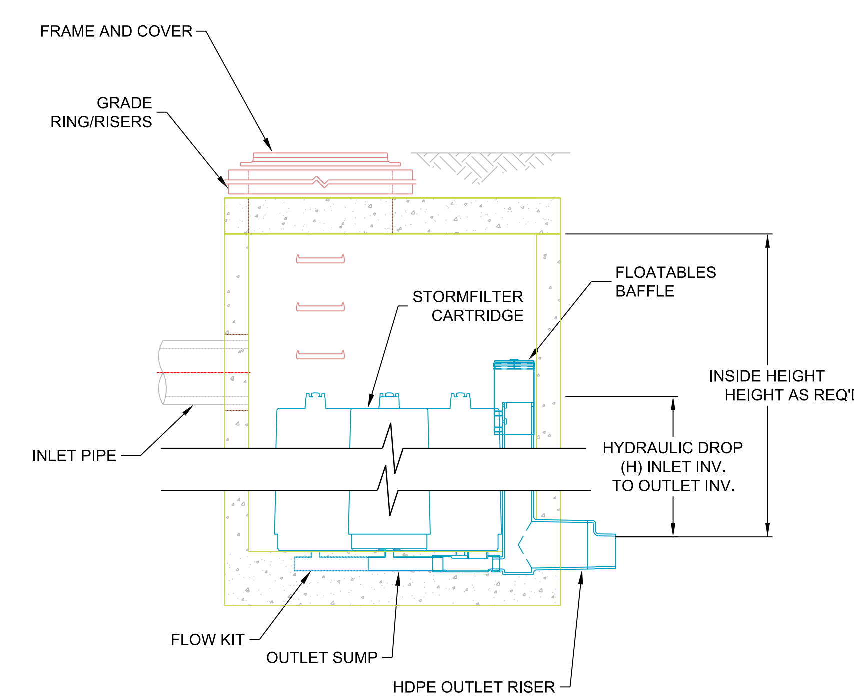
KEYNOTES

1. 5 FT DIA CONC MANHOLE WITH CONTECH GAC FILLED STORMFILTERS. SEE DETAIL THIS DWG
2. 2 FT SQUARE TRENCH DRAIN WITH 12" DIAMETER HDPE SDR 11 PERFORATED PIPE. BACKFILL TRENCH WITH DRAIN GRAVEL AND WRAP PERIMETER IN GEOTEXTILE. TEE FITTING FROM FRENCH DRAINS TO CONNECTING PIPE.
3. 12" DIA HDPE SDR 11 CONNECTING PIPE
4. 12" DIA HDPE SDR 11 PERFORATED PIPE. TRENCH IN BEACH. MAINTAIN MINIMUM 4 FT COVER. LENGTH VARIES, SEE DWG 101-CE-105.
5. CORE THROUGH NEW AND EXISTING WALL SECTIONS. PLACE PIPE AND SEAL ANNULUS.
6. NEW WALL COMPONENTS. SEE DWG 101-CE-300
7. ISS TREATED MATERIAL
8. 12" DIA WELL CASING. EXTEND BELOW ISS TREATED MATERIAL. ELEVATION VARIES, SEE ISS TREATMENT TABLE.
9. PERFORATED WELL SCREEN BELOW ISS TREATMENT LIMITS. MINIMUM 4 FT BELOW LIMITS.
10. CHECK VALVE



CONTECH SW MANHOLE PLAN VIEW

NTS



SECTION A-A

NO.	DATE	REVISION	BY	APVD

DSGN | DR BT | CHK BT | APVD KS

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

COMMON ELEMENTS
DETAILS - PASSIVE GROUNDWATER TREATMENT

VARIES
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	101-CE-301
SHEET	of

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLTION. SEE DWG 101-CE-103 FOR DEMOLITION CHANGES.
2. COVER GRADES ARE CONCEPTUAL. STORMWATER DITCHES AND GRADING FEATURES ALONG THE PERIMETER WALL ARE NOT SHOWN. GRADING AT WALL DOES NOT REFLECT TRANSITIONING TO MATCH FINAL WALL ELEVATION.

KEYNOTES

1. SEE DWG 200-C101 FOR ALTERNATIVE 2 FINAL COVER.
2. NEW ELECTRICAL AND I&C SYSTEM WILL BE LOCATED IN SAME TRENCH AS PIPE RUN.
3. NEW WELL FIELD WILL HAVE SERVICE POWER FROM EXISITNG MCC.

LEGEND

PIPE RACK

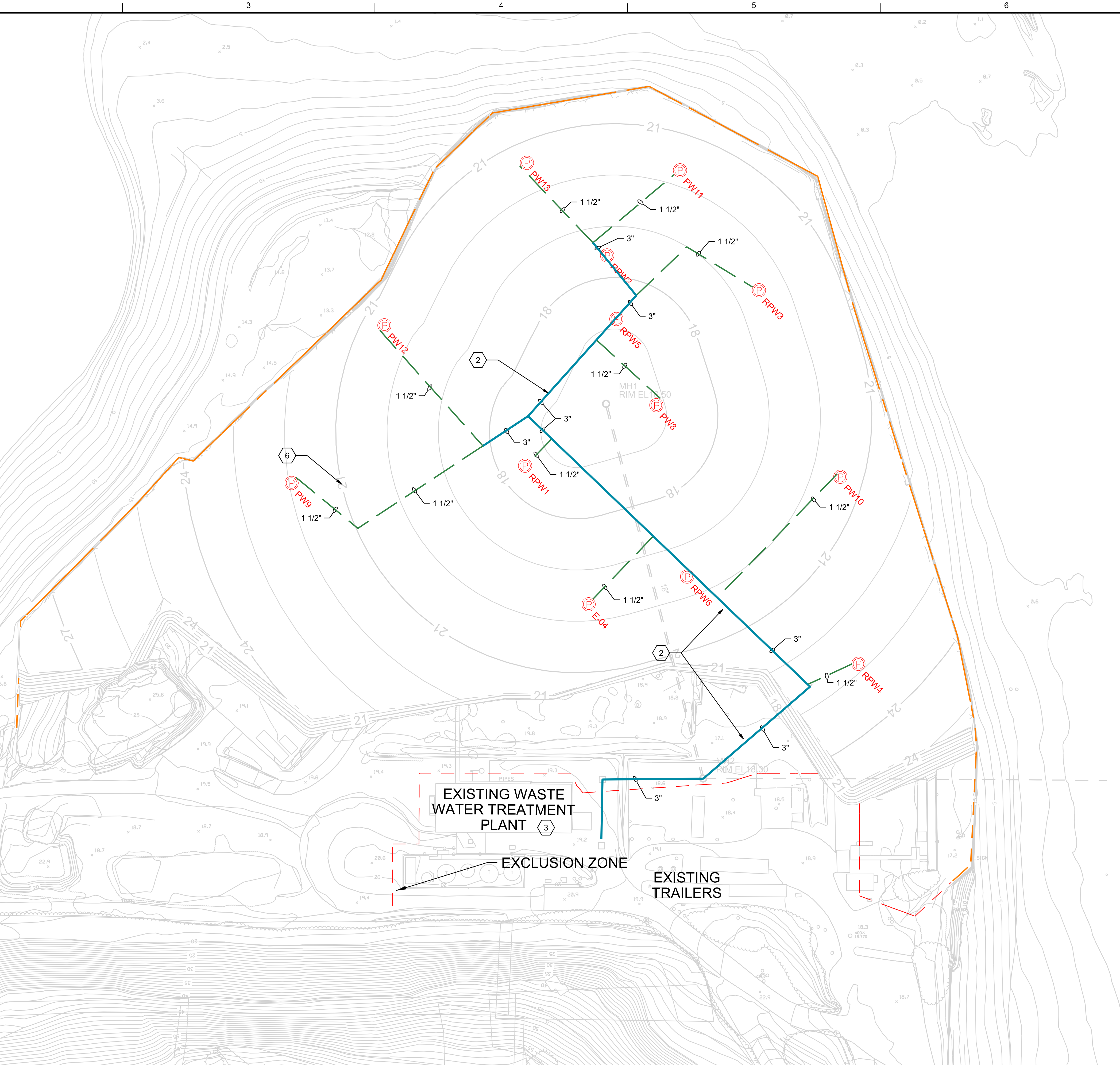
EXTRACTION WELL PIPING & UTILITY TRENCH

PW9 NEW EXTRACTION PUMP SYSTEMS

N

0 50 100 150

1"=50'



PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

REVISION | NO. | DATE | BY | APVD

DSGN | DR | CHK | APVD

DS | MD | MD

CH2MHILL®

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 2 CONTAINMENT
SITE PLAN - WELLS AND PIPING

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	200-C-100
SHEET	of

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. COVER GRADES ARE CONCEPTUAL FOR ALTERNATIVES 2, 4, 5, AND 6. STORMWATER DITCHES AND GRADING FEATURES ALONG THE PERIMETER WALL ARE NOT SHOWN.
3. COVER GRADES FOR ALTERNATIVE 4 (ISS) ARE NOMINALLY 6 FT HIGHER THAN SHOWN EXCEPT THE GRADING WILL TRANSITION TO THE ELEVATIONS AT THE NEW SHEET PILE WALL AS SHOWN. SEE THE ISS SECTION ON 101-CE-300 FOR TRANSITION.

KEYNOTES

1. MH1 WITH BIRDCAGE DEBRIS BARRIER. LOCATE 72" DIAMETER MANHOLE AT LOW POINT OF COVER.
2. NEW PERIMETER WALL MAXIMUM ELEVATION 25.0 FT. GRADING FEATURES FOR COVER ELEVATIONS ABOVE 25 FT NOT SHOWN.
3. APPROXIMATE LOCATION EXISTING OUTFALL PIPING FROM TREATMENT PLANT. INTERCEPT EXISTING PIPE AND CONNECT TO NEW 72" MANHOLE.
4. NEW OUTFALL PIPE. SEE DWG 101-CE-104.
5. COVER SLOPE NOMINALLY 2% AWAY FROM COVER BOUNDARY TO CENTER OF SITE LOW POINT AT MH1.
6. FINAL COVER BOUNDARY.
7. 3:1 SLOPE DOWN TO EXISTING.

LEGEND

NEW PERIMETER WALL AND COVER LIMITS

COVER LIMITS

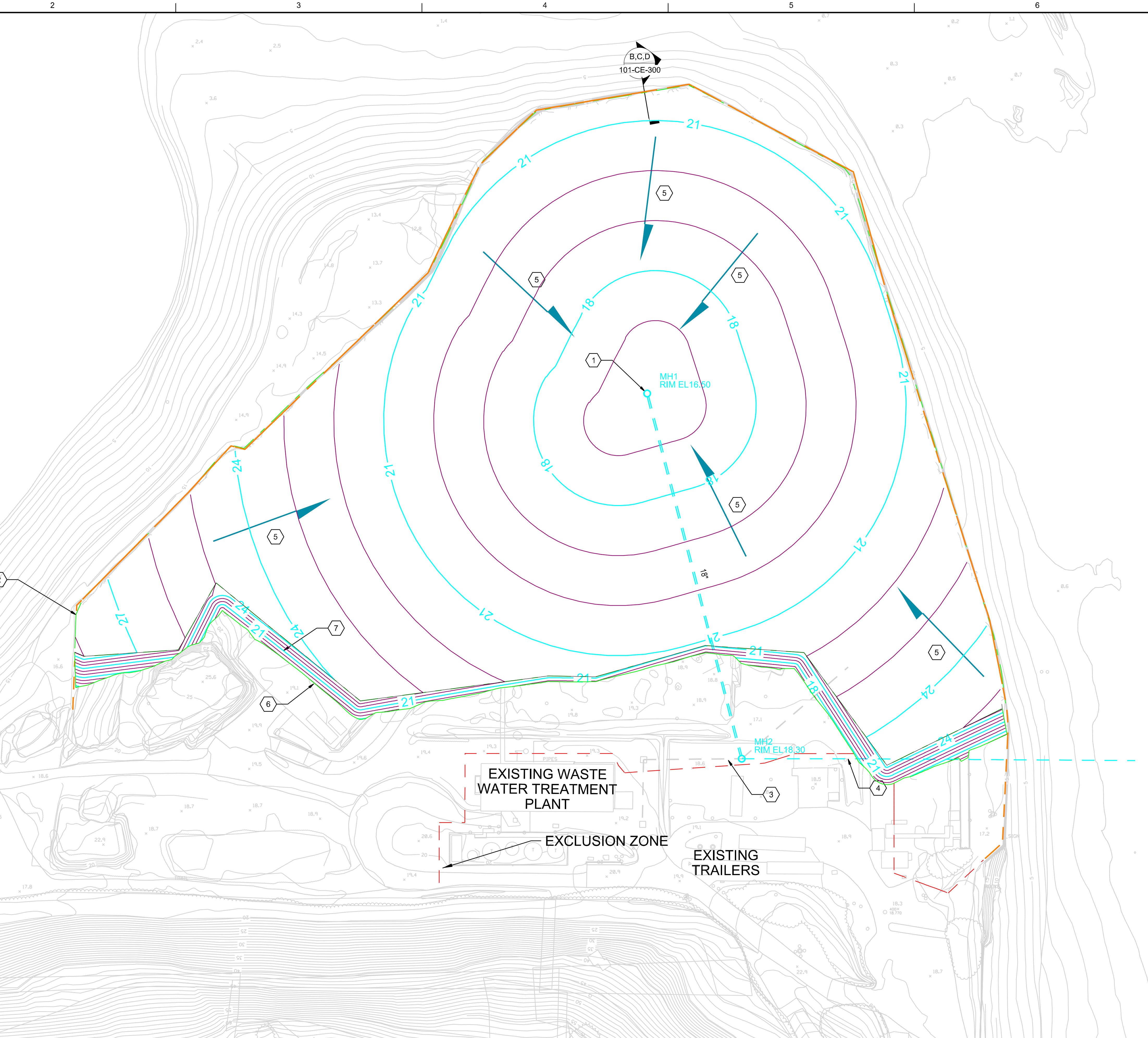
NEW BURIED SW OR OUTFALL PIPE

24 PROPOSED COVER CONTOUR

N

0 50 100 150

1"=50'



NO.	DATE	REVISION	BY	APVD

DSGN | DR BCT | CHK BCT | APVD | TO

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

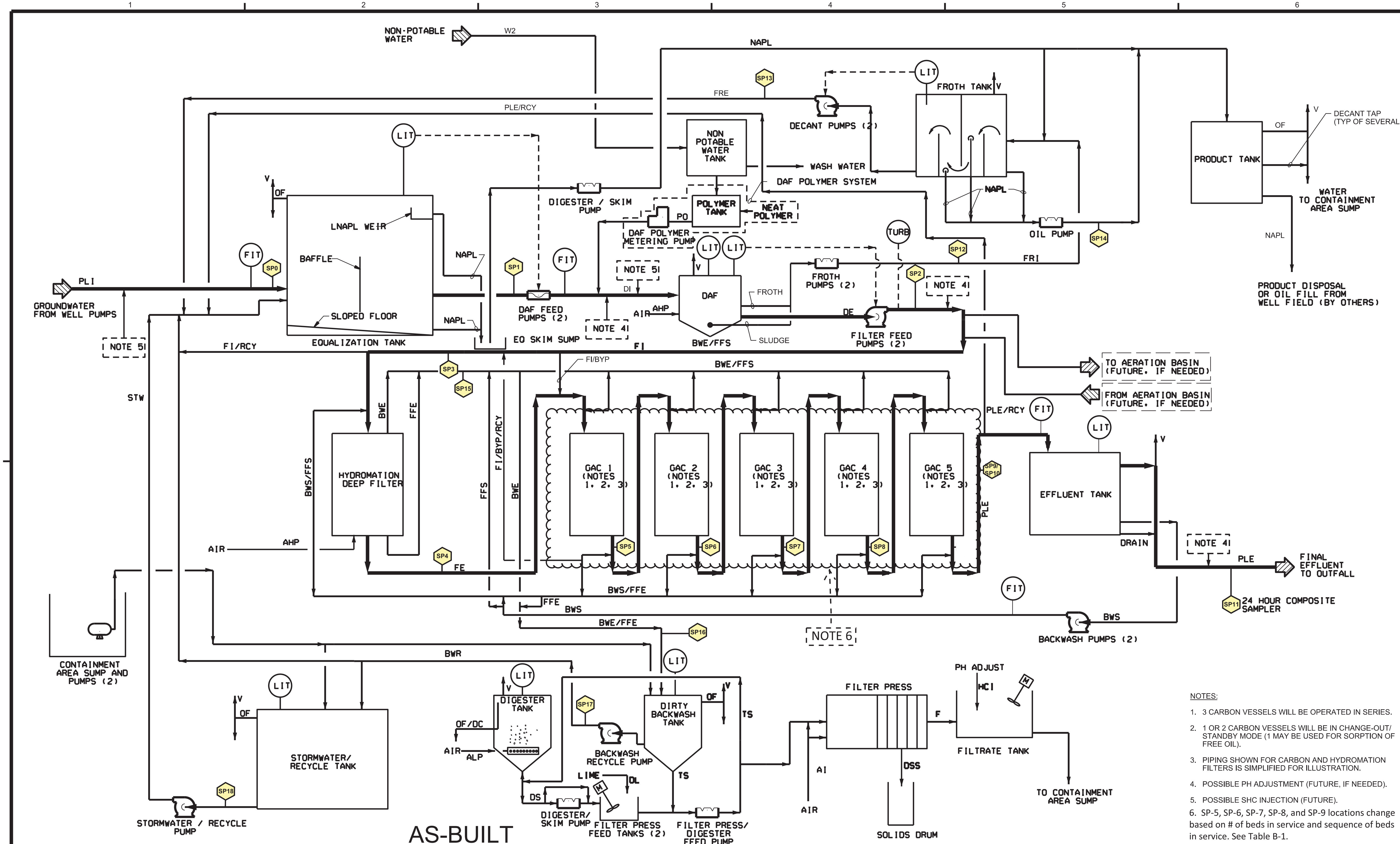
CH2MHILL®

ALTERNATIVE 2 CONTAINMENT
SITE PLAN - FINAL CAP

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	200-C-101
SHEET	of



AS-BUILT

NOTES:

1. 3 CARBON VESSELS WILL BE OPERATED IN SERIES.
2. 1 OR 2 CARBON VESSELS WILL BE IN CHANGE-OUT/ STANDBY MODE (1 MAY BE USED FOR SORPTION OF FREE OIL).
3. PIPING SHOWN FOR CARBON AND HYDROMATION FILTERS IS SIMPLIFIED FOR ILLUSTRATION.
4. POSSIBLE PH ADJUSTMENT (FUTURE, IF NEEDED).
5. POSSIBLE SHC INJECTION (FUTURE).
6. SP-5, SP-6, SP-7, SP-8, and SP-9 locations change based on # of beds in service and sequence of beds in service. See Table B-1.

DSGN GT HICKMAN					
DR PD VALENTINE	3	4/27/10	REVISED AS-BUILT	JB	ROW
CHK MW DAVIS	2	5/14/09	PRELIMINARY AS-BUILT	DLS	ROW
APVD KT SCHEFFLER	1	3/4/09	AS-BUILT FIELD DATA - PRELIMINARY	JFF	GS
	NO.	DATE	REVISION	BY	APVD

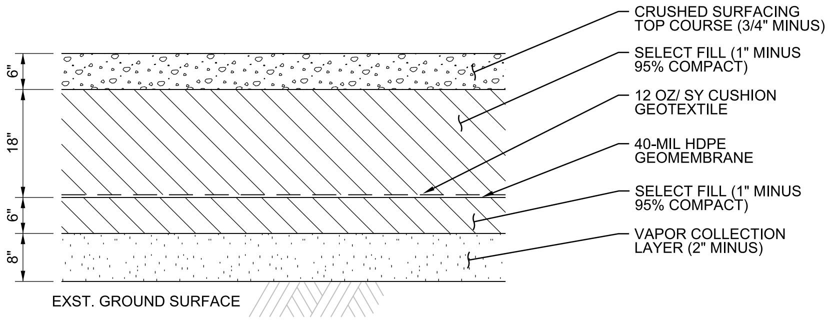
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

US ENVIRONMENTAL PROTECTION AGENCY
WYCKOFF GROUNDWATER TREATMENT PLANT
BAINBRIDGE ISLAND, WA

SHEET	14
DWG 200-CE-102	14
DATE	JANUARY 4 2006
PROJ	316783.FD.B

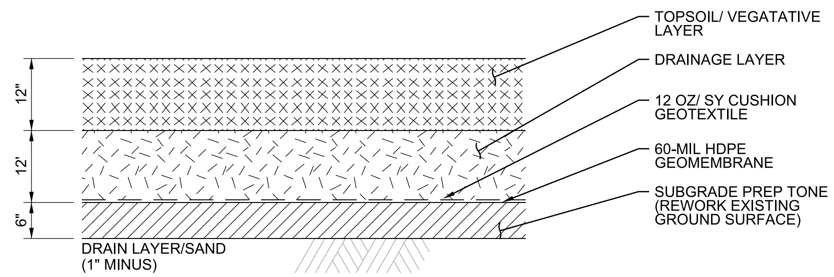
FILENAME: 01ng014d_316783.dgn PLOT DATE: 4/28/2010 PLOT TIME: 8:52:54 AM



1 TEMPORARY VAPOR CAP

NTS

400-C-102



2 FINAL CAP

NTS

200-C-101

NO.	DATE	REVISION	BY	APVD

DSGN MWR | DR MWR | CHK D SUNSERI | APVD MWR

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 2 CONTAINMENT

CAP SECTIONS

VARIES

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	200-C-301
SHEET	of

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. EXCAVATE ALL ISS TREATMENT AREAS TO 7 FEET BELOW GRADE BEFORE TREATMENT. AMEND SOIL WITH CEMENT AND PLACE AND GRADE AFTER ISS TREATMENT.
3. SEE DWG 300-C-300 FOR THE SEQUENTIAL STEPS OF ISS/JET GROUT TREATMENT.

KEYNOTES

1. 3 - 30 FT SQUARE MIXING CELLS. MOVE AREA AS TREATMENT PROGRESSES.
2. ISS TREATMENT BOUNDARY. SEE 101-C-100 AND 100-C-102 FOR ISS AND JET GROUT AREAS. TOTAL AREA =7.7218 ACRES
3. SLOPE GRADED AREA TO DRAIN TO SW INFILTRATION AREA AS CONSTRUCTION PROGRESSES.
4. SW INFILTRATION/POND AREA. PROVIDE 10FT DEEP GRAVEL TRENCH AND SURFACE. AREA = 10800 SQ FT.
5. PROVIDE 5 FT HIGH BERM ALL AROUND FACILITY TO PREVENT FLOODING.
6. FULL DEPTH TREATMENT BOUNDARY. ALL AREA WITHIN BOUNDARY TREATED FROM EXST GROUND SURFACE TO TARGOST REFUSAL DEPTH.

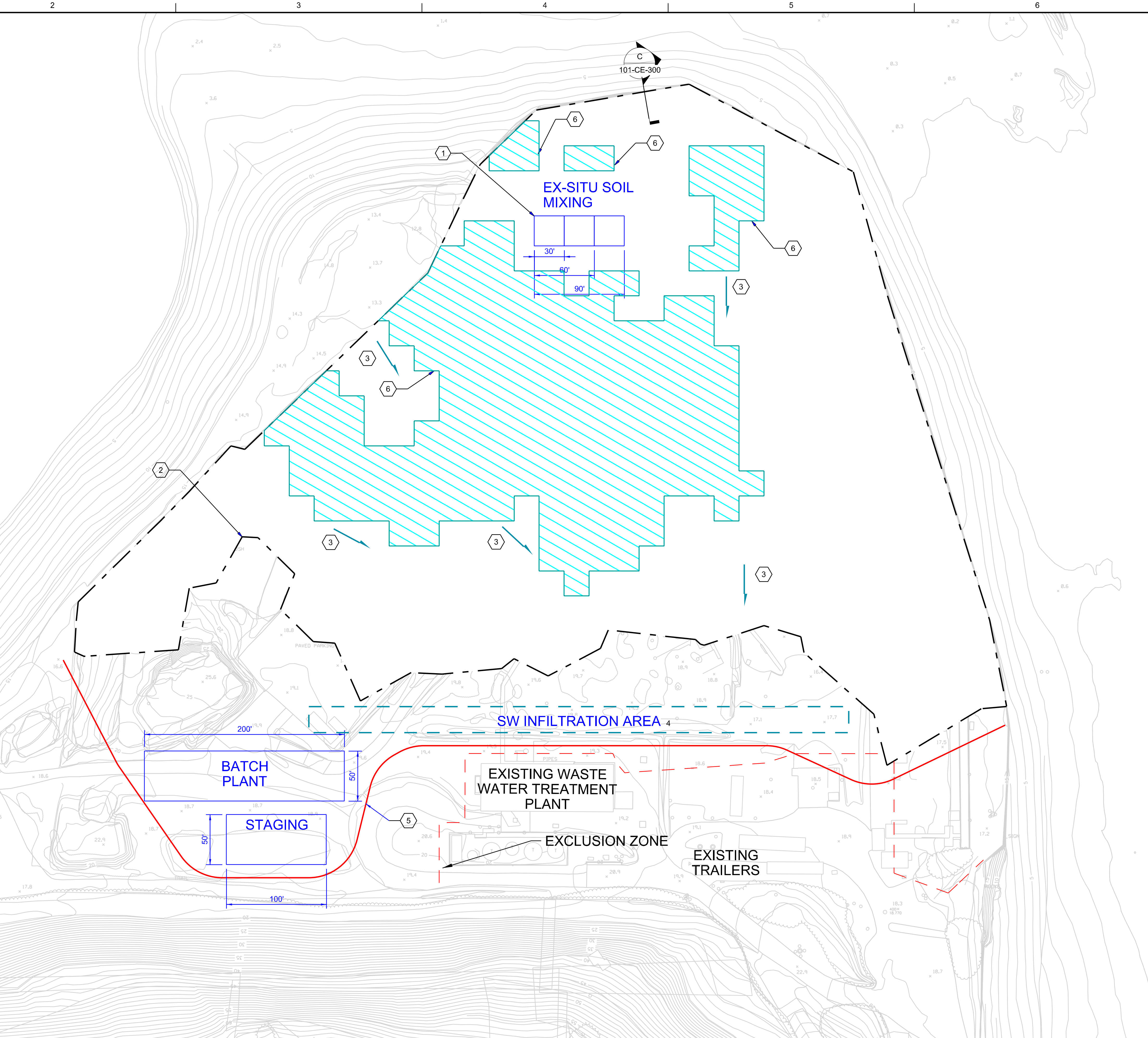
LEGEND

- TREATMENT LIMITS
- BERM
- SW INFILTRATION AREA

N

0 50 100 150

1"=50'



CH2MHILL

ALTERNATIVE 4 ISS TREATMENT
OVERALL SITE PLAN

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK | APVD
BCT

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	300-C-100
SHEET	of

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL.

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. ALPHA-NUMERIC GRIDS ARE 25 FT SQUARE.

KEYNOTES

(1) ISS CRUST ZONE OF HIGHER UNCONFINED COMPRESSIVE STRENGTH.

(2) ISS AUGER MIXING TO START APPROX. 7' BELOW EXISTING GRADE.

LEGEND

ISS TREATMENT LIMITS

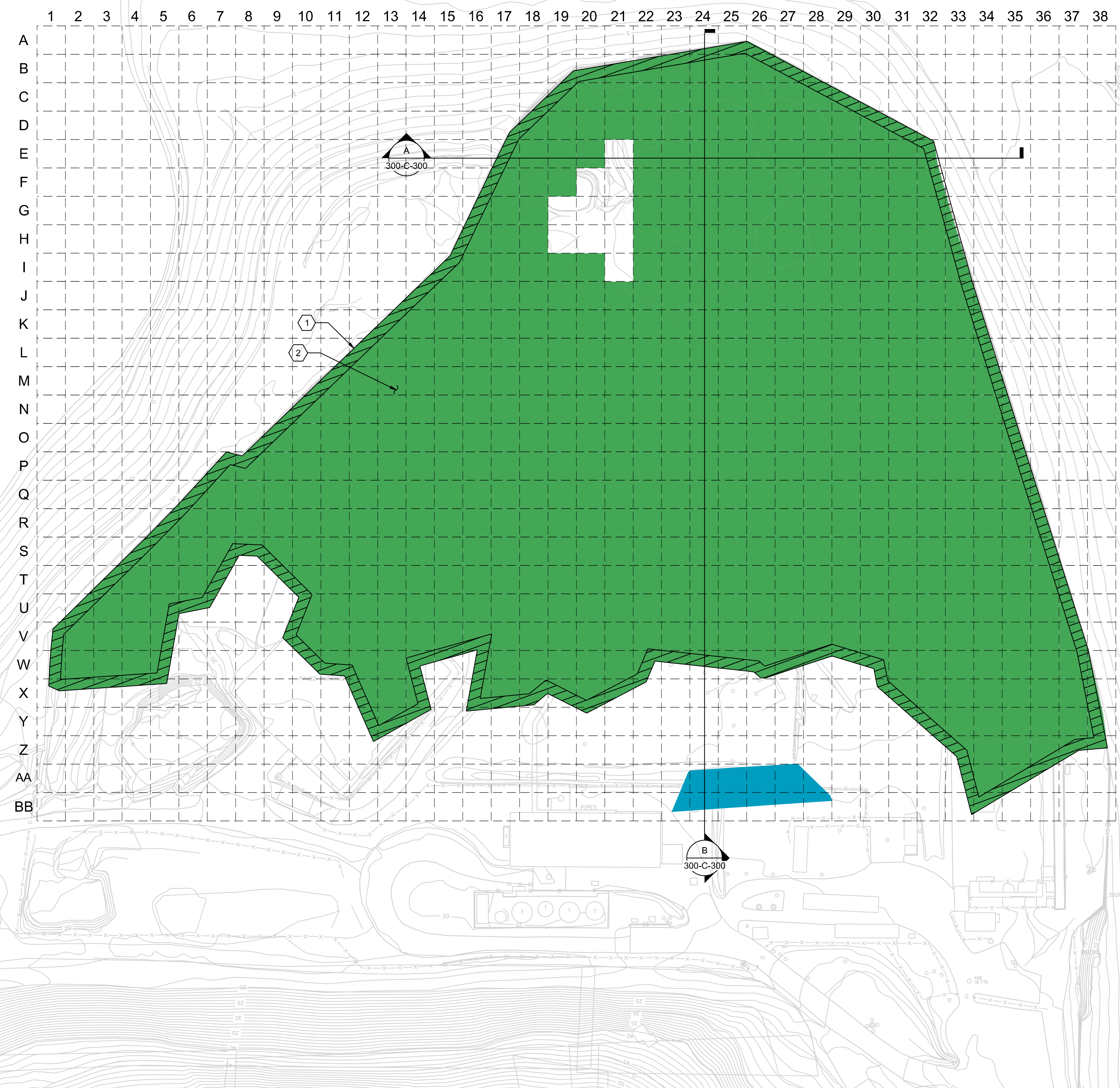
8' EXCAVATION ONLY, EX-SITU SOIL MIX AND REPLACE

ISS CRUST

N

0 50 100 150

1"=50'



ALTERNATIVE 4 ISS TREATMENT

SITE PLAN

ISS TREATMENT

CH2MHILL®

FOCUSED FEASIBILITY STUDY

WYCKOFF

EPA

NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK | APVD

TO | BCT | TO

1"=50 FT

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.

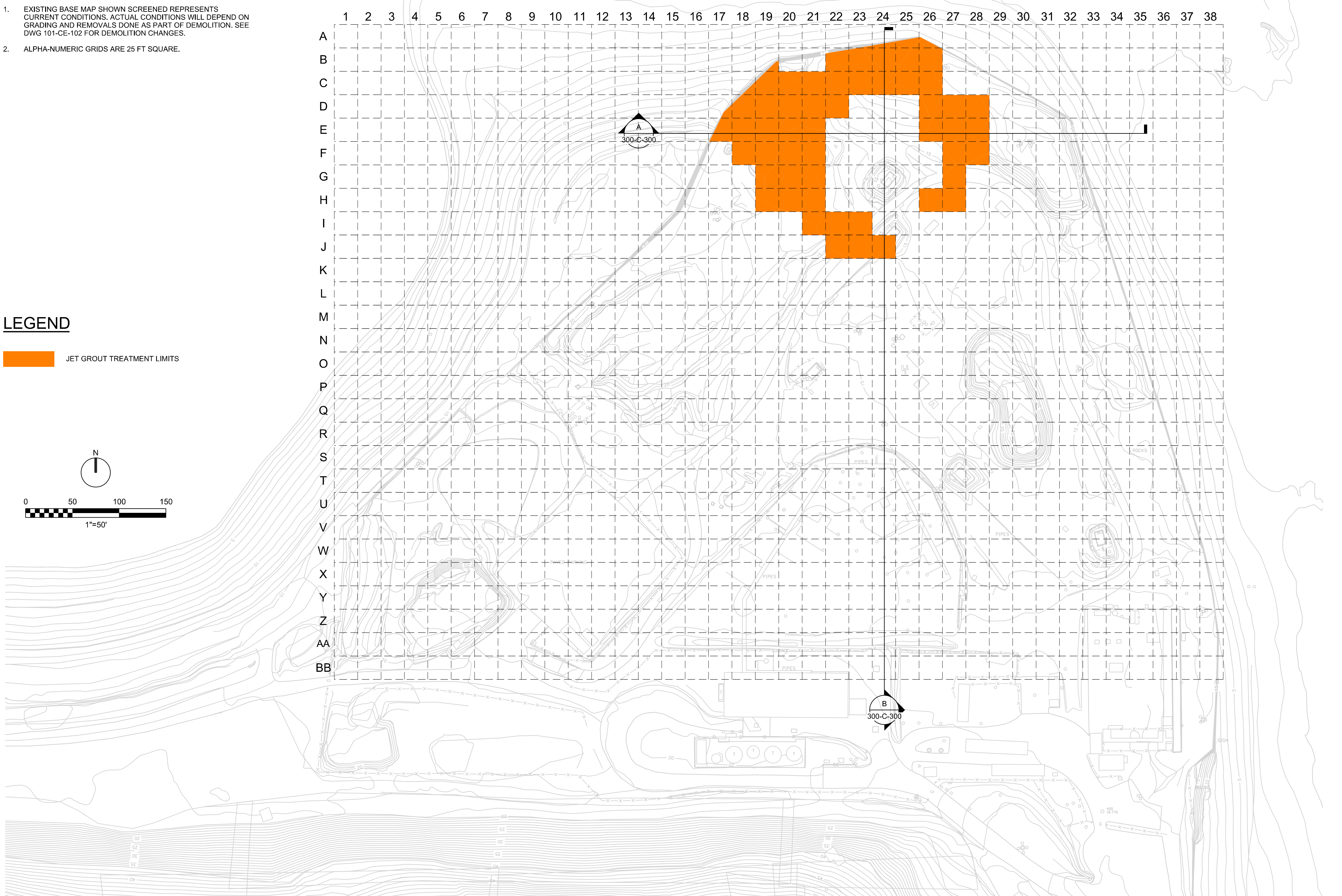
0 1"

DATE	
PROJ	438527
DWG	300-C-101
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. ALPHA-NUMERIC GRIDS ARE 25 FT SQUARE.



FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 4 ISS
SITE PLAN
JET GROUT TREATMENT

CH2MHILL®

NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK JP | APVD

1"=50' FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	300-C-300
SHEET	of

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SEE DWG 300-C-102 FOR ISS TREATMENT DETAILS NOT DESCRIBED ON THIS DWG.

KEYNOTES

1. GROUNDWATER TREATMENT SYSTEM MANHOLE.
2. COLLECTION MANHOLE.
3. DRAIN PIPE THROUGH SHEET PILE WALL
4. SUBSURFACE DRAIN PIPE

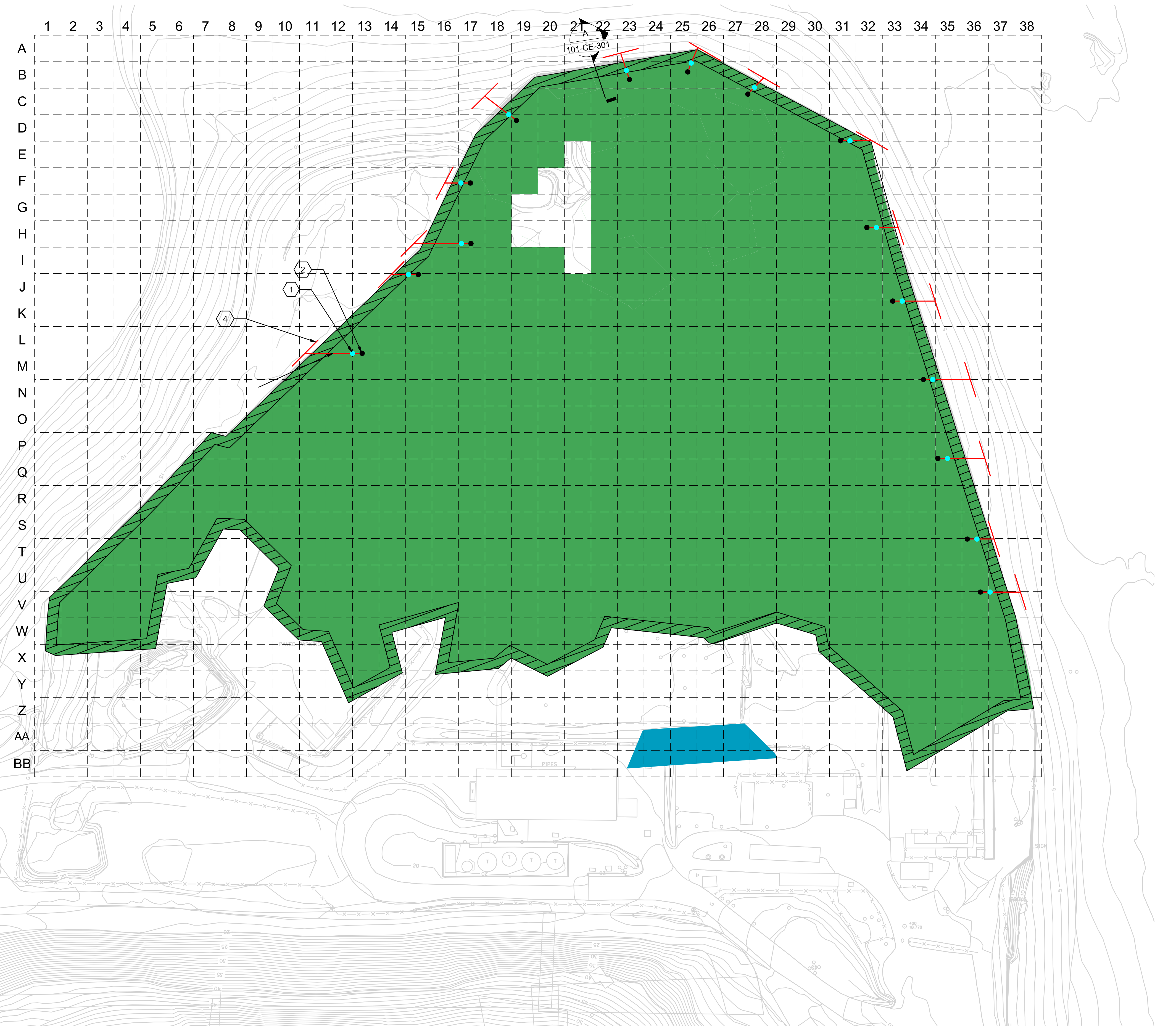
LEGEND

- ISS TREATMENT LIMITS
- 8' EXCAVATION ONLY, EX-SITU SOIL MIX AND REPLACE
- ISS CRUST
- COLLECTION MANHOLE
- TREATMENT WELL
- DRAIN PIPE

N

0 50 100 150

1"=50'



FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 4 ISS TREATMENT
PASSIVE GROUNDWATER TREATMENT SYSTEM

CH2MHILL®

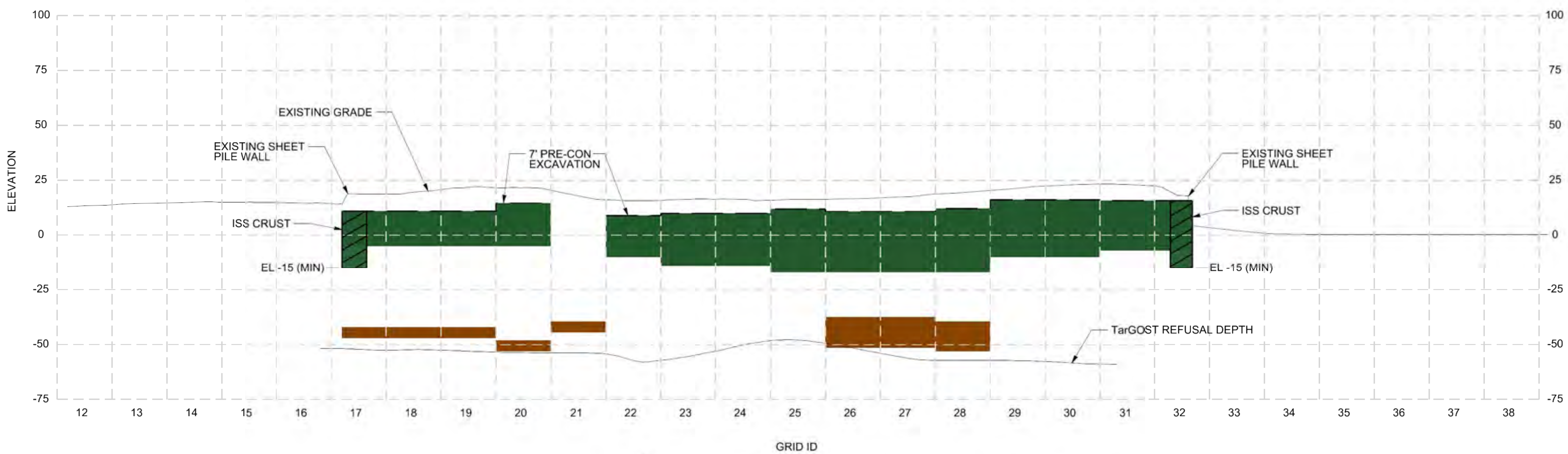
NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK | APVD

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	300-C-103
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

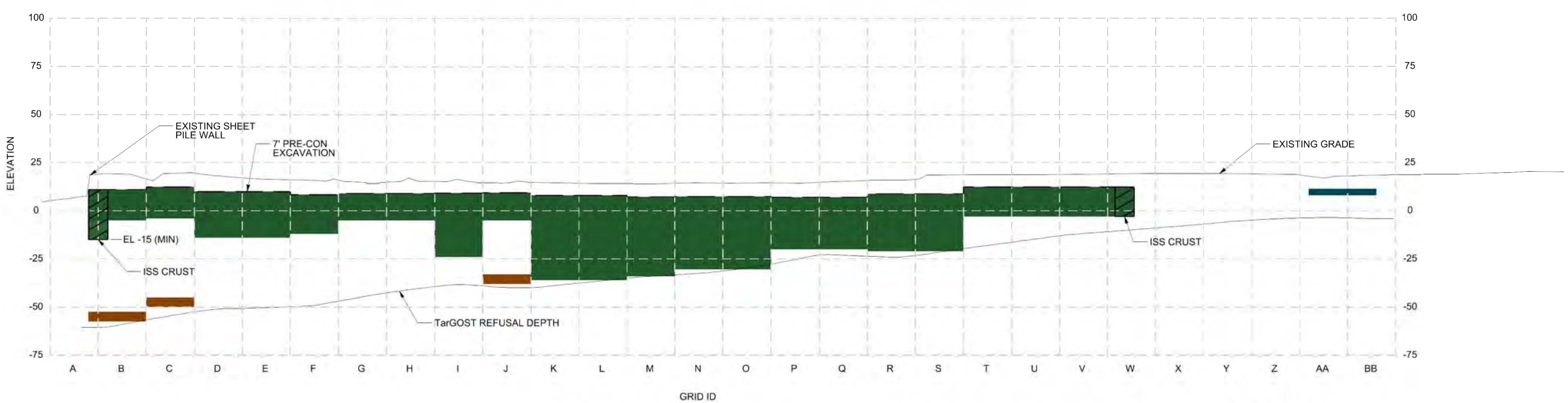


A
300-C-102

WEST / EAST SITE SECTION

SCALE: 1"=30'

NOTE: SEE DWG 300-C-301 FOR CONSTRUCTION SCHEMATICS



B
300-C-102

NORTH / SOUTH SITE SECTION

SCALE: 1"=30'

NOTE: SEE DWG 300-C-301 FOR CONSTRUCTION SCHEMATICS

LEGEND

- ISS TREATMENT LIMITS
- 8' EXCAVATION ONLY, EX-SITU SOIL MIX AND REPLACE
- JET GROUT
- ISS CRUST

NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK JP | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

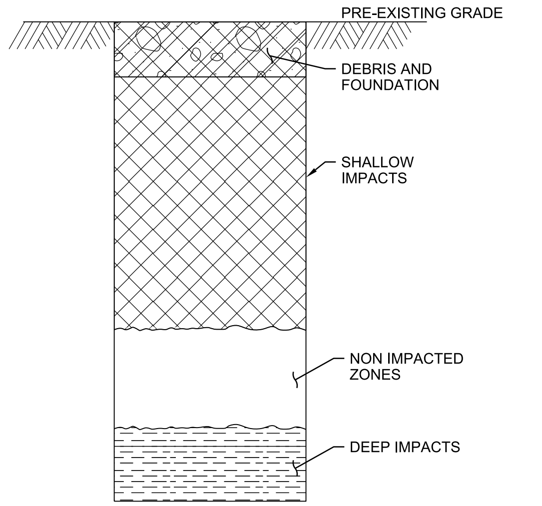
CH2MHILL®

ALTERNATIVE 4 ISS
ISS CROSS SECTIONS
ISS / JET GROUT

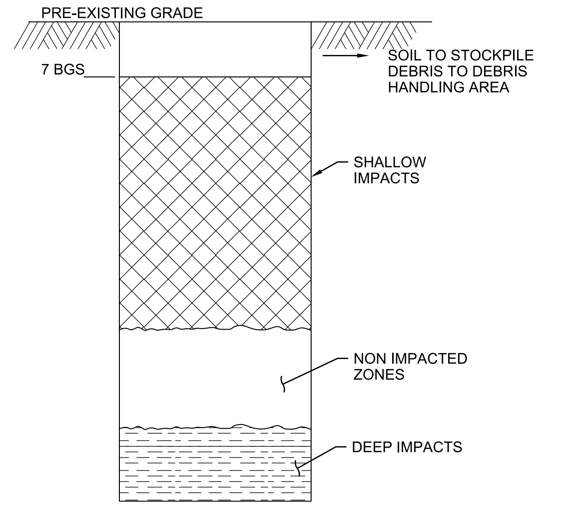
1"=30' FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	300-C-300
SHEET	of

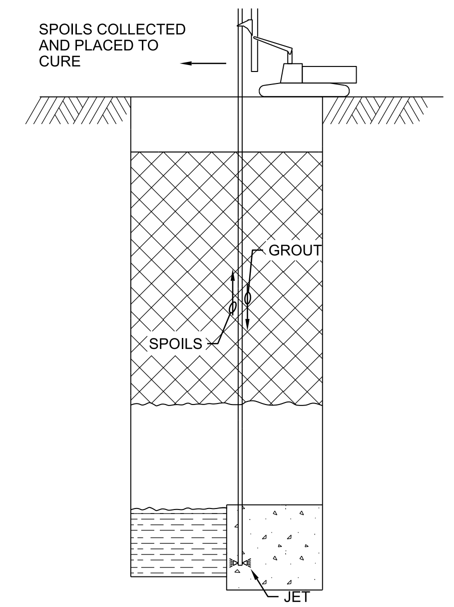
$PWURL $PWPATH FILENAME: 300-C-300_438527.dgn PLOT DATE: 2014\05\18 PLOT TIME: 8:51:35 PM



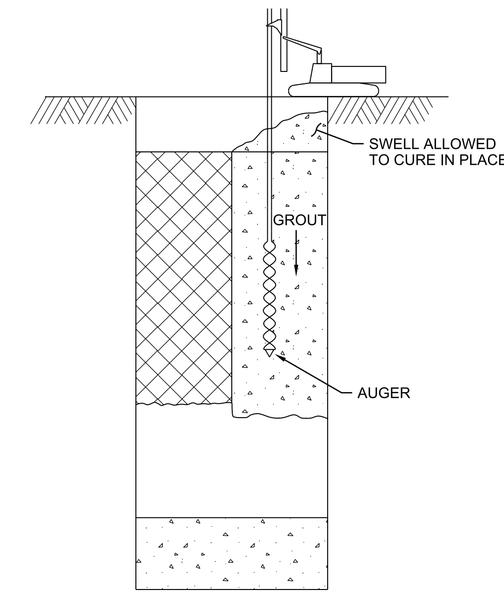
EXISTING CONDITIONS
NTS



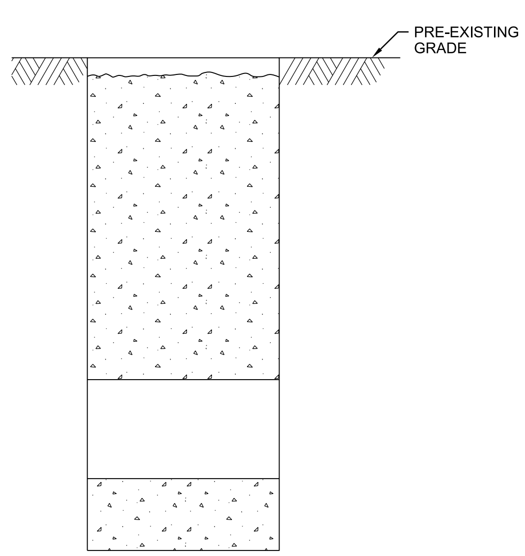
STEP 1
7' EXCAVATION AND
DEBRIS/ FOUNDATION REMOVAL
NTS



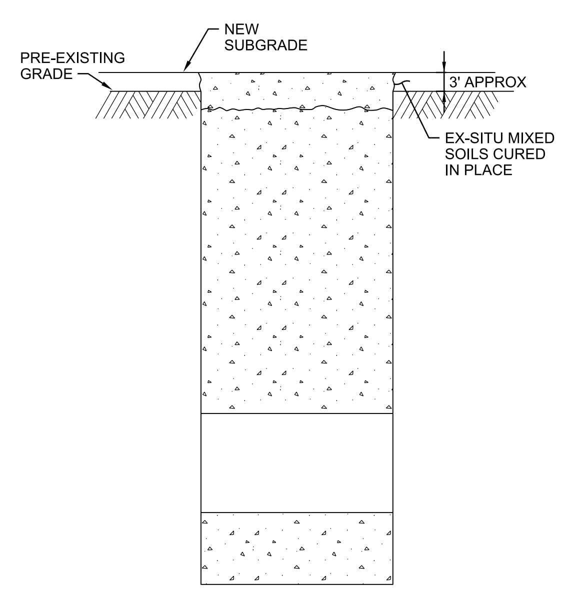
STEP 2
JET GROUT
DEEP IMPACTS
NTS



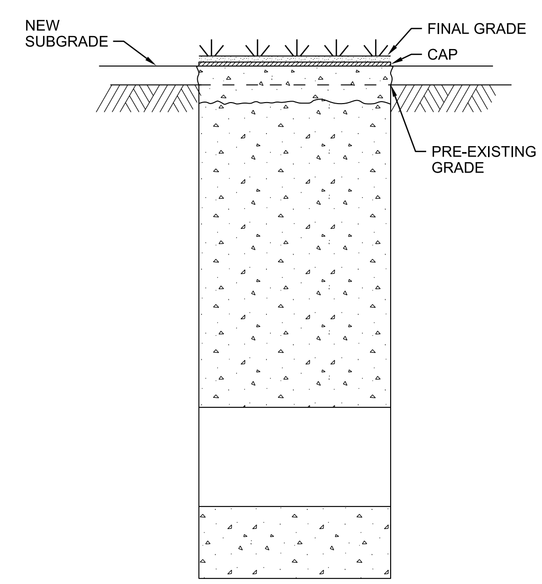
STEP 3
AUGER ISS OF
SHALLOW IMPACTS
NTS



STEP 4
POST ISS CONDITIONS
NTS



STEP 5
EX-SITU MIXING OF
EXCAVATED SOILS AND
PLACEMENT OVER ISS
NTS



STEP 6
CAP PLACEMENT
AND FINAL CONDITIONS
NTS

GENERAL NOTES

1. TYPICAL SCHEMATIC SECTIONS ARE SHOWN FOR THE SEQUENCE OF ISS/JET GROUT CONSTRUCTION BEGINNING WITH EXISTING CONDITIONS AND PROGRESSING THROUGH ISS/JET GROUT ACTIVITIES.

NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK JP | APVD

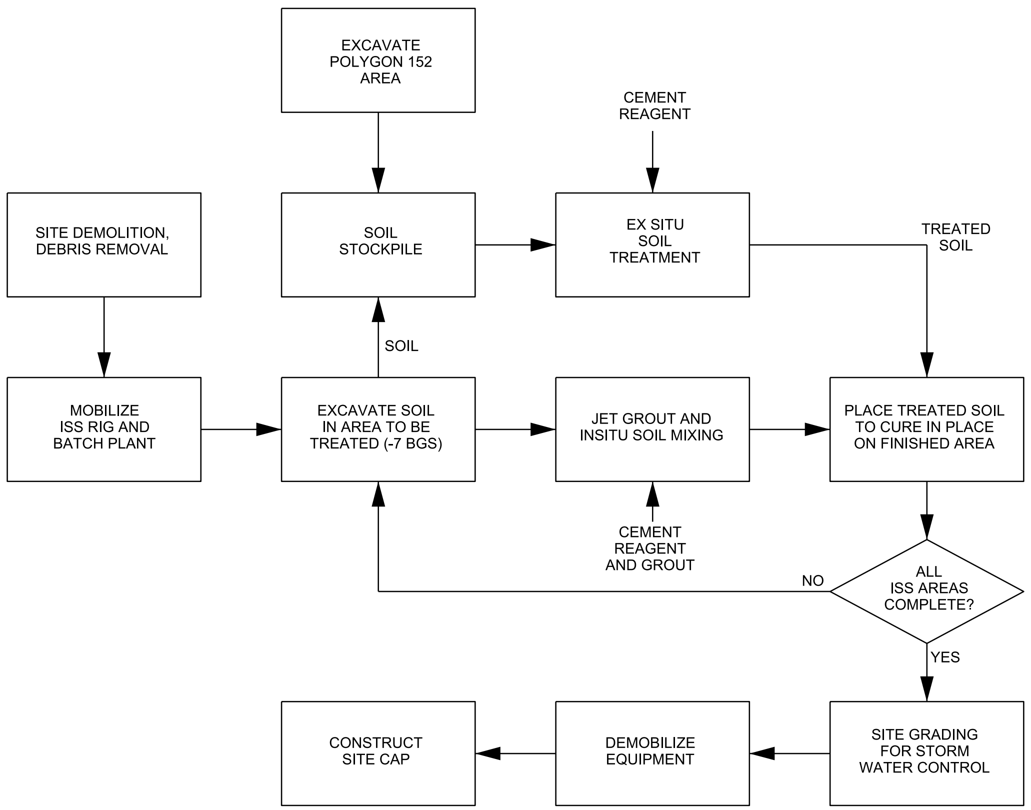
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 4 ISS
ISS PROGRESSION
ISS / JET GROUT

1"=30 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	300-C-301
SHEET	of



NO.	DATE	REVISION	BY	APVD

DSGN M. DAVIS | DR | CHK | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 4
PROCESS FLOW DIAGRAM

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	300-C-600
SHEET	of

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SEE DRAWING 500-C-100 FOR LOCATION OF DEWATERING WELLS THAT WILL BE USED FOR DEWATERING THERMAL TREATMENT AREAS PRIOR TO STEAM INJECTION.

KEYNOTES

1. NAPL EXTRACTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
2. SEE DWG 400-C-104 FOR PIPING TO EXST WATER TREATMENT PLANT.
3. INSTALL VAPOR COVER BEFORE DRILLING WELLS. BOOT AROUND WELL TO PROVIDE AIRTIGHT SEAL. SEE DWG 200-C-301 FOR DETAILS.
4. SEE DWG 400-C-104 FOR DEWATER WELL PIPING.

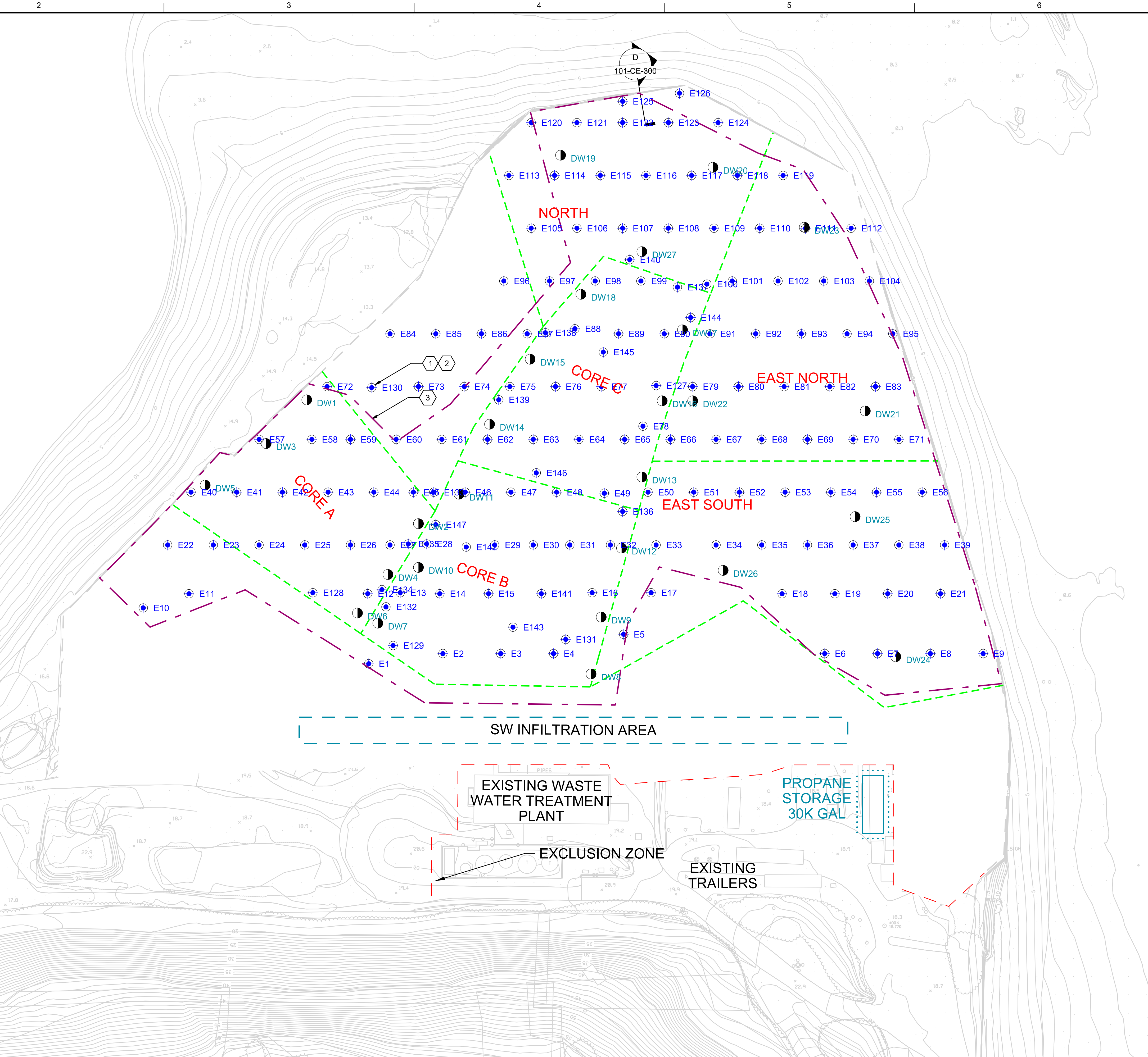
LEGEND

- SHEET PILE WALLS
- E84 EXTRACTION WELL
- VAPOR COVER LIMITS
- DW5 DEWATER WELL

N

0 50 100 150

1"=50'



NO.	DATE	REVISION	BY	APVD

DSGN BS
DR BS
CHK BCT
APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 5 THERMAL
SITE PLAN
NAPL EXTRACTION & COVER

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE
PROJ 438527
DWG 400-C-100
SHEET of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. EXTRACTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
2. STEAM INJECTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
3. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101.
4. JET GROUT TREATMENT AREA. SEE ALTERNATIVE 4 FOR TREATMENT REQUIREMENTS.

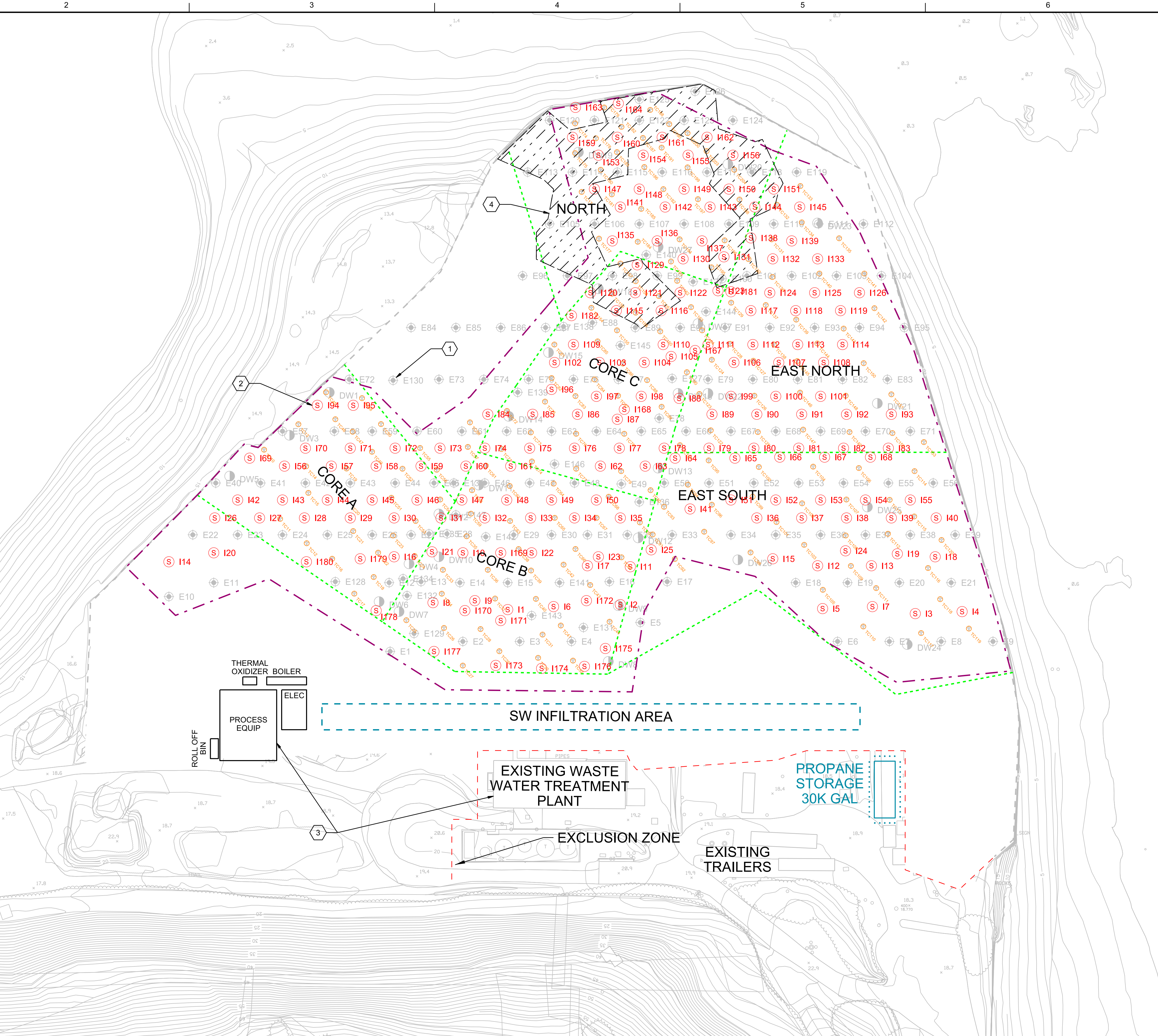
LEGEND

- VAPOR COVER LIMITS
- JET GROUT TREATMENT AREA
- SHEET PILE WALLS
- E130 EXTRACTION WELL
- I42 STEAM INJECTION WELL
- THERMOCOUPLES
- DW5 DEWATER WELLS

N

0 50 100 150

1"=50'



NO.	DATE	REVISION	BY	APVD

DSGN BS | DR BS | CHK BCT | APVD BS

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 5 THERMAL

SITE PLAN - THERMAL WELLS AND JET GROUT TREATMENT

1"=50 FT

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.

0 1"

DATE	
PROJ	438527
DWG	400-C-101
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. SEE DWG 200-C-301 FOR VAPOR COVER DETAILS.
2. VAPOR EXTRACTION WELLHEAD. 3" SCH 80 CPVC PERFORATED PIPE IN VAPOR LAYER OF VAPOR CAP. SEE DWG 200-C-301. ABOVE GROUND PIPE IS 1-½" CPVC CONNECTED TO VAPOR EXTRACTION HEADER.
3. AIR INJECTION WELLHEAD. 3" SCH 80 CPVC PERFORATED PIPE IN VAPOR LAYER OF VAPOR CAP. SEE DWG 200-C-301. SUPPLY PIPE IS 1-½" CARBON STEEL.
4. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101

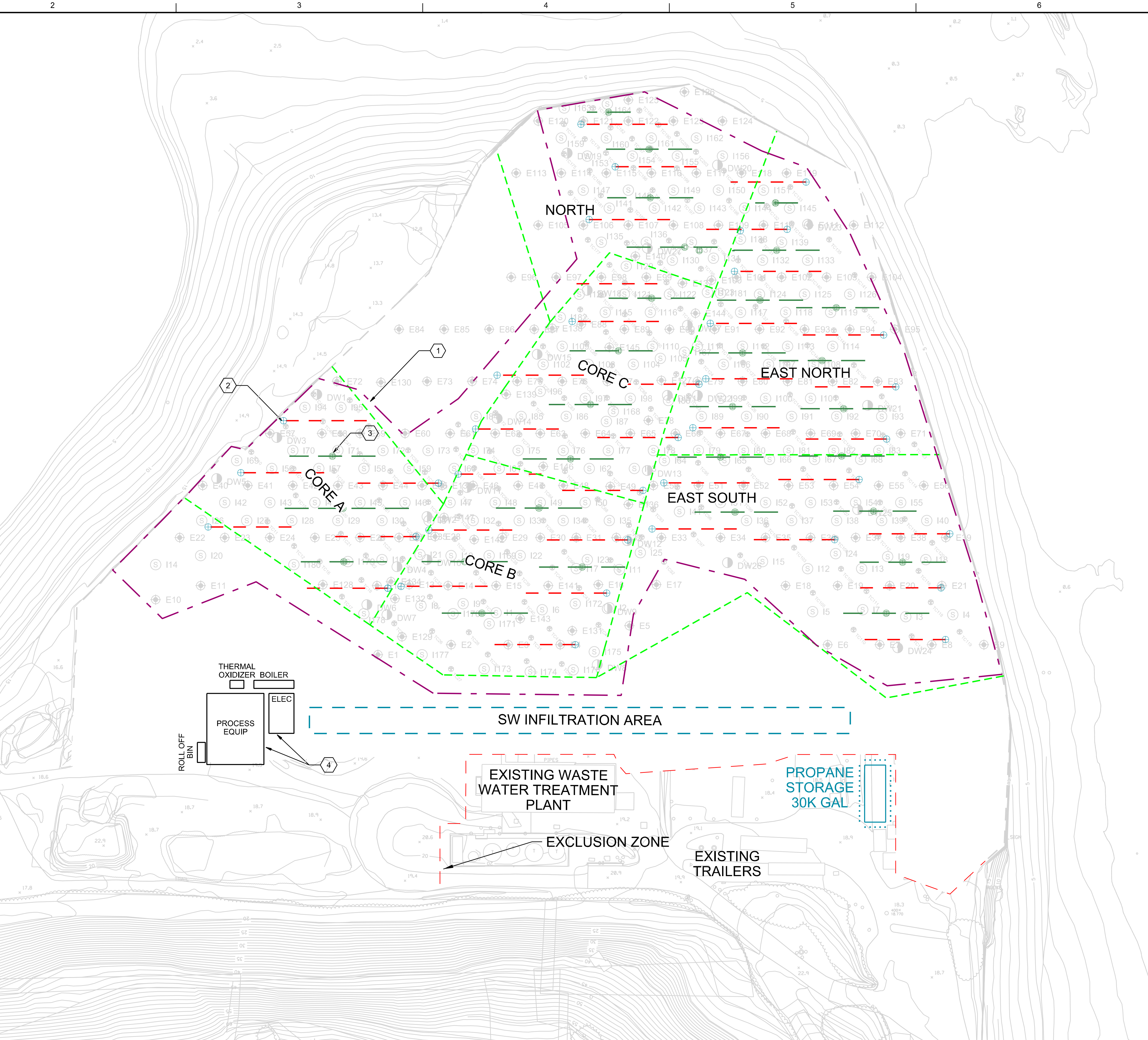
LEGEND

- EXISTING SHEET PILE WALL
- VAPOR COVER LIMITS
- SHEET PILE WALLS
- VAPOR EXTRACTION PIPING AND WELL
- AIR INJECTION PIPING AND WELL
- E84 EXTRACTION WELL
- I42 STEAM INJECTION WELL
- THERMOCOUPLE
- DW1 DEWATER WELL

N

0 50 100 150

1"=50'



NO.	DATE	REVISION	BY	APVD

DSGN BS
DR BS
CHK BCT
APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL

ALTERNATIVE 5THERMAL
SITE PLAN
VAPOR REMOVAL FROM AND AIR INJECTION INTO COVER (JET GROUT)

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-102
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. BIOSPARGING WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
2. BIOSPARGING WELLHEAD CONVERTED FROM STEAM INJECTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
3. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101.

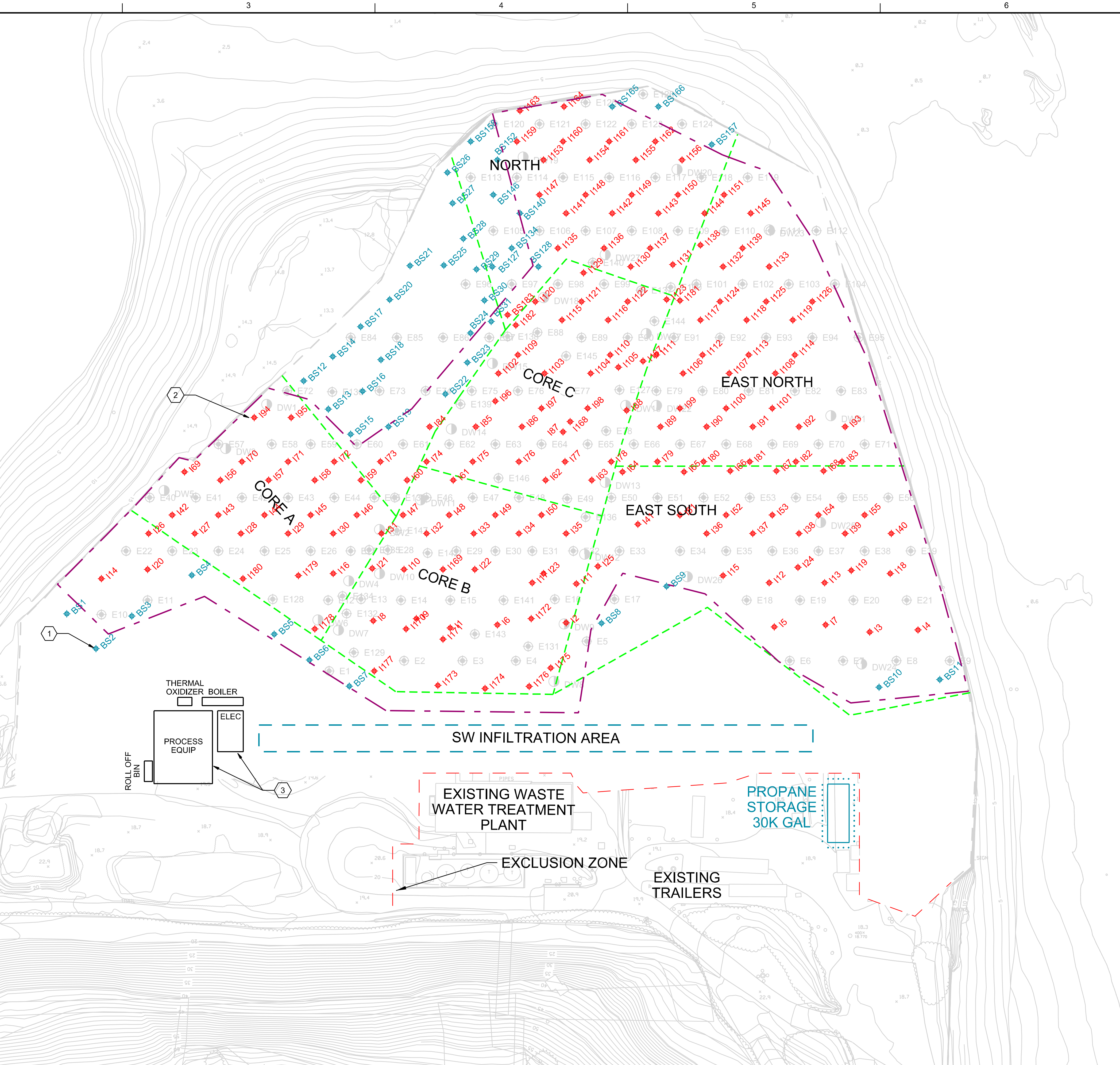
LEGEND

- EXISTING SHEET PILE WALL
- VAPOR COVER LIMITS
- SHEET PILE WALLS
- E130 EXTRACTION WELL
- BS5 BIOSPARGING WELL
- I43 BIOSPARGING WELL CONVERTED FROM STEAM INJECTION WELL
- DW1 DEWATER WELL

N

0 50 100 150

1"=50'



NO.	DATE	REVISION	BY	APVD

DSGN BS | DR BCT | CHK BS | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

ALTERNATIVE 5 THERMAL
SITE PLAN - ENHANCED AEROBIC

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-103
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

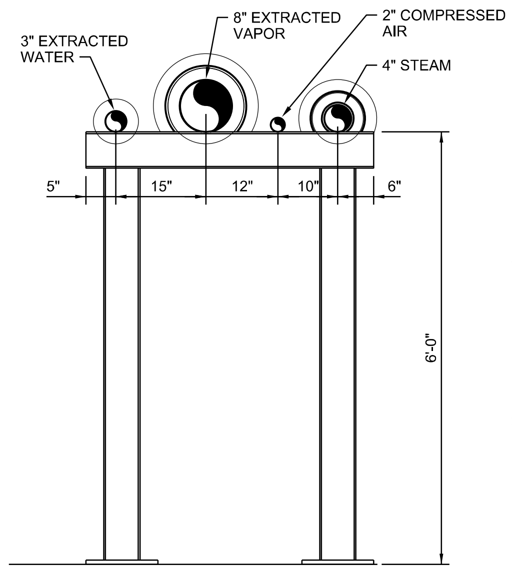
LEGEND

NON-ELEVATED PIPERACK

ELEVATED PIPERACK

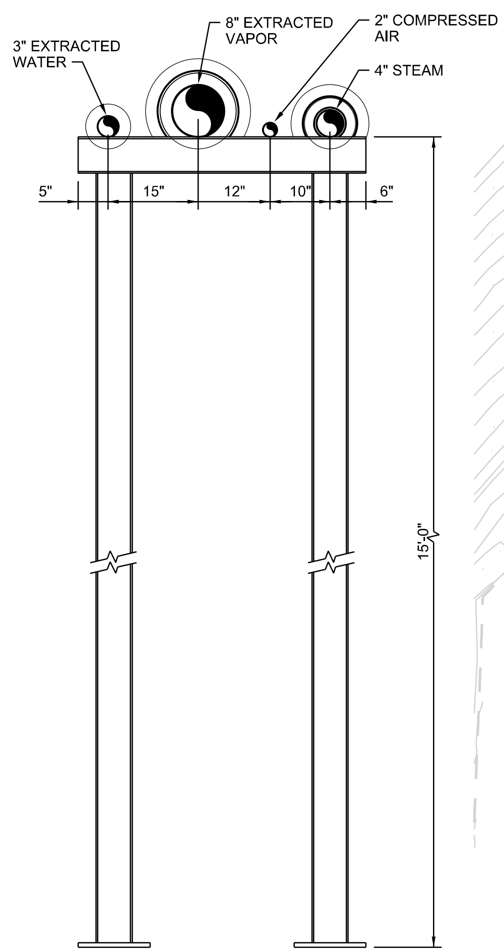
NOTES:

1. IN GENERAL, THE DISTANCE BETWEEN THE NON-ELEVATED PIPERACKS IS SUFFICIENT SPACING TO ALLOW TRUCK TRAFFIC BETWEEN THE RACKS. DURING DETAILED DESIGN, SOME WELL LOCATIONS AND/ OR PIPE RACKS MAY BE MOVED TO ASSURE MAINTENANCE ACCESS TO WELLS.
2. ELEVATED PIPE RACKS WILL BE AT A HEIGHT AND WILL HAVE COLUMN SPACING TO ALLOW TRUCK TRAFFIC TO PASS UNDERNEATH THE PIPE RACK.
3. AIR INJECTION AND VAPOR EXTRACTION POINTS INTO THE VAPOR COVER ARE NOT SHOWN. LOCATIONS OF THESE WILL BE ADJUSTED AS NEEDED TO ASSURE ACCESS TO WELLS.
4. THERMOCOUPLE LOCATIONS ARE NOT SHOWN. THESE ARE AT GRADE AND WILL HAVE COVERS RATED FOR TRUCK TRAFFIC.
5. ELECTRICAL WIRING WILL BE ROUTED ON CABLE TRAYS LOCATED ABOVE PIPE RACKS.
6. EXTRACTED WATER HEADERS WILL BE USED FOR NAPL EXTRACTION, DEWATERING PRIOR TO STEAM INJECTION, AND GROUNDWATER EXTRACTION DURING STEAM INJECTION. ISOLATION VALVES AND SOME ADDITIONAL PIPE CONNECTIONS MAY BE NEEDED TO ALLOW DEWATERING OF ONE TREATMENT CELL TO OCCUR SIMULTANEOUSLY WITH STEAMING OF ANOTHER CELL.



A SECTION

3/4"=1'-0"



B SECTION

3/4"=1'-0"

PIPE RACK PLAN

1"=40'-0"

NO.	DATE	REVISION	BY	APVD

DSGN M DAVIS | DR D SUNSERI | CHK | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL.

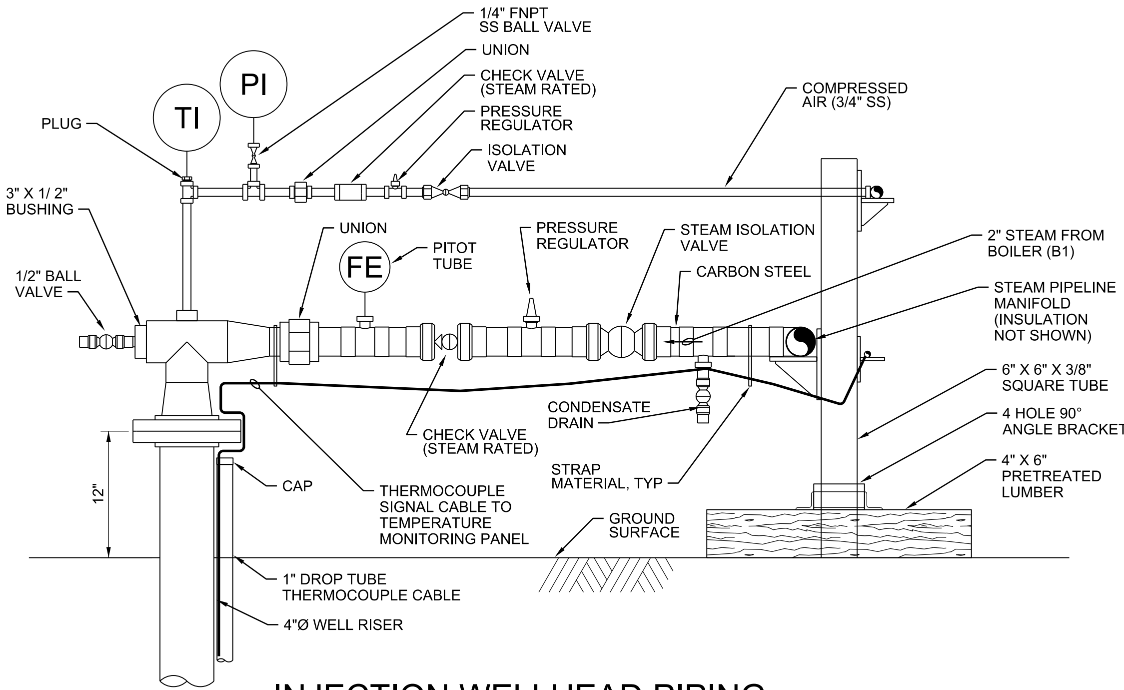
CH2MHILL®

ALTERNATIVE 5
PIPING PLAN

1"=40 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE
PROJ 438527
DWG 400-C-104
SHEET of

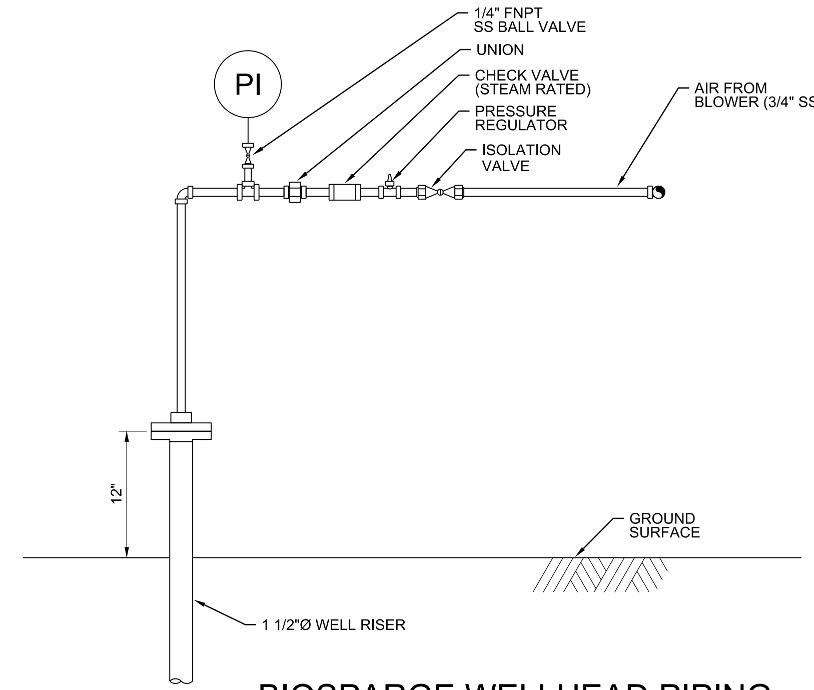
$PWURL $PWPATH FILENAME: 400-C-104_438527.dgn PLOT DATE: 2014\06\19 PLOT TIME: 9:49:58 AM



INJECTION WELLHEAD PIPING

NTS

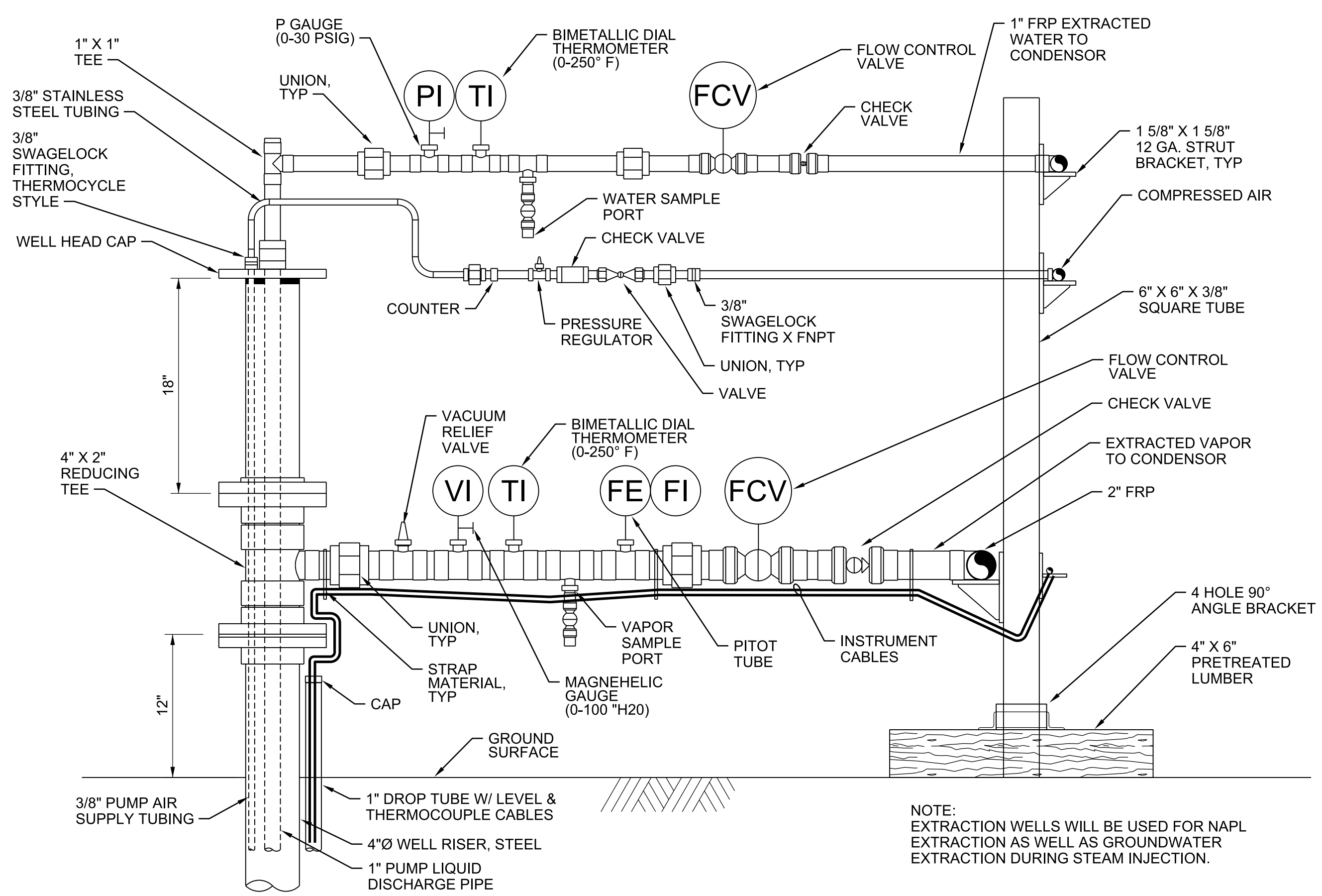
NOTE:
ONCE STEAM INJECTION IS COMPLETE, THESE WELLS WILL BE CONVERTED TO BIOSPARGING. ALL AIR PIPING WILL REMAIN IN-PLACE. STEAM PIPING AND THERMOCOUPLES CAN BE REMOVED.



BIOSPARGE WELLHEAD PIPING

NTS

NOTE:
THIS WELLHEAD IS ONLY USED IN AREAS WHERE NO STEAM INJECTION WELLS HAVE BEEN INSTALLED IN AREAS THAT RECEIVE ISCO TREATMENT, 1 1/2" Ø WELLS USED FOR ISCO WILL BE CONVERTED TO BIOSPARGING ONCE ISCO IS COMPLETE.



NOTE:
EXTRACTION WELLS WILL BE USED FOR NAPL EXTRACTION AS WELL AS GROUNDWATER EXTRACTION DURING STEAM INJECTION.

EXTRACTION WELLHEAD PIPING

NTS

NO.	DATE	REVISION	BY	APVD

DSGN C KATZEN | DR D SUNSERI | CHK | APVD

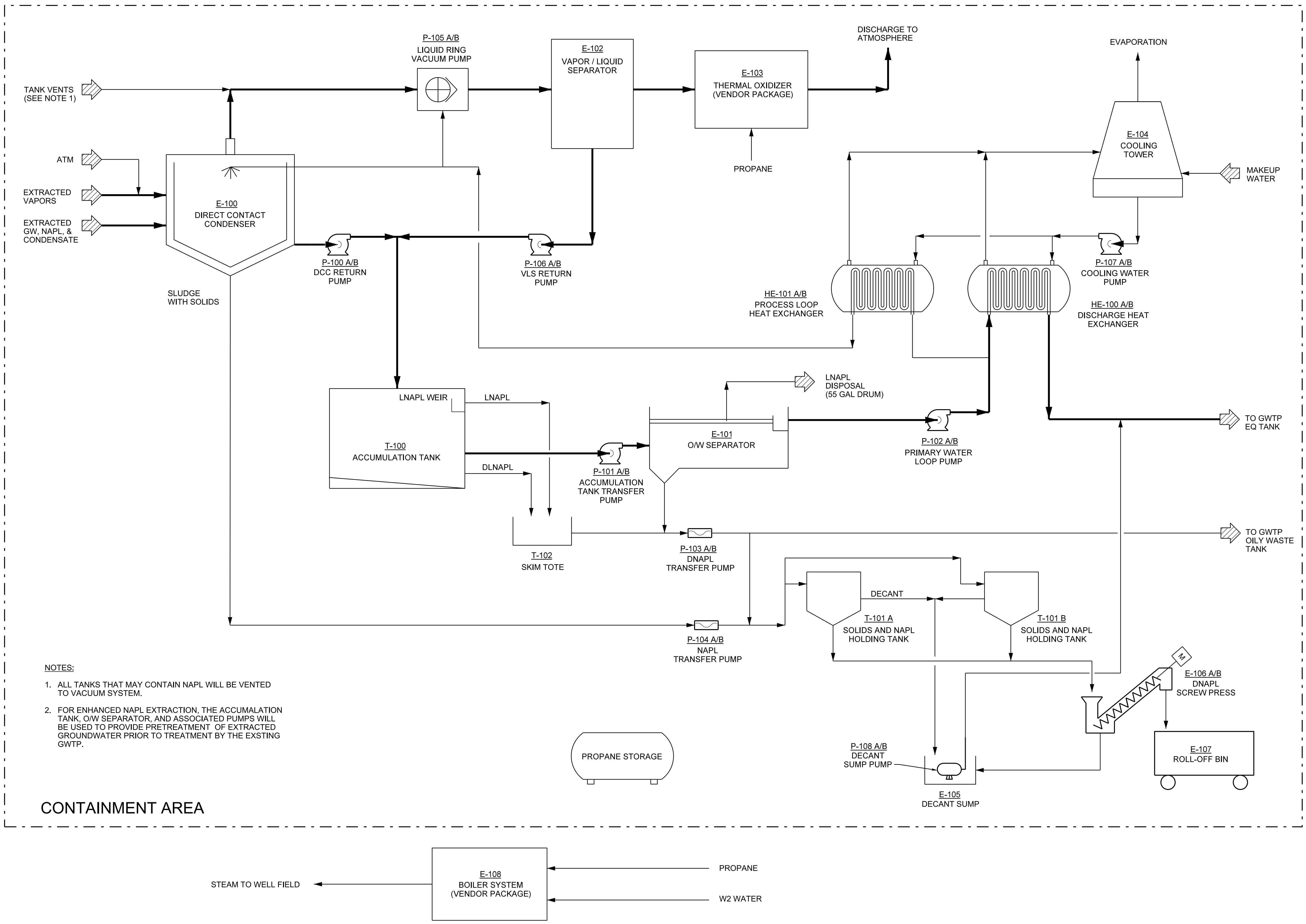
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

WELLHEAD DETAILS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-500
SHEET	of



NO.	DATE	REVISION	BY	APVD

DSGN MD | DR VMS | CHK BS | APVD

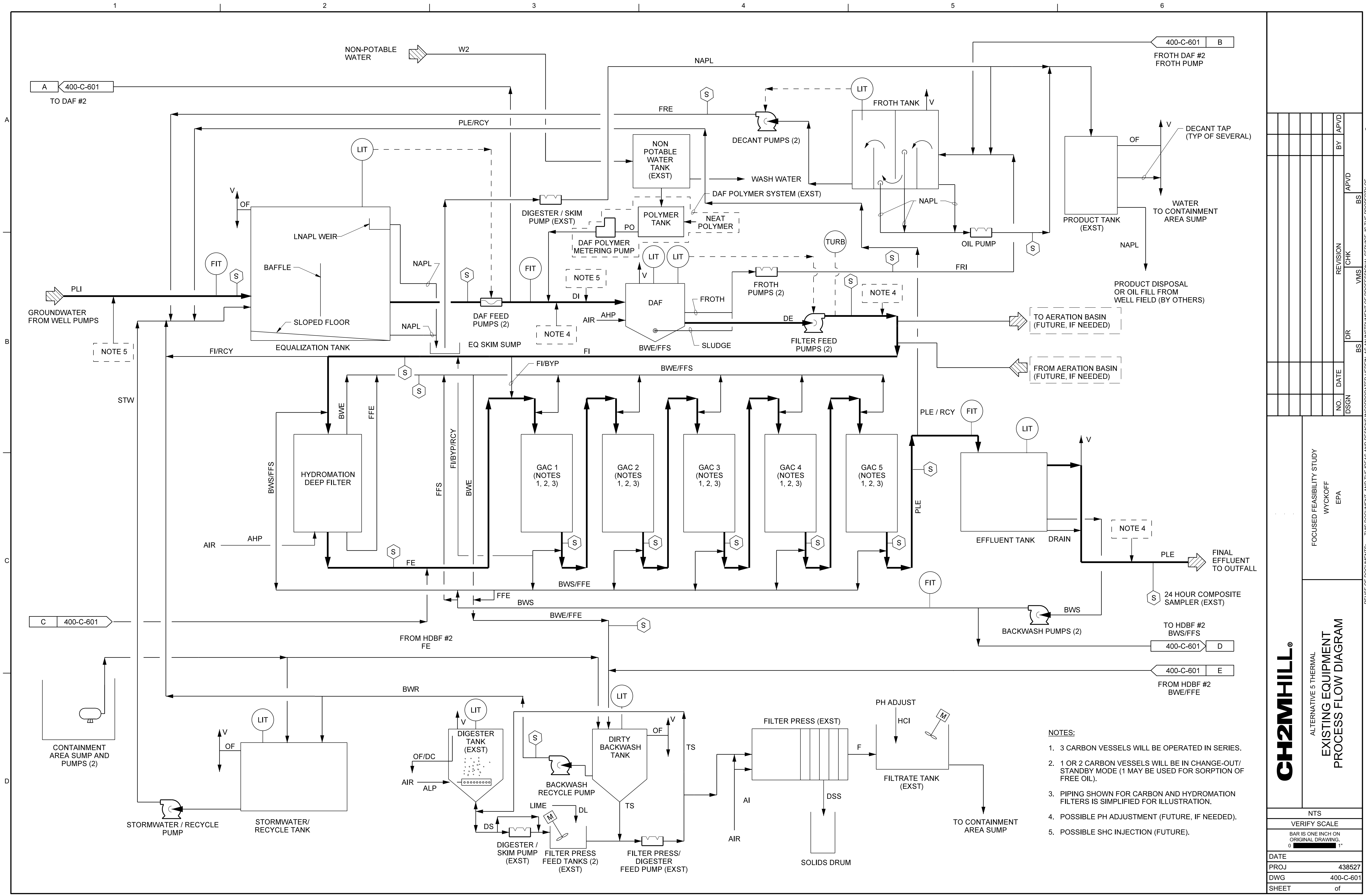
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

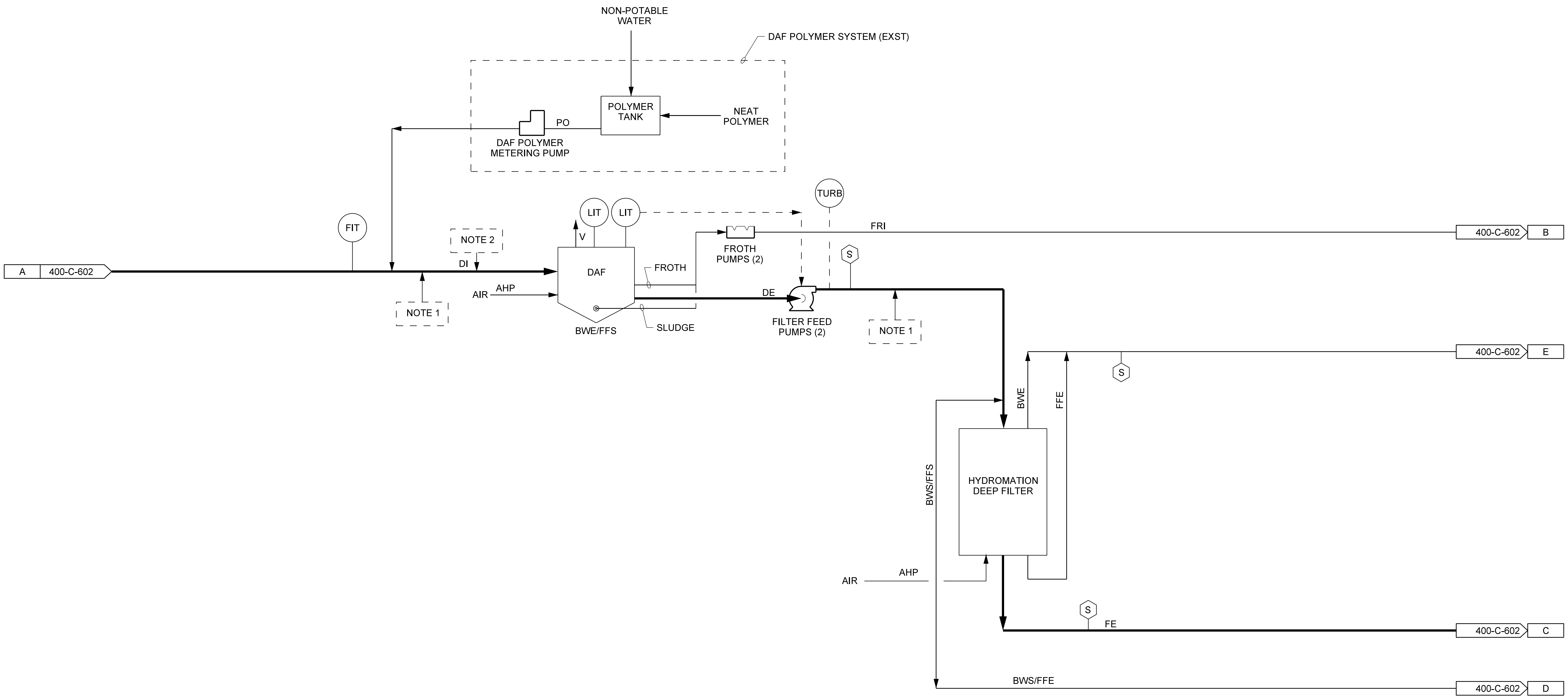
ALTERNATIVE 5 THERMAL
PROCESS FLOW DIAGRAM 1

NTS
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-600
SHEET	of



$PWURL pw://projectwise.ch2m.com:DEN001/Documents/438527&space;-&space;AES10&space;0079-WYCKOFF&space;GW&space;SOILS/Feasability&space;Study&space;WIP/HY/Dlv/400-C-601_438627.dgn FILENAME: 400-C-601_438627.dgn PLOT DATE: 5/6/2014 PLOT TIME: 6:47:21 PM



NOTES:

1. POSSIBLE PH ADJUSTMENT (FUTURE, IF NEEDED).
2. POSSIBLE SHC INJECTION (FUTURE).

CH2MHILL

ALTERNATIVE 5 THERMAL

PROCESS FLOW DIAGRAM 2

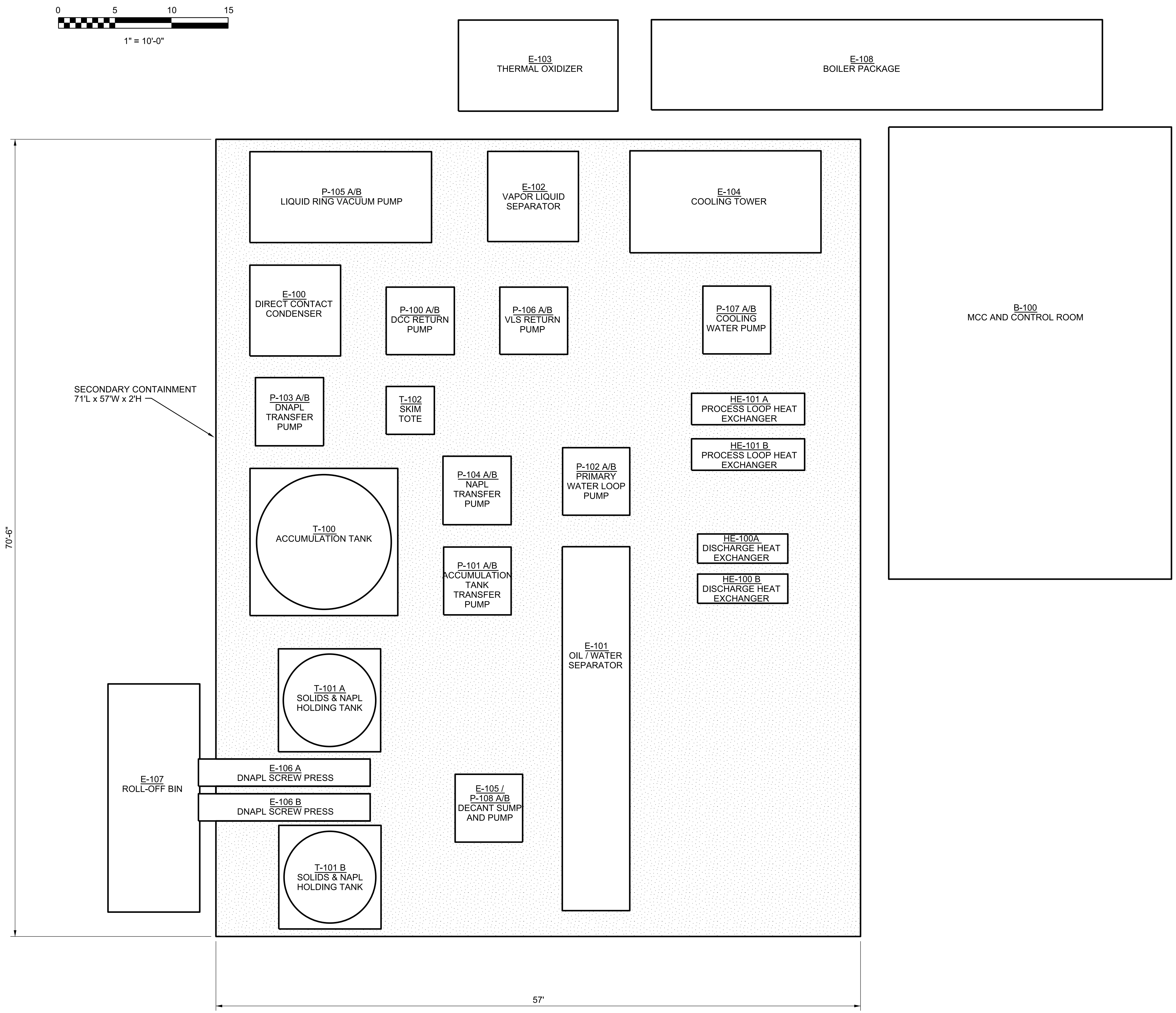
FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

NO.	DATE	REVISION	BY	APVD

DSGN MD | DR VMS | CHK BS | APVD

NTS
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-C-602
SHEET	of



NO.	DATE	REVISION	BY	APVD

DSGN C. KATZEN | DR V. MAXEY | CHK M. DAVIS | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 5
TREATMENT SYSTEM PLAN

NTS
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	400-M-101
SHEET	of

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.
2. SEE TABLE 1 FOR FACILITY SIZES AND CONTENT. SEE DETAILED COST ESTIMATE SPREADSHEET FOR DETAILS.
3. REFER TO DWG 500-C-600 FOR THE MTTD PFD.
4. THE PROPANE TANK WILL BE HARD PIPED BELOW GROUND TO THE MTTD. WATER TO THE DUST CONTROL TANK FROM THE EXISTING WELL SUPPLY WILL BE HARD PIPED. WATER FROM THE STORAGE TANK AT THE WWTP WILL BE HARD PIPED TO THE MTTD FRACTIONATION TANK FOR QUENCH WATER. WATER COLLECTED AT THE PUMP STATIONS ASSOCIATED WITH THE DRAINAGE SYSTEM (SOUTH OF THE TREATED SOIL STOCKPILE AREA) WILL BE HARD PIPED TO INFILTRATION AREA.
5. SOILS THAT ARE SATURATED WITH WATER MAY BE TEMPORARILY STAGED IN AN ADJOINING CONTAMINATED CELL FOR DEWATERING.
6. THE MTTD LAYOUT WILL CHANGE SLIGHTLY IF AN ACID GAS SCRUBBER IS REQUIRED. THE SCRUBBER WOULD FOLLOW THE AFTERBURNER. REFER TO PDF.
7. DEWATERING WILL BE CONDUCTED BY A SERIES OF TWO EXTRACTION WELLS PER SHEETPILE CELL. DEWATERING WOULD BE CONDUCTED SIMULTANEOUS AT THE CELL BEING EXCAVATED AND BACKFILLED AS WELL AS THE NEXT CELL TO BE EXCAVATED. OTHER WELLS OUTSIDE THE CORE AREA WILL BE OPERATED AS REQUIRED TO SUPPORT DEWATERING. BURIED HDPE PIPING WITH STUB UPS WILL BE INSTALLED TO THE WWTP. WATER FROM THE WELLS WILL BE CONNECTED TO THIS LINE(S) WITH HOSES AND CAM LOCKS. WELLS WILL BE POWERED BY WHISPER QUITE GENSET(S).
8. AN IMPERMEABLE LINER WILL BE PLACED ON THE BOTTOM SURFACE OF THE EXCAVATION OF EACH CELL PRIOR TO BACKFILL. A GEOSYNTHETIC CLAY LINER (GCL) WILL BE USED.
9. THE SOIL BLENDING AND HANDLING BUILDING WILL BE VENTILATED THROUGH GRANULAR ACTIVATED CARBON (GAC).
10. SEE DWG 500-C-103 FOR DEWATERING WELL PIPING

FACILITY	SIZING: LENGTH	WIDTH	HEIGHT	DIAMETER	AREA	VOLUME	UNIT	COMPONENTS
TREATED SOILS AWAITING ANALYSIS	124	110						ASPHALT PAD. 2X HIGH ECOLOGY BLOCKS FOR CONTAINMENT.
TREATED SOILS STOCKPILE	570	100	14			17706	cy	ASPHALT PAD. 3X HIGH ECOLOGY BLOCKS. MAX 1:1 SIDESLOPES
SOIL BLENDING AND HANDLING	300	100						ASPHALT PAD. 2X HIGH ECOLOGY BLOCKS. SPRUNG BUILDING.
NEW SHEET PILE WALLS					189,255			FROM GROUND SURFACE TO 2' BELOW AQUITARD LAYER. QTO=QUANTITY TAKE OFF
MTTD	110	100						ASPHALT PAD.
DUST CONTROL TANK	40	10						12 FT X 50 FT FRACTIONATION TANK ON GRAVEL PAD
DIESEL TANK	40	10						40 FT X 8 FT ISO TANK DOUBLE CONTAINED ON ASPHALT CONTAINMENT SLAB WITH SUMP AND CURB
PROPANE STORAGE	75	30		11		30,000	gal	2X 10FTX52FT CONC SLABS. 30 BOLLARDS.
FRACTIONATION TANK	40	10	10			60,000	gal	2X TANKS WITH 30 FT X 50 FT CONTAINMENT SLAB
WATER SUPPLY SURGE TANK			4.3	20	314	10,000	gal	20,000 GALLON FRACTIONATION TANK ON GRAVEL PAD
AIR HANDLING/GAC	20	12	15					GRAVEL SURFACING
DECON PAD WITH PWRD WHEEL WASH	40	16						PREFABRICATED MODULAR UNIT WITH POWERED WHEEL WASH AND PRESSURE WASH, CONCRETE PAD AND COLLECTION SUMP. PERIMETER CURBS, SPRAY CURTAINS. HEAVY LOAD RATING.
750 KW GENSET	20	8	11					MODULAR. AC PAVEMENT SECONDARY CONTAINMENT PAD. OPERATES MTTD AND SOIL BLENDING AND HANDLING BUILDING.
20-50 KW GENSETS AT MULTIPLE LOCATIONS TO SUPPORT DEWATERING WELLS, DECON PAD, AND OTHER INFRASTRUCTURE	12	5	5					MODULAR. GRAVEL SURFACING WITH SECONDARY CONTAINMENT
FUEL CELL	40	8	10					GRAVEL SURFACING.
SUMP PUMP/STATION								PRE-FAB 6 FT DIAMETER PUMP STATION CONNECTED TO DRAIN MANHOLE

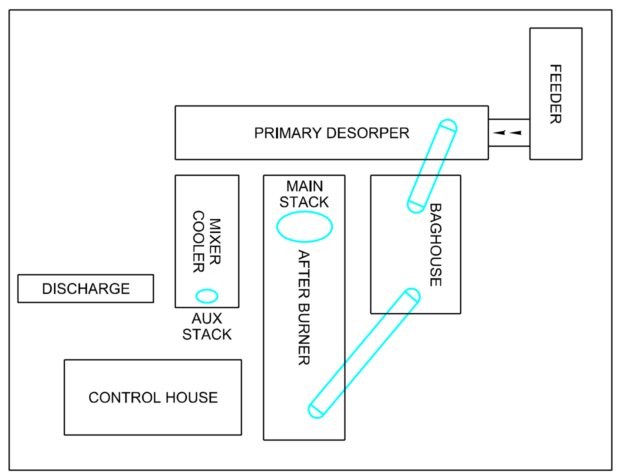
NOTES:
1. ALL DIMENSIONS LENGTH IN FT, AREA SQ FT UNLESS INDICATED OTHERWISE
2. SEE COST SPREADSHEETS FOR DETAILS.

KEYNOTES

1. EXCAVATE CORE AREAS TO 20 FT BELOW EXISTING GROUND AND TREAT WITH MTTD. AFTER THE CORE AREA IS BACKFILLED TREAT WITH THERMAL ENHANCEMENT.
2. AREAS RECEIVE THERMAL ENHANCED EXTRACTION.
3. STORAGE TANK FOR QUENCH WATER SUPPLIED BY EXISTING WELL SUPPLY.
4. PUMP STATIONS FOR DRAINAGE FROM TREATED SOIL STOCKPILE.
5. SOUTH TREATMENT BOUNDARY.
6. AREA RECEIVES NAPL EXTRACTION AND BIOSPARGING ONLY.
7. POLYGON 152. EXCAVATE SOIL TO A DEPTH OF 7 FT AND TREAT.
8. AREAS CAN BE USED FOR STAGING TREATED SOILS (INCLUDING TREATED SOILS AWAITING ANALYSIS) AND SOILS THAT DO NOT REQUIRE MTTD PENDING ANALYSIS.
9. CONSTRUCT STORMWATER INFILTRATION AREA AFTER EXCAVATION OF POLYGON 152. APPROX. 540 FT X 40 FT WITH 7FT PEA GRAVEL.

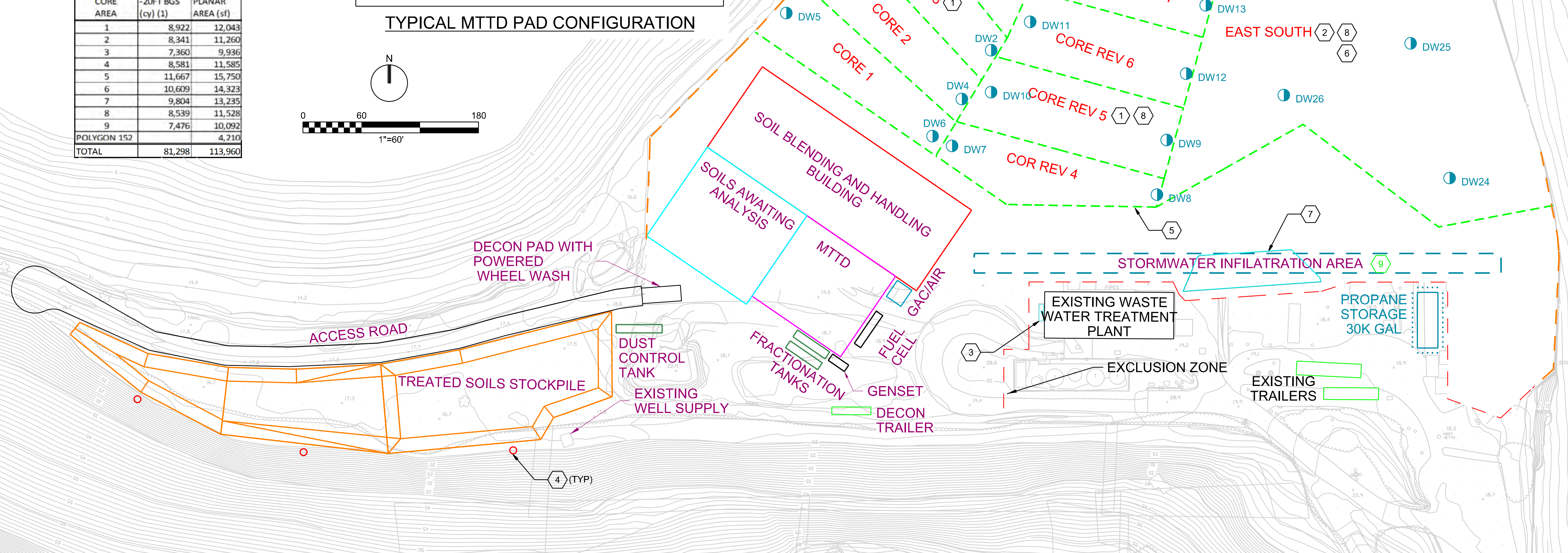
LEGEND

- APPROXIMATE BOUNDARY EXISTING/REFURBISHED SHEET PILE WALL
- NEW SHEET PILE WALL
- DW22 DEWATER WELL



TYPICAL MTTD PAD CONFIGURATION

TABLE 2		
CORE AREA	VOLUME TO -20FT BGS (cy) (1)	TOP PLANAR AREA (sf)
1	8,922	12,043
2	8,341	11,260
3	7,360	9,936
4	8,581	11,585
5	11,667	15,750
6	10,609	14,323
7	9,804	13,235
8	8,539	11,528
9	7,476	10,092
POLYGON 152		4,210
TOTAL	81,298	113,960



FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 6 MTTD

OVERALL SITE PLAN

1"=60 FT	
VERIFY SCALE	
BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"	
DATE	
PROJ	438527
DWG	500-C-100
SHEET	of

NO.	DATE	REVISION	BY	APVD

DSGN AR | DR AR | CHK BCT | APVD AR

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

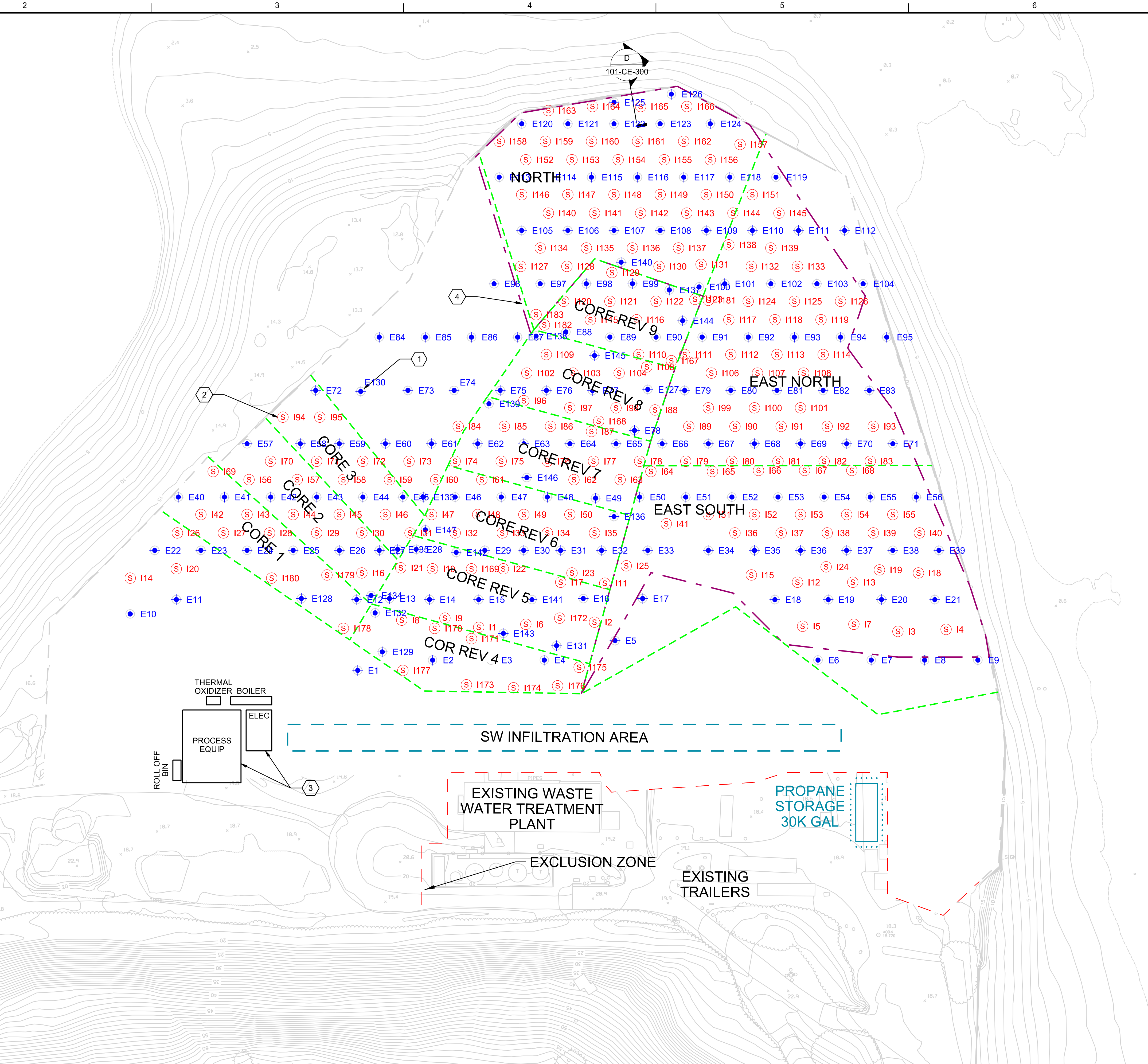
1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. EXTRACTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
2. STEAM INJECTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
3. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101.
4. INSTALL VAPOR COVER BEFORE DRILLING WELLS. BOOT AROUND WELL TO PROVIDE AIRTIGHT SEAL. SEE DWG 200-C-301 FOR DETAILS.

LEGEND

- EXISTING SHEET PILE WALL
- VAPOR COVER LIMITS
- SHEET PILE WALLS
- E130 EXTRACTION WELL
- I42 STEAM INJECTION WELL
- DW3 DEWATER WELL



CH2MHILL®

ALTERNATIVE 6 THERMAL
SITE PLAN - NAPL EXTRACTION & COVER, THERMAL

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

NO.	DATE	REVISION	BY	APVD
DSGN	BS	DR	BCT	CHK	BS	APVD

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	500-C-101
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

GENERAL NOTES

1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLTION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. SEE DWG 200-C-301 FOR VAPOR COVER DETAILS.
2. VAPOR EXTRACTION WELLHEAD. 3" SCH 80 CPVC PERFORATED PIPE IN VAPOR LAYER OF VAPOR CAP. SEE DWG 200-C-301. ABOVE GROUND PIPE IS 1-$\frac{1}{2}$" CPVC CONNECTED TO VAPOR EXTRACTION HEADER.
3. AIR INJECTION WELLHEAD. 3" SCH 80 CPVC PERFORATED PIPE IN VAPOR LAYER OF VAPOR CAP. SEE DWG 200-C-301. SUPPLY PIPE IS 1-$\frac{1}{2}$" CARBON STEEL.
4. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101

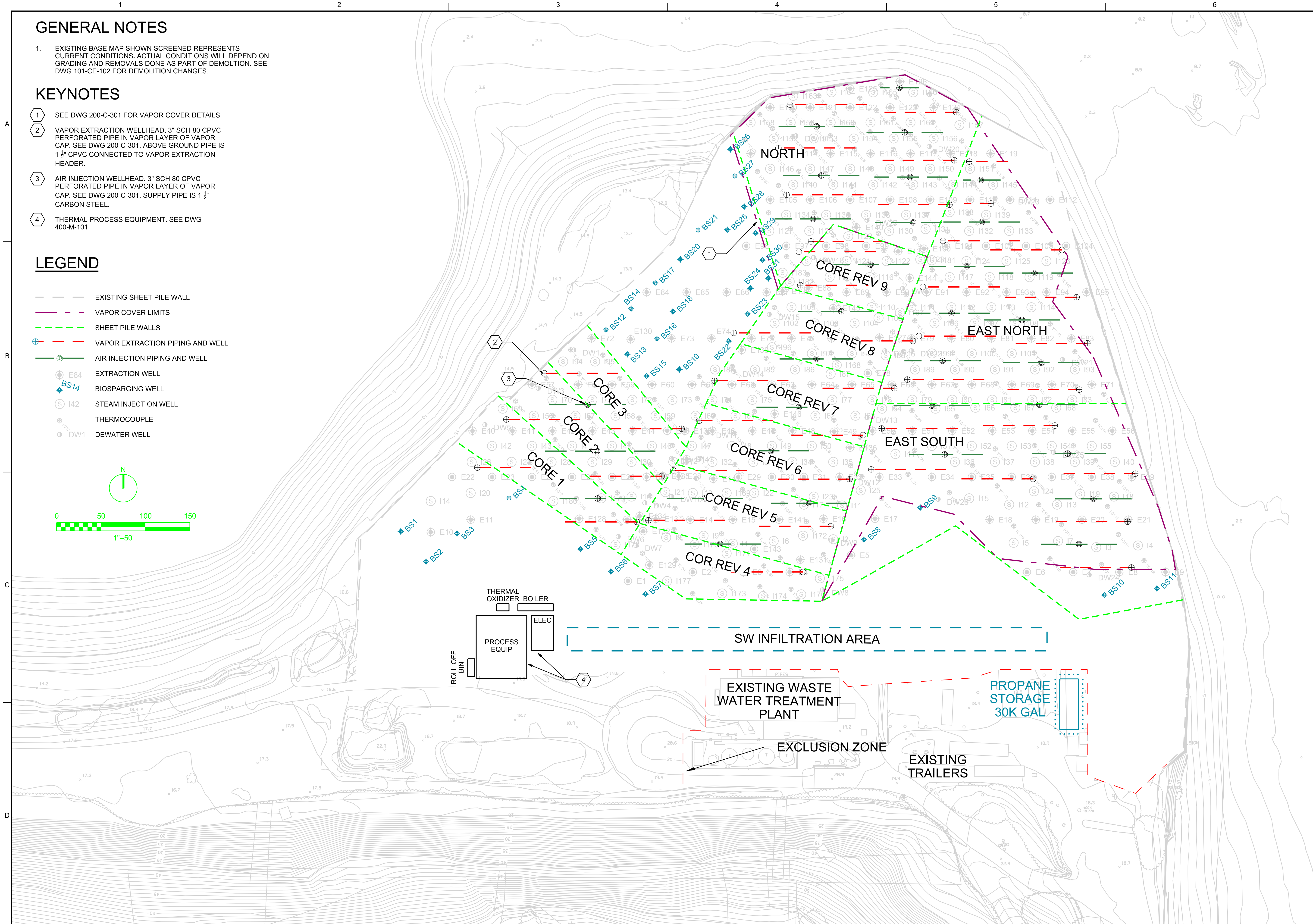
LEGEND

- EXISTING SHEET PILE WALL
- VAPOR COVER LIMITS
- SHEET PILE WALLS
- VAPOR EXTRACTION PIPING AND WELL
- AIR INJECTION PIPING AND WELL
- E84 EXTRACTION WELL
- BS14 BIOSPARGING WELL
- I42 STEAM INJECTION WELL
- THERMOCOUPLE
- DW1 DEWATER WELL

N

0 50 100 150

1"=50'



ALTERNATIVE 6 THERMAL

SITE PLAN

COVER, PIPING, BIOSPARGING, VAPOR REMOVAL AND AIR INJECTION

FOCUSED FEASIBILITY STUDY

WYCKOFF

EPA

CH2MHILL®

1"=50 FT	
VERIFY SCALE	
BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"	
DATE	
PROJ	438527
DWG	500-C-102
SHEET	of

NO.	DATE	REVISION	BY	APVD
DSGN BS	DR	CHK BCT	APVD BS	

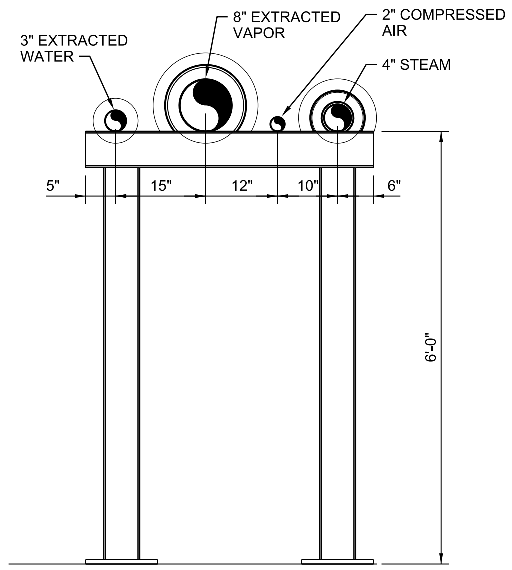
PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

LEGEND

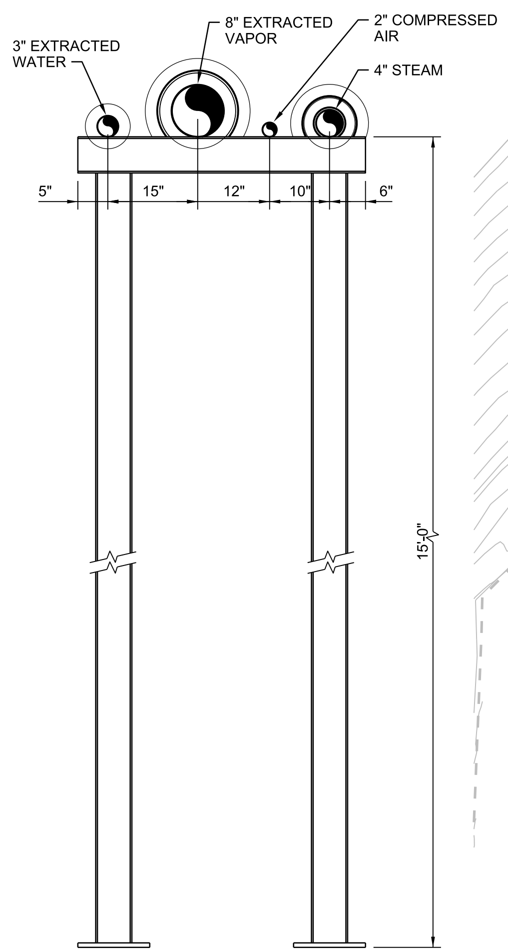
- – – – NON-ELEVATED PIPERACK
- ——— ELEVATED PIPERACK

NOTES:

1. IN GENERAL, THE DISTANCE BETWEEN THE NON-ELEVATED PIPERACKS IS SUFFICIENT SPACING TO ALLOW TRUCK TRAFFIC BETWEEN THE RACKS. DURING DETAILED DESIGN, SOME WELL LOCATIONS AND/ OR PIPE RACKS MAY BE MOVED TO ASSURE MAINTENANCE ACCESS TO WELLS.
2. ELEVATED PIPE RACKS WILL BE AT A HEIGHT AND WILL HAVE COLUMN SPACING TO ALLOW TRUCK TRAFFIC TO PASS UNDERNEATH THE PIPE RACK.
3. AIR INJECTION AND VAPOR EXTRACTION POINTS INTO THE VAPOR COVER ARE NOT SHOWN. LOCATIONS OF THESE WILL BE ADJUSTED AS NEEDED TO ASSURE ACCESS TO WELLS.
4. THERMOCOUPLE LOCATIONS ARE NOT SHOWN. THESE ARE AT GRADE AND WILL HAVE COVERS RATED FOR TRUCK TRAFFIC.
5. ELECTRICAL WIRING WILL BE ROUTED ON CABLE TRAYS LOCATED ABOVE PIPE RACKS.



A SECTION
3/4"=1'-0"



B SECTION
3/4"=1'-0"

PIPE RACK PLAN
1"=40'-0"

NO.	DATE	REVISION	BY	APVD

DSGN M. DAVIS | DR D SUNSERI | CHK | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 6
PIPING PLAN

1"=40 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	500-C-103
SHEET	of

GENERAL NOTES

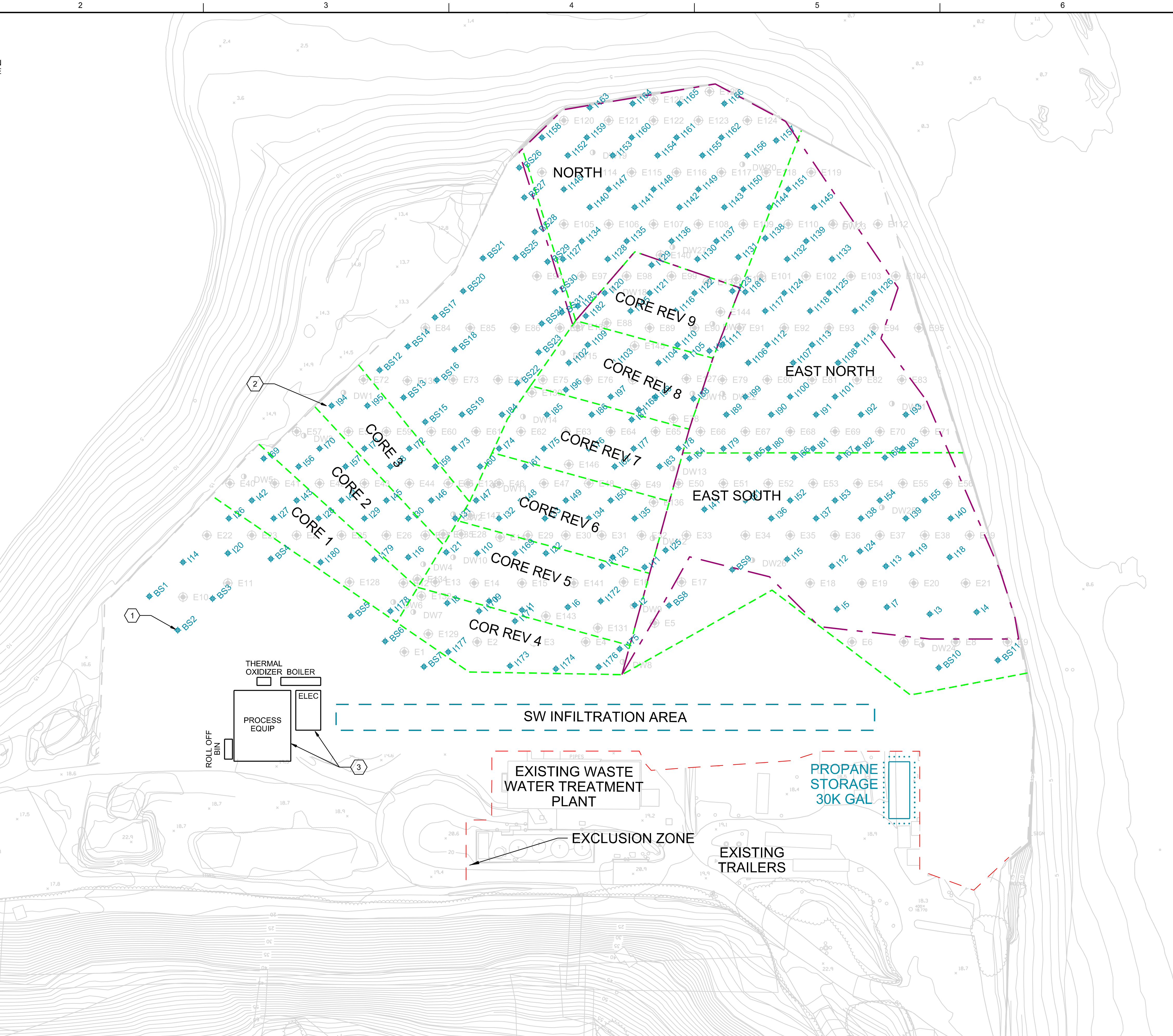
1. EXISTING BASE MAP SHOWN SCREENED REPRESENTS CURRENT CONDITIONS. ACTUAL CONDITIONS WILL DEPEND ON GRADING AND REMOVALS DONE AS PART OF DEMOLITION. SEE DWG 101-CE-102 FOR DEMOLITION CHANGES.

KEYNOTES

1. BIOSPARGING WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
2. BIOSPARGING WELLHEAD CONVERTED FROM STEAM INJECTION WELLHEAD. SEE DWG 400-C-500 FOR DETAILS.
3. THERMAL PROCESS EQUIPMENT. SEE DWG 400-M-101.

LEGEND

- EXISTING SHEET PILE WALL
- VAPOR COVER LIMITS
- SHEET PILE WALLS
- E130 EXTRACTION WELL
- BS5 BIOSPARGING WELL
- I43 BIOSPARGING WELL CONVERTED FROM STEAM INJECTION WELL
- DW1 DEWATER WELL



NO. | DATE | REVISION | BY | APVD

DSGN BS | DR BS | CHK BCT | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

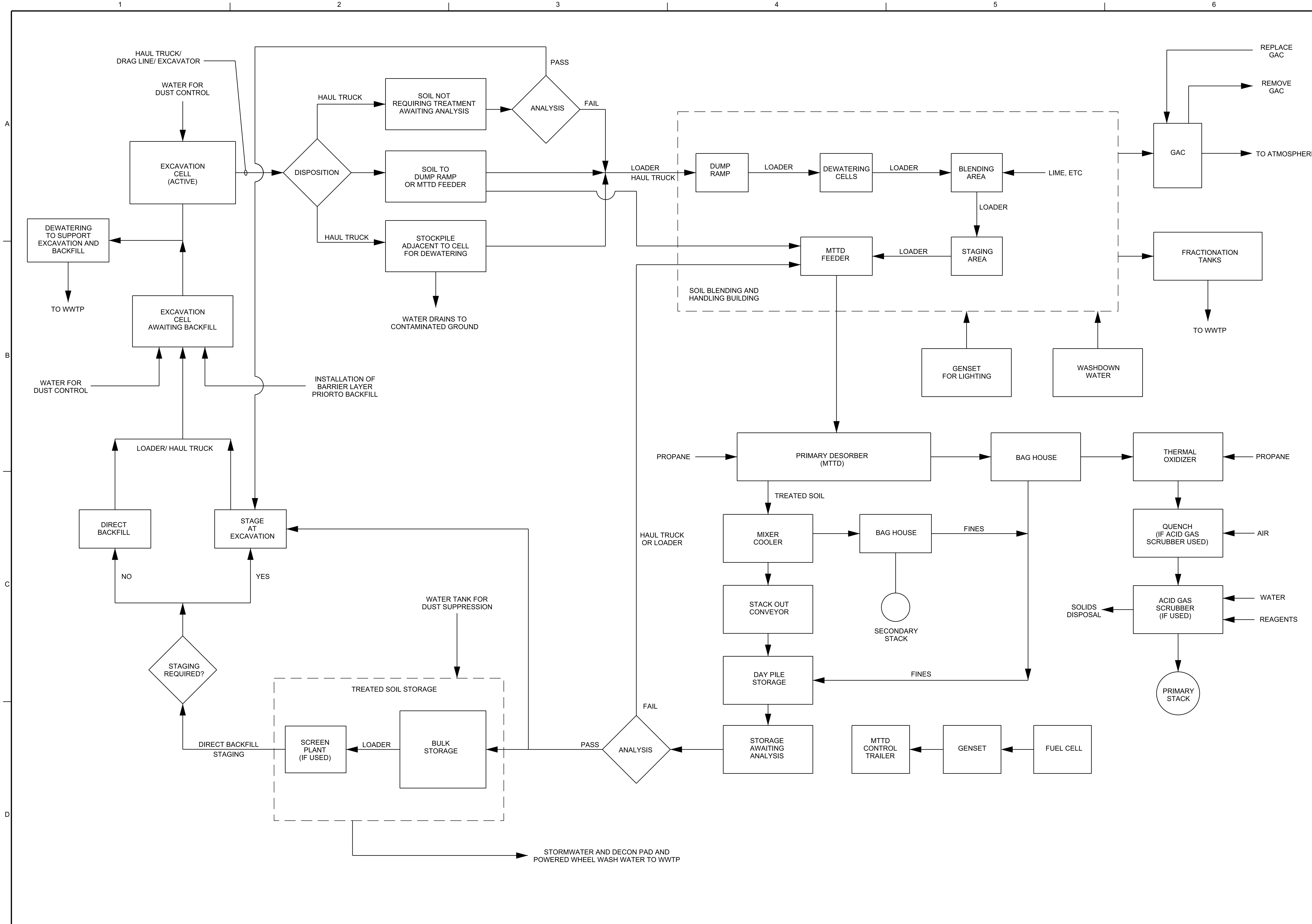
ALTERNATIVE 6 MTTD THERMAL
SITE PLAN - ENHANCED AEROBIC

1"=50 FT
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	500-C-104
SHEET	of

PLANNING PURPOSES ONLY. NOT FOR CONSTRUCTION

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL.



NO.	DATE	REVISION	BY	APVD

DSGN | DR G BURLEY | CHK | APVD

FOCUSED FEASIBILITY STUDY
WYCKOFF
EPA

CH2MHILL®

ALTERNATIVE 6 MTTD
PROCESS FLOW DIAGRAM

NTS
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	438527
DWG	500-C-600
SHEET	of

Appendix C
Common Element and Remedial Action Alternative Cost Estimates

TABLE C-1

Remedial Action Alternative Cost Estimate Comparison

Soil and Groundwater OUs - Former Process Area

Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington

		Alternative 2	Alternative 4	Alternative 4a	Alternative 5	Alternative 5a	Alternative 6	Alternative 7
Pre-construction Activities		$869,000	$869,000	$869,000	$869,000	$869,000	$869,000	$869,000
Access Roads		$288,000	$288,000	$288,000	$288,000	$288,000	$288,000	$288,000
Concrete Demo		N/A	$2,195,000	$2,195,000	$2,195,000	$2,195,000	$2,195,000	$2,195,000
Debris Removal-Sitewide		N/A	$3,194,000	$3,194,000	$3,194,000	$3,194,000	$3,194,000	$1,127,000
Bulkhead Removal		$8,762,000	$8,762,000	$8,762,000	$8,762,000	$8,762,000	$8,762,000	$8,762,000
Other Demo		$1,271,000	$2,993,000	$2,993,000	$2,993,000	$2,993,000	$2,993,000	$2,993,000
Storm Water Infiltration Trench		N/A	$214,000	$214,000	$214,000	$214,000	$214,000	$214,000
Sheet Pile Wall		$13,287,000	N/A	N/A	$13,287,000	$13,287,000	$13,287,000	$0
Concrete Perimeter Wall		$11,176,000	$7,931,000	$7,931,000	$11,176,000	$11,176,000	$11,176,000	$7,931,020
Outfall		$3,293,000	$3,293,000	$3,293,000	$3,293,000	$3,293,000	$3,293,000	$3,293,000
Passive Drainage		N/A	$1,303,000	$1,303,000	$1,129,000	$1,129,000	$1,129,000	$1,129,275
Site Cap		$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000	$4,100,000
	COMMON ELEMENTS SUBTOTALS:	***$43,046,000***	***$35,142,000***	***$35,142,000***	***$51,500,000***	***$51,500,000***	***$51,500,000***	***$32,901,295***
REMEDIAL TECHNOLOGIES								
Alternative 2 - Hydraulic Containment		$1,560,000						
Alternative 4 - ISS Treatment			$50,069,000	$57,457,000				
Alternative 5 - Thermal + Jet Grouting North Unit					$41,046,000	$41,046,000		
Alternative 6 - Thermal + MTTD							$99,917,000	
Alternative 7 - ISS Core + Thermal								$30,696,000
	REMEDIAL TECHNOLOGY SUBTOTALS:	***$1,560,000***	***$50,069,000***	***$57,457,000***	***$41,046,000***	***$41,046,000***	***$99,917,000***	***$30,696,000***
WTP O&M Costs								
WTP Operations		$50,985,000	$2,364,000	$4,728,000	$7,092,000	$9,456,000	$7,880,000	$8,668,000
100-yr O&M and Periodic Costs (non-discounted)								
Replace WTP Equipment/Piping		$600,000	$0	$0	$0	$0	$0	$0
Replace WTP Electrical/Mechanical		$12,000,000	$0	$0	$0	$0	$0	$0
Maintain Onsite Roads		$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000
Passive Treatment System Operations		$0	$2,664,000	$2,664,000	$5,396,000	$5,396,000	$5,396,000	$2,840,000
EAB		$0	$0	$0	$1,128,000	$1,128,000	$940,000	$1,504,000
NAPL Recovery		$0	$0	$0	$2,562,000	$2,562,000	$2,562,000	$0
Steam Enhancement		$0	$0	$0	$0	$0	$0	$8,064,000
Thermal Operations		$0	$0	$0	$37,455,000	$37,455,000	$37,760,000	$8,334,000
Well Abandonment		$0	$0	$0	$1,357,489	$1,357,489	$1,412,323	$1,357,489
5-yr Reviews		$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
GWTP Demolition		$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
Final Completion Report		$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
		$14,175,000	**$4,239,000**	**$4,239,000**	**$49,473,489**	**$49,473,489**	**$49,645,323**	**$23,674,489**
	50%	**$164,649,000**	**$137,721,000**	**$152,349,000**	**$223,666,500**	**$227,212,500**	**$313,413,000**	**$143,910,000**
Non-Discounted Cost (2014)		**$109,766,000**	**$91,814,000**	**$101,566,000**	**$149,111,000**	**$151,475,000**	**$208,942,000**	**$95,940,000**
	-30%	**$76,836,200**	**$64,270,000**	**$71,100,000**	**$104,380,000**	**$106,030,000**	**$146,260,000**	**$67,160,000**
	50%	**$105,885,000**	**$129,465,000**	**$137,145,000**	**$201,165,000**	**$196,215,000**	**$278,535,000**	**$127,725,000**
Present Worth Cost		**$70,590,000**	**$86,310,000**	**$91,430,000**	**$134,110,000**	**$130,810,000**	**$185,690,000**	**$85,150,000**
	-30%	**$49,413,000**	**$60,417,000**	**$64,001,000**	**$93,877,000**	**$91,567,000**	**$129,983,000**	**$59,605,000**

DRAFT

TABLE C-2
Alternatives Estimated Annual Summary

Year	Alternative 2- Containment	Alternative 4 - ISS	Alternative 4a - ISS with $15 million/Yr Cap	Alternative 5 - Thermal Enhanced Extraction and ISS	Alternative 5a - Thermal Enhanced Extraction and ISS with $15 million/Yr Cap	Alternative 6 - Excavation, Thermal Desoprtion, and Thermal Enhanced Extraction	Alternative 7 - ISS of Core Area and Thermal Enhanced Extraction for Remaining Target Zones
0	$0	$0	$0	$0	$0	$0	$0
1	$0	$0	$0	$0	$0	$0	$0
2	$22,881,000	$19,303,000	$10,541,000	$25,391,000	$10,541,000	$19,303,000	$17,236,000
3	$17,115,000	$34,146,000	$12,863,000	$28,564,000	$15,658,000	$17,388,000	$19,948,000
4	$6,175,000	$34,146,000	$10,277,958	$35,746,000	$14,075,000	$60,580,000	$15,637,000
5	$515,000	$333,000	$16,799,257	$1,642,000	$15,257,000	$40,913,000	$5,008,000
6	$515,000	$333,000	$16,503,899	$9,133,000	$12,440,667	$1,642,000	$5,008,000
7	$515,000	$333,000	$17,027,565	$9,321,000	$12,440,667	$9,194,000	$2,365,000
8	$535,000	$353,000	$13,687,000	$8,487,000	$13,314,667	$9,402,000	$2,385,000
9	$515,000	$333,000	$333,000	$8,467,000	$9,133,000	$8,528,000	$2,365,000
10	$515,000	$333,000	$333,000	$8,467,000	$9,321,000	$8,528,000	$2,365,000
11	$515,000	$1,333,000	$1,333,000	$2,958,489	$8,467,000	$9,657,000	$2,365,000
12	$515,000	$333,000	$333,000	$4,572,000	$8,467,000	$472,000	$3,494,275
13	$535,000	$20,000	$353,000	$304,000	$10,973,489	$304,000	$9,592,509
14	$515,000	$0	$333,000	$284,000	$472,000	$16,972,323	$4,384,000
15	$515,000	$0	$333,000	$284,000	$4,572,000	$284,000	$284,000
16	$515,000	$0	$0	$284,000	$284,000	$284,000	$284,000
17	$515,000	$0	$0	$1,284,000	$1,284,000	$284,000	$1,284,000
18	$535,000	$20,000	$20,000	$304,000	$304,000	$304,000	$304,000
19	$515,000	$0	$0	$284,000	$284,000	$284,000	$284,000
20	$515,000	$0	$0	$284,000	$284,000	$1,284,000	$284,000
21	$515,000	$0	$0	$284,000	$284,000	$284,000	$284,000
22	$515,000	$0	$0	$284,000	$284,000	$284,000	$284,000
23	$535,000	$20,000	$20,000	$304,000	$304,000	$284,000	$20,000
24	$515,000	$0	$0	$284,000	$284,000	$304,000	$0
25	$4,225,000	$25,000	$25,000	$309,000	$309,000	$309,000	$25,000

TABLE C-3
Cost Estmate for Alternative 2

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
GENERAL SITE ACTIVITIES					
Pre-construction Activites - Common Elements (2016)					
Permitting	1	LS	$21,000	$21,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$117,000	$117,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$50,000	$50,000	
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$552,000	$33,120	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$552,000	$44,160	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$552,000	$66,240	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$695,520	$173,880	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$869,000**	
Access Roads (2016)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$3	$4,133	
Project Management	8%		$173,533	$13,883	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$173,533	$17,353	USEPA 540-R-00-002 Guidence Document
Remedial Design	15%		$173,533	$26,030	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$230,798	$57,700	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$288,000**	
Rock/Soil/Bulkhead Removal (2016)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	
Crush Rock	16,857	CY	$10	$168,570	
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	
Project Management	5%		$5,890,725	$294,536	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$5,890,725	$353,444	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$5,890,725	$471,258	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$7,009,963	$1,752,491	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$8,762,000**	
Miscellaneous Demolition (2016)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$116,000	$116,000	HCSS Estimate
Odor Control	4	WK	$9,600	$38,400	Allowance
Level C PPE Upgrade	1	LS	$210,850	$210,850	
Project Management	6%		$806,950	$48,417	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$806,950	$64,556	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$806,950	$96,834	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$1,016,757	$254,189	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$1,271,000**	
Install New Perimeter SP Wall, Non ISS (2017)					
P/D AZ50 Sheet Pile	3,700	TN	$1,900	$7,030,000	Vendor Quote
Unload Sheet Pile	169	LD	$2,000	$338,000	
Install Perimeter SP Wall (AZ50)	142,200	SF	$11	$1,564,200	

TABLE C-3
Cost Estmate for Alternative 2

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Project Management	5%		$8,932,200	$446,610	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$8,932,200	$535,932	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$8,932,200	$714,576	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$10,629,318	$2,657,330	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$13,287,000**	
Non-ISS Concrete Perimeter Wall (2016)					
Excavation - Non-ISS Perimeter Wall	14,646	CY	$62	$908,052	
Install Concrete Plug	1,475	CY	$220	$324,500	
Odor Control	8	WK	$9,600	$76,800	Allowance
P/D/I Rebar	1,100	TN	$3,000	$3,300,000	
P/D/I Concrete	13,201	CY	$220	$2,904,220	
Project Management	5%		$7,513,572	$375,679	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$7,513,572	$450,814	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$7,513,572	$601,086	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$8,941,151	$2,235,287.67	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$11,176,000**	
Construct Outfall (2017)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	3,500 sf @ 51.8 lbs/ton
Unload Sheet Pile	5	LD	$2,000	$10,000	
Install Sheet Pile	3,500	SF	$10	$35,000	
Dewatering	20	DY	$800	$16,000	
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	
Project Management	5%		$2,214,036	$110,702	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,214,036	$132,842	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,214,036	$177,123	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,634,703	$658,676	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,293,000**	
Final Site Cap (2018)					
Subgrade Preparation	39,150	SY	$3	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$7	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900	$63,800	HCSS Estimate
Restoration	13	AC	$3,200	$41,600	Engineer's Estimate
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$4,100,000**	
REMEDIAL ACTION ALTERNATIVE					
Alternative 2 - Hydraulic Containment (Midpoint = 2018)					
Pre-construction Activities					
Precon Submittals - Driller	1	LS	$25,000	$25,000	
Mob/Demob - Driller	1	LS	$5,000	$5,000	
Site Preparation	1	LS	$50,000	$50,000	Setup equip/mat'l laydown areas; erosion controls
Survey	15	Day	$2,900	$43,500	
			Subtotal:	**$123,500**	
Extraction System Installation					
Install New Extraction Wells	4	ea	$20,000	$80,000	Vendor Quote
Refurbish Existing Wells	9	ea	$2,300	$20,700	Vendor Quote
Well Surface Completions	4	ea	$1,800	$7,200	Vendor Quote
Install New Well Pumps	6	ea	$56,000	$336,000	Vendor Quote - Incl. valves, piping, flowmeter,

TABLE C-3
Cost Estmate for Alternative 2

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Wellhead Infrastructure	6	ea	$10,000	$60,000	12'x8'x1' Vault, w/ sump
Trenching Excavation	350	cy	$15	$5,250	1.5' x 3' x 2100' trench
3" FRP Piping	2,100	LF	$22	$46,200	
FRP Valves, Fittings, Insulation	1	ls	$11,550	$11,550	Allowance: 25% of piping cost
Purchase/Deliver Bedding Sand	260	tn	$15	$3,900	6" below and 6" above pipe ==> 15"
Trench Backfill - sand/spoils	350	cy	$30	$10,500	6' lifts, by hand
I&C	4	ea	$5,000	$20,000	Allowance
Electrical (Power and I&C)	1	ls	$100,800	$100,800	Allowance: 30% of installed pump cost
GWTP Modifications	1	ls	$50,000	$50,000	Allowance for GWTP I&C modifications
			Subtotal:	**$752,100**	
Stormwater System					
P/D/I 5' dia x 10' deep	2	ea	$7,500	$15,000	RSMeans 33 49 13
Drainage Ditch	1,100	lf	$5	$5,500	Southern edge only
Trenching Excavation	150	cy	$15	$2,250	4'x2'x400' trench
P/D/I Stormwater Piping	400	lf	$22	$8,800	RSMeans 33 41 13.50
Trench Backfill - sand/spoils	130	cy	$30	$3,900	6' lifts, by hand
			Subtotal:	**$35,450**	
PROJECT MANAGEMENT	6%		$911,050	$54,663	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	8%		$911,050	$72,884	Based on EPA 540-R-00-002
REMEDIAL DESIGN	12%		$911,050	$109,326	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$336,873**	
CONTINGENCY (10% scope + 15% bid)	25%		$1,247,923	$311,981	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS				**$1,560,000**	

OPERATION & MAINTENANCE COSTS

OPERATION & MAINTENANCE COSTS OF GWTP

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Operator(s)	3,120	hr	$80	$249,600	1.5 FTEs Operating GWTP
Electrical Usage	1	ls	$15,000	$15,000	Based on current Usage
Waste Disposal	1	ls	$25,000	$25,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$11,000	$11,000	Allowance
Maintenance	10%		$300,600	$30,060	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Undefined Scope Allowance	10%		$420,660	$42,066	
PROJECT MANAGEMENT	6%		$462,726	$27,764	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL O&M COSTS OF GWTP				**$515,000**	

PERIODIC COSTS

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Maintain Onsite Roads	1	ls	$25,000	$25,000	Allowance - regrade/repair onsite roads
Replace GWTP Piping/Equipment	1	ls	$200,000	$200,000	Allowance: Every 25 years
Replace GWTP Mechical/Electrical	1	ls	$4,000,000	$4,000,000	Allowance: Every 25 years
GWTP Demolition	1	ls	$1,000,000	$1,000,000	Allowance
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS

Base Year: 2014 — 1.9% Discount Rate — OMB - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value	
0	Annual O&M Costs	$0	1.00	$ -	2014
1	Annual O&M Costs	$0	0.98	$ -	2015
2	Capital Costs	$22,366,000	0.96	$ 21,539,715	2016
2	Annual O&M Costs	$515,000	0.96	$ 495,974	2016
3	Capital Costs	$16,580,000	0.95	$ 15,669,747	2017

TABLE C-3
Cost Estmate for Alternative 2

DRAFT

	Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)		NOTES	
3	Annual O&M Costs				$515,000	0.95	$ 486,726	2017
3	5 Year Review (2017)				$20,000	0.95	$ 18,902	2017
4	Capital Costs				$5,660,000	0.93	$ 5,249,521	2018
4	Annual O&M Costs				$515,000	0.93	$ 477,651	2018
5	Annual O&M Costs				$515,000	0.91	$ 468,745	2019
6	Annual O&M Costs				$515,000	0.89	$ 460,005	2020
7	Annual O&M Costs				$515,000	0.88	$ 451,427	2021
8	Annual O&M Costs				$515,000	0.86	$ 443,010	2022
8	5 Year Review (2022)				$20,000	0.86	$ 17,204	2022
9	Annual O&M Costs				$515,000	0.84	$ 434,750	2023
10	Annual O&M Costs				$515,000	0.83	$ 426,644	2024
11	Annual O&M Costs				$515,000	0.81	$ 418,689	2025
12	Annual O&M Costs				$515,000	0.80	$ 410,882	2026
13	Annual O&M Costs				$515,000	0.78	$ 403,221	2027
13	5 Year Review (2027)				$20,000	0.78	$ 15,659	2027
14	Annual O&M Costs				$515,000	0.77	$ 395,702	2028
15	Annual O&M Costs				$515,000	0.75	$ 388,324	2029
16	Annual O&M Costs				$515,000	0.74	$ 381,084	2030
17	Annual O&M Costs				$515,000	0.73	$ 373,978	2031
18	Annual O&M Costs				$515,000	0.71	$ 367,005	2032
18	5 Year Review (2032)				$20,000	0.71	$ 14,253	2032
19	Annual O&M Costs				$515,000	0.70	$ 360,162	2033
20	Annual O&M Costs				$515,000	0.69	$ 353,446	2034
21	Annual O&M Costs				$515,000	0.67	$ 346,856	2035
22	Annual O&M Costs				$515,000	0.66	$ 340,389	2036
23	Annual O&M Costs				$515,000	0.65	$ 334,042	2037
23	5 Year Review (2037)				$20,000	0.65	$ 12,973	2037
24	Annual O&M Costs				$515,000	0.64	$ 327,813	2038
25	Annual O&M Costs				$515,000	0.62	$ 321,701	2039
25	Maintain Onsite Roads				$25,000	0.62	$ 15,617	2039
25	Replace GWTP Piping/Equipment				$200,000	0.62	$ 124,932	2039
25	Replace GWTP Mechical/Electrical				$4,000,000	0.62	$ 2,498,650	2040
26	Annual O&M Costs				$515,000	0.61	$ 315,703	2040
27	Annual O&M Costs				$515,000	0.60	$ 309,816	2041
28	Annual O&M Costs				$515,000	0.59	$ 304,040	2042
28	5 Year Review (2042)				$20,000	0.59	$ 11,807	2042
29	Annual O&M Costs				$515,000	0.58	$ 298,371	2043
30	Annual O&M Costs				$515,000	0.57	$ 292,807	2044
31	Annual O&M Costs				$515,000	0.56	$ 287,348	2045
32	Annual O&M Costs				$515,000	0.55	$ 281,990	2046
33	Annual O&M Costs				$515,000	0.54	$ 276,732	2047
33	5 Year Review (2047)				$20,000	0.54	$ 10,747	2047
34	Annual O&M Costs				$515,000	0.53	$ 271,572	2048
35	Annual O&M Costs				$515,000	0.52	$ 266,508	2049
36	Annual O&M Costs				$515,000	0.51	$ 261,539	2050
37	Annual O&M Costs				$515,000	0.50	$ 256,663	2051
38	Annual O&M Costs				$515,000	0.49	$ 251,877	2052
38	5 Year Review (2052)				$20,000	0.49	$ 9,782	2052
39	Annual O&M Costs				$515,000	0.48	$ 247,180	2053
40	Annual O&M Costs				$515,000	0.47	$ 242,572	2054
41	Annual O&M Costs				$515,000	0.46	$ 238,049	2055
42	Annual O&M Costs				$515,000	0.45	$ 233,610	2056
43	Annual O&M Costs				$515,000	0.45	$ 229,254	2057
43	5 Year Review (2057)				$20,000	0.45	$ 8,903	2057
44	Annual O&M Costs				$515,000	0.44	$ 224,980	2058
45	Annual O&M Costs				$515,000	0.43	$ 220,785	2059
46	Annual O&M Costs				$515,000	0.42	$ 216,668	2060
47	Annual O&M Costs				$515,000	0.41	$ 212,628	2061
48	Annual O&M Costs				$515,000	0.41	$ 208,663	2062
48	5 Year Review (2062)				$20,000	0.41	$ 8,103	2062
49	Annual O&M Costs				$515,000	0.40	$ 204,773	2063
50	Annual O&M Costs				$515,000	0.39	$ 200,955	2064
50	Replace GWTP Piping/Equipment				$200,000	0.39	$ 78,041	2064
50	Replace GWTP Mechical/Electrical				$4,000,000	0.39	$ 1,560,813	2064
51	Annual O&M Costs				$515,000	0.38	$ 197,208	2065
52	Annual O&M Costs				$515,000	0.38	$ 193,531	2066
53	Annual O&M Costs				$515,000	0.37	$ 189,922	2067
53	5 Year Review (2067)				$20,000	0.37	$ 7,376	2067
54	Annual O&M Costs				$515,000	0.36	$ 186,381	2068
55	Annual O&M Costs				$515,000	0.36	$ 182,906	2069
56	Annual O&M Costs				$515,000	0.35	$ 179,495	2070
57	Annual O&M Costs				$515,000	0.34	$ 176,148	2071
58	Annual O&M Costs				$515,000	0.34	$ 172,864	2072

TABLE C-3
Cost Estmate for Alternative 2

DRAFT

Item Description		Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES			
58	5 Year Review (2072)				$20,000	0.34	$	6,713	2072
59	Annual O&M Costs				$515,000	0.33	$	169,641	2073
60	Annual O&M Costs				$515,000	0.32	$	166,478	2074
61	Annual O&M Costs				$515,000	0.32	$	163,374	2075
62	Annual O&M Costs				$515,000	0.31	$	160,327	2076
63	Annual O&M Costs				$515,000	0.31	$	157,338	2077
63	5 Year Review (2077)				$20,000	0.31	$	6,110	2077
64	Annual O&M Costs				$515,000	0.30	$	154,404	2078
65	Annual O&M Costs				$515,000	0.29	$	151,525	2079
66	Annual O&M Costs				$515,000	0.29	$	148,700	2080
67	Annual O&M Costs				$515,000	0.28	$	145,927	2081
68	Annual O&M Costs				$515,000	0.28	$	143,206	2082
68	5 Year Review (2082)				$20,000	0.28	$	5,561	2082
69	Annual O&M Costs				$515,000	0.27	$	140,536	2083
70	Annual O&M Costs				$515,000	0.27	$	137,916	2084
71	Annual O&M Costs				$515,000	0.26	$	135,344	2085
72	Annual O&M Costs				$515,000	0.26	$	132,821	2086
73	Annual O&M Costs				$515,000	0.25	$	130,344	2087
73	5 Year Review (2087)				$20,000	0.25	$	5,062	2087
74	Annual O&M Costs				$515,000	0.25	$	127,914	2088
75	Annual O&M Costs				$515,000	0.24	$	125,529	2089
75	Replace GWTP Piping/Equipment				$200,000	0.24	$	48,749	2091
75	Replace GWTP Mechical/Electrical				$4,000,000	0.24	$	974,981	2091
76	Annual O&M Costs				$515,000	0.24	$	123,188	2090
77	Annual O&M Costs				$515,000	0.23	$	120,891	2091
78	Annual O&M Costs				$515,000	0.23	$	118,637	2092
78	5 Year Review (2092)				$20,000	0.23	$	4,607	2092
79	Annual O&M Costs				$515,000	0.23	$	116,425	2093
80	Annual O&M Costs				$515,000	0.22	$	114,254	2094
81	Annual O&M Costs				$515,000	0.22	$	112,124	2095
82	Annual O&M Costs				$515,000	0.21	$	110,033	2096
83	Annual O&M Costs				$515,000	0.21	$	107,982	2097
83	5 Year Review (2097)				$20,000	0.21	$	4,193	2097
84	Annual O&M Costs				$515,000	0.21	$	105,968	2098
85	Annual O&M Costs				$515,000	0.20	$	103,992	2099
86	Annual O&M Costs				$515,000	0.20	$	102,053	2100
87	Annual O&M Costs				$515,000	0.19	$	100,151	2101
88	Annual O&M Costs				$515,000	0.19	$	98,283	2102
88	5 Year Review (2102)				$20,000	0.19	$	3,817	2102
89	Annual O&M Costs				$515,000	0.19	$	96,451	2103
90	Annual O&M Costs				$515,000	0.18	$	94,652	2104
91	Annual O&M Costs				$515,000	0.18	$	92,887	2105
92	Annual O&M Costs				$515,000	0.18	$	91,155	2106
93	Annual O&M Costs				$515,000	0.17	$	89,456	2107
93	5 Year Review (2107)				$20,000	0.17	$	3,474	2107
94	Annual O&M Costs				$515,000	0.17	$	87,788	2108
95	Annual O&M Costs				$515,000	0.17	$	86,151	2109
96	Annual O&M Costs				$515,000	0.16	$	84,545	2110
97	Annual O&M Costs				$515,000	0.16	$	82,968	2111
98	Annual O&M Costs				$515,000	0.16	$	81,421	2112
98	5 Year Review (2112)				$20,000	0.16	$	3,162	2112
99	Annual O&M Costs				$515,000	0.16	$	79,903	2113
100	Annual O&M Costs				$515,000	0.15	$	78,413	2114
100	GWTP Demolition				$1,000,000	0.15	$	152,259	2114
100	Final Completion Report				$150,000	0.15	$	22,839	2114
TOTAL VALUE ANALYSIS					**$109,770,000**			**$70,590,000**	

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%. It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

TABLE C-4a
Cost Estimate for Alternative 4

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
GENERAL SITE ACTIVITIES					
Pre-construction Activites - Common Elements (2016)					
Permitting	1	LS	$21,000	$21,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$117,000	$117,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$552,000	$33,120	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$552,000	$44,160	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$552,000	$66,240	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$695,520	$173,880	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$869,000**	
Access Roads (2016)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$3	$4,133	
Project Management	8%		$173,533	$13,883	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$173,533	$17,353	USEPA 540-R-00-002 Guidence Document
Remedial Design	15%		$173,533	$26,030	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$230,798	$57,700	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$288,000**	
Demolition - Concrete Structures (2016)					
Surface Decontamination	7,200	SY	$10	$72,000	
Concrete Demolition - Easy	2,010	CY	$40	$80,400	
Concrete Demolition - Difficult	6,020	CY	$70	$421,400	
Concrete Crushing	8,030	CY	$60	$481,800	
Spread Crushed Concrete Oniste	8,030	CY	$20	$160,600	
Recycle Rebar	650	TN	-$290.0	-$188,500	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$250,900	$250,900	Allowance
Project Management	6%		$1,393,800	$83,628	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$1,393,800	$111,504	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$1,393,800	$167,256	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$1,756,188	$439,047	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$2,195,000**	
Debris Removal - Site Wide (2016)					
Excavation/Debris Removal (5-ft)	66,578	CY	$10	$665,780	
Odor Control	12	WK	$9,600	$115,200	
Backfill - Site Wide	66,578	CY	$2	$133,156	
T&D Debris - Hazardous	900	TN	$1,000	$900,000	
Level C PPE Upgrade	1	LS	$332,890	$332,890	Allowance
Project Management	5%		$2,147,026	$107,351	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,147,026	$128,822	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,147,026	$171,762	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,554,961	$638,740	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,194,000**	
Rock/Soil/Bulkhead Removal (2016)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	$0.30/lb incineration + haul to SLC
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	$0.30/lb incineration + haul to SLC
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	

TABLE C-4a
Cost Estimate for Alternative 4

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Crush Rock	16,857	CY	$10	$168,570	
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	Allowance
Project Management	5%		$5,890,725	$294,536	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$5,890,725	$353,444	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$5,890,725	$471,258	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$7,009,963	$1,752,491	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$8,762,000**	
Miscellaneous Demolition (2016)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose Pilot Plant SP	24,300	SF	$30	$729,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$116,000	$116,000	HCSS Estimate
Odor Control	4	WK	$9,600	$38,400	Allowance
Level C PPE Upgrade	1	LS	$575,350	$575,350	Allowance
Project Management	6%		$1,900,450	$114,027	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$1,900,450	$152,036	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$1,900,450	$228,054	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,394,567	$598,642	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$2,993,000**	
Storm Water Infiltration Trench (2016)					
Excavation	2,800	CY	$17	$47,600	
P/D Drain Gravel	4,536	TN	$24	$108,864	
Spread Drain Gravel	6,400	TN	$9	$57,600	
Project Management	8%		$214,064	$17,125	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$214,064	$21,406	USEPA 540-R-00-002 Guidence Document
Construction Management	15%		$214,064	$32,110	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$284,705	$71,176	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$214,000**	
Construct Outfall (2017)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	
Unload Sheet Pile	5	LD	$2,000	$10,000	
Install Sheet Pile	3,500	SF	$10	$35,000	
Dewatering	20	DY	$800	$16,000	
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	
Project Management	5%		$2,214,036	$110,702	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,214,036	$132,842	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,214,036	$177,123	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,634,703	$658,676	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,293,000**	
ISS Passive Drainage System (2018)					
MH Excavations, ISS PWT	1,500	CY	$37	$55,500	
P/D Treatment Manholes	15	EA	$24,000	$360,000	
Install Treatment MH	15	EA	$4,000	$60,000	
Install Contech GAC Storm Filters	1	LS	$15,000	$15,000	
Install Hydraulic Collection Wells	15	EA	$6,000	$90,000	
Install Discharge Lines	15	EA	$9,000	$135,000	
Backfill Manholes	1,500	CY	$30	$45,000	
Repair Cap	1,000	SY	$67	$67,000	
Project Management	6%		$827,500	$49,650	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$827,500	$66,200	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$827,500	$99,300	USEPA 540-R-00-002 Guidence Document

TABLE C-4a
Cost Estimate for Alternative 4

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Contingency (10% Scope+15% Bid)	25%		$1,042,650	$260,663	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$1,303,000**	
ISS Concrete Perimeter Wall (2017)					
Excavation - ISS Perimeter Wall	10,007	CY	$34	$340,238	
Install Concrete Plug	1,475	CY	$220	$324,500	
P/D/I Rebar	930	TN	$3,000	$2,790,000	
P/D/P Concrete	8,532	CY	$220	$1,877,040	
Project Management	5%		$5,331,778	$266,589	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$5,331,778	$319,907	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$5,331,778	$426,542	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$6,344,816	$1,586,204	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$7,931,000**	
Final Site Cap (2018)					
Subgrade Preparation	39,150	SY	$3.00	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$6.75	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2.25	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30.00	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60.00	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900.00	$63,800	HCSS Estimate
Restoration	13	AC	$3,200.00	$41,600	Engineer's Estimate
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$4,100,000**	
REMEDIAL ACTION ALTERNATIVE					
Alternative 4 - ISS (Midpoint = 2017)					
Pre-construction Activities (ISS Subcontractor)					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	Erosion Controls, Staging/Stockpile Areas
Survey (Throughout Project)	50	DY	$2,900	$145,000	
			Subtotal:	**$255,000**	
MOBILIZATION					
Equipment Costs (Transportation)					
ISS Crane	2	ea	$60,000	$120,000	Engineer's Estimate
Jet Grout Rig - Casa Grande C-7	1	ea	$25,000	$25,000	Engineer's Estimate
Drilling Attachment	2	ea	$38,000	$76,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$28,000	$28,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$3,200	$3,200	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$34,500	$34,500	Engineer's Estimate
Crane Mats	3	ea	$3,200	$9,600	Engineer's Estimate
Crew Truck	3	ea	$1,500	$4,500	Engineer's Estimate
Tool Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Project Trailer and Generator	2	ea	$4,000	$8,000	Engineer's Estimate
Forklift	1	ea	$2,000	$2,000	Engineer's Estimate
Manlift	1	ea	$2,000	$2,000	Engineer's Estimate
Excavator, CAT 336D	1	ea	$2,500	$2,500	Engineer's Estimate
Excavator, CAT 345D	1	ea	$2,500	$2,500	Engineer's Estimate
Loader, CAT 966H	1	ea	$2,000	$2,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	1	ea	$2,000	$2,000	Engineer's Estimate
Equipment Costs (4 week Mob)					
ISS Rig - Manitowoc/Attachment	4	wk	$21,100	$84,400	Engineer's Estimate
Jet Grout Rig	4	wk	$15,000	$60,000	Engineer's Estimate
Batch Plant and Silo(s)	4	wk	$3,900	$15,600	Engineer's Estimate
Grout Pumping System/Metering	4	wk	$3,000	$12,000	Engineer's Estimate
Hose, Connectors, Whip Checks	4	wk	$1,600	$6,400	Engineer's Estimate
Wash Down Tank	4	wk	$1,500	$6,000	Engineer's Estimate

TABLE C-4a
Cost Estimate for Alternative 4

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Drill Tools	4	wk	$2,500	$10,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	4	wk	$750	$3,000	Engineer's Estimate
Forklift, CAT 1255 12k#	4	wk	$3,500	$14,000	Engineer's Estimate
Manlift, 60-ft	4	wk	$2,000	$8,000	Engineer's Estimate
Excavator, CAT 336D	4	wk	$6,000	$24,000	Engineer's Estimate
Excavator, CAT 345D	4	wk	$7,100	$28,400	Engineer's Estimate
Loader, CAT 966H	4	wk	$4,000	$16,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	4	wk	$3,500	$14,000	Engineer's Estimate
Crew Truck	12	wk	$1,200	$14,400	Engineer's Estimate
Tool Truck	4	wk	$1,100	$4,400	Engineer's Estimate
Subcontractors					
Electrical	1	LS	$15,000	$15,000	Engineer's Estimate
Welders	1	LS	$25,000	$25,000	Engineer's Estimate
Personnel (based on 5-day week)					
Batch Plan Operator	4	wk	$7,475	$29,900	Engineer's Estimate
Crane Operator	8	wk	$6,175	$49,400	Engineer's Estimate
Equipment Operator	8	wk	$5,525	$44,200	Engineer's Estimate
Jet Grout Superintendent	4	wk	$6,500	$26,000	Engineer's Estimate
Jet Grout Operator	4	wk	$7,475	$29,900	Engineer's Estimate
ISS Attachment Operator	8	wk	$7,475	$59,800	Engineer's Estimate
Labor, Foreman	4	wk	$4,550	$18,200	Engineer's Estimate
Labor, General	8	wk	$3,900	$31,200	Engineer's Estimate
ISS Superintendent	4	wk	$6,500	$26,000	Engineer's Estimate
QA/QC Manager	8	wk	$8,125	$65,000	Engineer's Estimate
Safety Manager	4	wk	$8,125	$32,500	Engineer's Estimate
Miscellaneous					
Derrick/barge/tug, 2 days+tug+plus fuel	1	ls	$100,000	$100,000	Allowance
Mob/Demob Derrick/Barge/tug	1	ls	$100,000	$100,000	Allowance
Crane Mat Purchase	30	ls	$2,500	$75,000	Engineer's Estimate
Miscellaneous Tools and Supplies	1	ls	$12,500	$12,500	Engineer's Estimate
Per Diem	448	day	$129	$57,792	Standard Per Diem Rate = Washington
			Subtotal:	**$1,441,292**	
Install Monitoring Wells (2016)					
Mob/Demob	1	ls	$5,000	$5,000	Vendor Quote
Install MW - Alt 4	20	ea	$15,750	$315,000	70-ft bgs
Develop Wells - Alt 4	20	ea	$1,600	$32,000	Engineer's Estimate
			Subtotal:	**$352,000**	
SITE WIDE EXCAVATION (7-FT)					
Equipment					
Excavator, CAT345D	18	wk	$7,100	$127,800	Engineer's Estimate
Loader, CAT 966H	18	wk	$4,000	$72,000	Engineer's Estimate
Water Truck	4	wk	$2,500	$10,000	Engineer's Estimate
Crew Truck	18	wk	$1,200	$21,600	Engineer's Estimate
Personnel					
Equipment Operator	36	wk	$5,525	$198,900	Engineer's Estimate
Water Truck Driver	4	wk	$4,875	$19,500	Engineer's Estimate
Labor, Foreman	18	wk	$4,550	$81,900	Engineer's Estimate
Labor, General	36	wk	$3,900	$140,400	Engineer's Estimate
Miscellaneous					
Stockpile Management	52	wk	$350	$18,200	Engineer's Estimate
Per Diems	662	day	$129	$85,334	Standard Per Diem Rate = Washington
			Subtotal:	**$775,634**	
JET GROUTING NORTH UNIT					
Equipment					
Jet Grout Rig	31	wk	$15,000	$465,000	Engineer's Estimate
Hose, Connectors, Whip Checks	31	wk	$1,600	$49,600	Engineer's Estimate
Wash Down Tank	31	wk	$1,500	$46,500	Engineer's Estimate
Excavator, CAT 336D L	31	wk	$6,000	$186,000	Engineer's Estimate
Forklift, CAT 1255 12k#	31	wk	$3,500	$108,500	Engineer's Estimate
Crew Truck	31	wk	$1,200	$37,200	Engineer's Estimate
Batch Plant and Silo(s)	31	wk	$3,900	$120,900	Engineer's Estimate
Horizontal Storage Silo (Pig)	31	wk	$750	$23,250	Engineer's Estimate
Generator, 350 kW	31	wk	$5,000	$155,000	Engineer's Estimate
Generator Fuel	24,800	gal	$4	$99,200	Engineer's Estimate
Tool Truck	31	wk	$1,100	$34,100	Engineer's Estimate

TABLE C-4a
Cost Estimate for Alternative 4

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Personnel					
Jet Grout Operator	31	wk	$7,475	$231,725	Engineer's Estimate
Equipment Operator	31	wk	$5,525	$171,275	Engineer's Estimate
Batch Plan Operator	31	wk	$7,475	$231,725	Engineer's Estimate
Labor, Foreman	31	wk	$4,550	$141,050	Engineer's Estimate
Labor, General	31	wk	$3,900	$120,900	Engineer's Estimate
Jet Grout Superintendent	31	wk	$6,500	$201,500	Engineer's Estimate
QA/QC Manager	31	wk	$8,125	$251,875	Engineer's Estimate
Safety Manager	31	wk	$8,125	$251,875	Engineer's Estimate
Materials					
P/D Portland Cement	1,300	tn	$125	$162,500	Engineer's Estimate
P/D Bentonite	65	tn	$325	$21,125	Engineer's Estimate
Miscellaneous					
Per Diems	1,736	day	$129	$223,944	Standard Per Diem Rate = Washington
			Subtotal:	**$3,334,744**	
AUGER MIX ISS					
Equipment					
ISS Rig - Manitowoc/Attacment	160	wk	$21,100	$3,376,000	Engineer's Estimate
Batch Plant and Silo(s)	80	wk	$3,900	$312,000	Engineer's Estimate
Grout Pumping System/Metering	160	wk	$3,000	$480,000	Engineer's Estimate
Hose, Connectors, Whip Checks	160	wk	$1,600	$256,000	Engineer's Estimate
Wash Down Tank	80	wk	$1,500	$120,000	Engineer's Estimate
Drill Tools	160	wk	$2,500	$400,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	160	wk	$750	$120,000	Engineer's Estimate
Teeth replacement/Tooth Packets	160	wk	$750	$120,000	Engineer's Estimate
Forklift, CAT TL1255 12k#	80	wk	$3,500	$280,000	Engineer's Estimate
Manlift	80	wk	$2,000	$160,000	Engineer's Estimate
Excavator, CAT336D	80	wk	$6,000	$480,000	Engineer's Estimate
Excavator, CAT345D	80	wk	$7,100	$568,000	Engineer's Estimate
Generator, 350 kW	80	wk	$5,000	$400,000	Engineer's Estimate
Generator Fuel	64,000	gal	$4	$256,000	Engineer's Estimate
Crew Truck	240	wk	$1,200	$288,000	Engineer's Estimate
Tool Truck	80	wk	$1,100	$88,000	Engineer's Estimate
Subcontractors					
Electrical	1	ls	$15,000	$15,000	Engineer's Estimate
Welders	1	ls	$25,000	$25,000	Engineer's Estimate
Personnel					
Batch Plant Operator	80	wk	$7,475	$598,000	Engineer's Estimate
Crane Operator	160	wk	$6,175	$988,000	Engineer's Estimate
Equipment Operator	160	wk	$5,525	$884,000	Engineer's Estimate
ISS Attachment Operator	160	wk	$7,475	$1,196,000	Engineer's Estimate
Labor, Foreman	80	wk	$4,550	$364,000	Engineer's Estimate
Labor, General	160	wk	$3,900	$624,000	Engineer's Estimate
ISS Superintendent	80	wk	$6,500	$520,000	Engineer's Estimate
QA/QC Manager	160	wk	$8,125	$1,300,000	Engineer's Estimate
Safety Manager	80	wk	$8,125	$650,000	Engineer's Estimate
Materials					
P/D Portland Cement	58,170	tn	$125	$7,271,250	Engineer's Estimate
P/D Bentonite	2,705	tn	$325	$879,125	Engineer's Estimate
Miscellaneous					
Per Diems	7,840	day	$129	$1,011,360	Standard Per Diem Rate = Washington
			Subtotal:	**$24,029,735**	
EX-SITU SOIL MIXING AND PLACEMENT					
Equipment					
Excavator, CAT 336D	25	wk	$6,000	$150,000	Engineer's Estimate
Loader, CAT 966H	25	wk	$4,000	$100,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	25	wk	$3,500	$87,500	Engineer's Estimate
Water Truck	25	wk	$2,500	$62,500	Engineer's Estimate
Personnel					
Equipment Operator	50	wk	$5,525	$276,250	Engineer's Estimate
Water Truck Driver	25	wk	$4,875	$121,875	Engineer's Estimate
Labor, Foreman	25	wk	$4,550	$113,750	Engineer's Estimate
Labor, General	50	wk	$3,900	$195,000	Engineer's Estimate
Materials					

TABLE C-4a
Cost Estimate for Alternative 4

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
P/D Portland Cement	14,600	TN	$125	$1,825,000	Engineer's Estimate
P/D Bentonite	730	TN	$325	$237,250	Engineer's Estimate
Miscellaneous					
Per Diems	1,050	day	$129	$135,450	Standard Per Diem Rate = Washington
			Subtotal:	**$3,304,575**	
DEMOBILIZATION (5 days/week)					
Equipment Costs (Transportation)					
ISS Crane	2	ea	$30,000	$60,000	Engineer's Estimate
Jet Grout Rig - Casa Grande C-7	1	ea	$12,500	$12,500	Engineer's Estimate
Drilling Attachment	2	ea	$19,000	$38,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$14,000	$14,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$1,600	$1,600	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$17,250	$17,250	Engineer's Estimate
Crane Mats	3	ea	$1,600	$4,800	Engineer's Estimate
Crew Truck	3	ea	$750	$2,250	Engineer's Estimate
Tool Truck	1	ea	$750	$750	Engineer's Estimate
Project Trailer and Generator	2	ea	$2,000	$4,000	Engineer's Estimate
Forklift, CAT TL1255 12k#	1	ea	$1,000	$1,000	Engineer's Estimate
Manlift	1	ea	$1,000	$1,000	Engineer's Estimate
Excavator, CAT336D	1	ea	$1,250	$1,250	Engineer's Estimate
Excavator, CAT345D	1	ea	$1,250	$1,250	Engineer's Estimate
Loader, CAT 966H	1	ea	$1,000	$1,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	1	ea	$1,000	$1,000	Engineer's Estimate
Equipment Costs (2 week demob)					
ISS Rig - Manitowoc/Attachment	2	wk	$21,100	$42,200	Engineer's Estimate
Jet Grout Rig - CasaGrande C-7	2	wk	$15,000	$30,000	Engineer's Estimate
Batch Plant and Silo(s)	2	wk	$3,900	$7,800	Engineer's Estimate
Grout Pumping System/Metering	2	wk	$3,000	$6,000	Engineer's Estimate
Hose, Connectors, Whip Checks	2	wk	$1,600	$3,200	Engineer's Estimate
Wash Down Tank	2	wk	$1,500	$3,000	Engineer's Estimate
Drill Tools	2	wk	$2,500	$5,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	2	wk	$750	$1,500	Engineer's Estimate
Forklift, CAT TL1255 12k#	2	wk	$3,500	$7,000	Engineer's Estimate
Manlift	2	wk	$2,000	$4,000	Engineer's Estimate
Excavator, CAT 336D	2	wk	$6,000	$12,000	Engineer's Estimate
Excavator, CAT 345D	2	wk	$7,100	$14,200	Engineer's Estimate
Loader, CAT 966H	2	wk	$4,000	$8,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	2	wk	$3,500	$7,000	Engineer's Estimate
Generators (2, 350kW)	-	wk	$5,000	$0	Vendor Quote
Crew Trucks	6	wk	$1,200	$7,200	Engineer's Estimate
Tool Truck	2	wk	$1,100	$2,200	Engineer's Estimate
Personnel					
Batch Plan Operator	2	wk	$7,475	$14,950	Engineer's Estimate
Crane Operator	4	wk	$6,175	$24,700	Engineer's Estimate
Equipment Operator	4	wk	$5,525	$22,100	Engineer's Estimate
Jet Grout Superintendent	2	wk	$6,500	$13,000	Engineer's Estimate
Jet Grout Operator	2	wk	$7,475	$14,950	Engineer's Estimate
ISS Attachment Operator	4	wk	$7,475	$29,900	Engineer's Estimate
Labor, General	4	wk	$3,900	$15,600	Engineer's Estimate
Labor, Foreman	2	wk	$4,550	$9,100	Engineer's Estimate
ISS Superintendent	2	wk	$6,500	$13,000	Engineer's Estimate
QA/QC Manager	4	wk	$8,125	$32,500	Engineer's Estimate
Safety Manager	2	wk	$8,125	$16,250	Engineer's Estimate
Miscellaneous					
Derrick/barge/tug, 2 days+tug+plus fuel	1	ls	$50,000	$50,000	Allowance
Mob/Demob Derrick/Barge/tug	1	ls	$50,000	$50,000	Allowance
Per Diems	224	day	$129	$28,896	Standard Per Diem Rate = Washington
			Subtotal:	**$656,896**	
PROJECT MANAGEMENT	5%		$34,149,876	$1,707,494	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$34,149,876	$2,048,993	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$34,149,876	$2,048,993	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$5,905,479**	
CONTINGENCY (10% scope + 15% bid)	25%		$40,055,354	$10,013,838.58	Based on EPA 540-R-00-002

TABLE C-4a
Cost Estimate for Alternative 4

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
TOTAL CAPITAL COSTS FOR ISS				**$50,069,000**	
OPERATIONS & MAINTENANCE COSTS					
ANNUAL OPERATION & MAINTENANCE COSTS OF GWTP (through 2018)					
Operator(s)	4,160	hr	$80	$332,800	2 FTEs Operating GWTP
Electrical Usage	1	ls	$60,000	$60,000	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Waste Disposal	1	ls	$100,000	$100,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$20,000	$20,000	Allowance
Maintenance	10%		$512,800	$51,280	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Undefined Scope Allowance	10%		$654,080	$65,408	
PROJECT MANAGEMENT	6%		$719,488	$43,169	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS OF GWTP				**$788,000**	
OPERATION & MAINTENANCE COSTS OF PASSIVE TREATMENT SYSTEM (YR2019 thru YR2026)					
Operator(s)	1,040	hr	$80	$83,200	0.5 FTEs
Maintenance	10%		$83,200	$8,320	Allowance
GAC Filled Storm Filter Changeout	420	ea	$200	$84,000	Quarterly changeout/recycle
T&D of Spent GAC Filters	40	drum	$400	$16,000	1 drum/manhole/event
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Undefined Scope Allowance	10%		$84,000	$8,400	
PROJECT MANAGEMENT	8%		$289,920	$23,194	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	10%		$198,400	$19,840	Based on EPA 540-R-00-002
TOTAL O&M COSTS				**$333,000**	
PERIODIC COSTS					
Maintain Onsite Roads	1	ls	$25,000	$25,000	Allowance - regrade/repair onsite roads
GWTP Demolition	1	ls	$1,000,000	$1,000,000	Allowance
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS

Base Year: 2014 — 1.9% Discount Rate — OMB - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value
0	Annual O&M Costs	$0	1.00	$ -
1	Annual O&M Costs	$0	0.98	$ -
2	Capital Costs	$18,515,000	0.96	$ 17,830,986
2	Annual O&M Costs	$788,000	0.96	$ 758,888
3	Capital Costs	$61,293,000	0.95	$ 57,927,972
3	5-yr Review (2017)	$20,000	0.95	$ 18,902
3	Annual O&M Costs	$788,000	0.95	$ 744,738
4	Capital Costs	$5,403,000	0.93	$ 5,011,160
4	Annual O&M Costs	$788,000	0.93	$ 730,852
5	Annual O&M Costs	$333,000	0.91	$ 303,091
6	Annual O&M Costs	$333,000	0.89	$ 297,440
7	Annual O&M Costs	$333,000	0.88	$ 291,894

TABLE C-4a
Cost Estimate for Alternative 4

DRAFT

	Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)		NOTES
8	Annual O&M Costs				$333,000	0.86	$ 286,451
8	5 Year Review (2022)				$20,000	0.86	$ 17,204
9	Annual O&M Costs				$333,000	0.84	$ 281,110
10	Annual O&M Costs				$333,000	0.83	$ 275,869
11	GWTP Demolition				$1,000,000	0.81	$ 812,988
11	Annual O&M Costs				$333,000	0.81	$ 270,725
12	Annual O&M Costs				$333,000	0.80	$ 265,677
13	5 Year Review (2027)				$20,000	0.78	$ 15,659
18	5 Year Review (2032)				$20,000	0.71	$ 14,253
23	5 Year Review (2037)				$20,000	0.65	$ 12,973
25	Maintain Onsite Roads				$25,000	0.62	$ 15,617
28	5 Year Review (2042)				$20,000	0.59	$ 11,807
33	5 Year Review (2047)				$20,000	0.54	$ 10,747
38	5 Year Review (2052)				$20,000	0.49	$ 9,782
43	5 Year Review (2057)				$20,000	0.45	$ 8,903
48	5 Year Review (2062)				$20,000	0.41	$ 8,103
53	5 Year Review (2067)				$20,000	0.37	$ 7,376
58	5 Year Review (2072)				$20,000	0.34	$ 6,713
63	5 Year Review (2077)				$20,000	0.31	$ 6,110
68	5 Year Review (2082)				$20,000	0.28	$ 5,561
73	5 Year Review (2087)				$20,000	0.25	$ 5,062
78	5 Year Review (2092)				$20,000	0.23	$ 4,607
83	5 Year Review (2097)				$20,000	0.21	$ 4,193
88	5 Year Review (2102)				$20,000	0.19	$ 3,817
93	5 Year Review (2107)				$20,000	0.17	$ 3,474
98	5 Year Review (2112)				$20,000	0.16	$ 3,162
102	Final Completion Report (2116)				$150,000	0.15	$ 21,995
TOTAL VALUE ANALYSIS					**$91,814,000**		**$86,310,000**

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%. It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

TABLE C-4B
Cost Estimate for Alternative 4a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
GENERAL SITE ACTIVITIES					
Permitting	1	LS	$21,000	$21,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$117,000	$117,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$552,000	$33,120	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$552,000	$44,160	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$552,000	$66,240	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$695,520	$173,880	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$869,000**	
Access Roads (2016)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$3	$4,133	
Project Management	8%		$173,533	$13,883	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$173,533	$17,353	USEPA 540-R-00-002 Guidence Document
Remedial Design	15%		$173,533	$26,030	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$230,798	$57,700	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$288,000**	
Demolition - Concrete Structures (2016)					
Surface Decontamination	7,200	SY	$10	$72,000	
Concrete Demolition - Easy	2,010	CY	$40	$80,400	
Concrete Demolition - Difficult	6,020	CY	$70	$421,400	
Concrete Crushing	8,030	CY	$60	$481,800	
Spread Crushed Concrete Oniste	8,030	CY	$20	$160,600	
Recycle Rebar	650	TN	-$290	-$188,500	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$250,900	$250,900	Allowance
Project Management	6%		$1,393,800	$83,628	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$1,393,800	$111,504	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$1,393,800	$167,256	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$1,756,188	$439,047	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$2,195,000**	
Debris Removal - Site Wide (2016)					
Excavation/Debris Removal (5-ft)	66,578	CY	$10	$665,780	
Odor Control	12	WK	$9,600	$115,200	
Backfill - Site Wide	66,578	CY	$2	$133,156	
T&D Debris - Hazardous	900	TN	$1,000	$900,000	
Level C PPE Upgrade	1	LS	$332,890	$332,890	Allowance
Project Management	5%		$2,147,026	$107,351	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,147,026	$128,822	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,147,026	$171,762	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,554,961	$638,740	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,194,000**	
Miscellaneous Demolition (2016)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose Pilot Plant SP	24,300	SF	$30	$729,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$116,000	$116,000	HCSS Estimate
Odor Control	4	WK	$9,600	$38,400	Allowance
Level C PPE Upgrade	1	LS	$575,350	$575,350	Allowance

TABLE C-4B
Cost Estimate for Alternative 4a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Project Management	6%		$1,900,450	$114,027	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$1,900,450	$152,036	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$1,900,450	$228,054	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,394,567	$598,642	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$2,993,000**	
Storm Water Infiltration Trench (2016)					
Excavation	2,800	CY	$17	$47,600	
P/D Drain Gravel	4,536	TN	$24	$108,864	
Spread Drain Gravel	6,400	TN	$9	$57,600	
Project Management	8%		$214,064	$17,125	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$214,064	$21,406	USEPA 540-R-00-002 Guidence Document
Construction Management	15%		$214,064	$32,110	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$284,705	$71,176	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$214,000**	
Rock/Soil/Bulkhead Removal (2017)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	$0.30/lb incineration + haul to SLC
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	$0.30/lb incineration + haul to SLC
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	
Crush Rock	16,857	CY	$10	$168,570	
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	Allowance
Project Management	5%		$5,890,725	$294,536	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$5,890,725	$353,444	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$5,890,725	$471,258	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$7,009,963	$1,752,491	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$8,762,000**	
Construct Outfall (2017)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	
Unload Sheet Pile	5	LD	$2,000	$10,000	
Install Sheet Pile	3,500	SF	$10	$35,000	
Dewatering	20	DY	$800	$16,000	
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	
Project Management	5%		$2,214,036	$110,702	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,214,036	$132,842	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,214,036	$177,123	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,634,703	$658,676	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,293,000**	
ISS Passive Drainage System (2022)					
MH Excavations, ISS PWT	1,500	CY	$37	$55,500	
P/D Treatment Manholes	15	EA	$24,000	$360,000	
Install Treatment MH	15	EA	$4,000	$60,000	
Install Contech GAC Storm Filters	1	LS	$15,000	$15,000	
Install Hydraulic Collection Wells	15	EA	$6,000	$90,000	
Install Discharge Lines	15	EA	$9,000	$135,000	
Backfill Manholes	1,500	CY	$30	$45,000	
Repair Cap	1,000	SY	$67	$67,000	
Project Management	6%		$827,500	$49,650	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$827,500	$66,200	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$827,500	$99,300	USEPA 540-R-00-002 Guidence Document

TABLE C-4B
Cost Estimate for Alternative 4a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Contingency (10% Scope+15% Bid)	25%		$1,042,650	$260,663	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$1,303,000**	
ISS Concrete Perimeter Wall (2022)					
Excavation - ISS Perimeter Wall	10,007	CY	$34	$340,238	
Install Concrete Plug	1,475	CY	$220	$324,500	
P/D/I Rebar	930	TN	$3,000	$2,790,000	
P/D/P Concrete	8,532	CY	$220	$1,877,040	
Project Management	5%		$5,331,778	$266,589	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$5,331,778	$319,907	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$5,331,778	$426,542	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$6,344,816	$1,586,204	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$7,931,000**	
Final Site Cap (2022)					
Subgrade Preparation	39,150	SY	$3	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$7	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900	$63,800	HCSS Estimate
Restoration	13	AC	$3,200	$41,600	Engineer's Estimate
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$4,100,000**	
REMEDIAL ACTION ALTERNATIVE					
Alternative 4 - ISS					
Pre-construction Activities (ISS Subcontractor)					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	Erosion Controls, Staging/Stockpile Areas
Survey (Throughout Project)	50	DY	$2,900	$145,000	
			Subtotal:	**$255,000**	
MOBILIZATION					
Equipment Costs (Transportation)					
ISS Crane	1	ea	$60,000	$60,000	Engineer's Estimate
Jet Grout Rig - Casa Grande C-7	1	ea	$25,000	$25,000	Engineer's Estimate
Drilling Attachment	1	ea	$38,000	$38,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$28,000	$28,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$3,200	$3,200	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$34,500	$34,500	Engineer's Estimate
Crane Mats	1	ea	$3,200	$3,200	Engineer's Estimate
Crew Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Tool Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Project Trailer and Generator	2	ea	$4,000	$8,000	Engineer's Estimate
Forklift	1	ea	$2,000	$2,000	Engineer's Estimate
Manlift	1	ea	$2,000	$2,000	Engineer's Estimate
Excavator, CAT 336D	1	ea	$2,500	$2,500	Engineer's Estimate
Excavator, CAT 345D	1	ea	$2,500	$2,500	Engineer's Estimate
Loader, CAT 966H	1	ea	$2,000	$2,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	1	ea	$2,000	$2,000	Engineer's Estimate
Equipment Costs (4 week Mob)					
ISS Rig - Manitowoc/Attachment	4	wk	$21,100	$84,400	Engineer's Estimate
Jet Grout Rig	4	wk	$15,000	$60,000	Engineer's Estimate
Batch Plant and Silo(s)	4	wk	$3,900	$15,600	Engineer's Estimate
Grout Pumping System/Metering	4	wk	$3,000	$12,000	Engineer's Estimate
Hose, Connectors, Whip Checks	4	wk	$1,600	$6,400	Engineer's Estimate
Wash Down Tank	4	wk	$1,500	$6,000	Engineer's Estimate
Drill Tools	4	wk	$2,500	$10,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	4	wk	$750	$3,000	Engineer's Estimate

TABLE C-4B
Cost Estimate for Alternative 4a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Forklift, CAT 1255 12k#	4	wk	$3,500	$14,000	Engineer's Estimate
Manlift, 60-ft	4	wk	$2,000	$8,000	Engineer's Estimate
Excavator, CAT 336D	4	wk	$6,000	$24,000	Engineer's Estimate
Excavator, CAT 345D	4	wk	$7,100	$28,400	Engineer's Estimate
Loader, CAT 966H	4	wk	$4,000	$16,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	4	wk	$3,500	$14,000	Engineer's Estimate
Crew Truck	4	wk	$1,200	$4,800	Engineer's Estimate
Tool Truck	4	wk	$1,100	$4,400	Engineer's Estimate
Subcontractors					
Electrical	1	LS	$15,000	$15,000	Engineer's Estimate
Welders	1	LS	$25,000	$25,000	Engineer's Estimate
Personnel (based on 5-day week)					
Batch Plan Operator	4	wk	$7,475	$29,900	Engineer's Estimate
Crane Operator	4	wk	$6,175	$24,700	Engineer's Estimate
Equipment Operator	4	wk	$5,525	$22,100	Engineer's Estimate
Jet Grout Superintendent	4	wk	$6,500	$26,000	Engineer's Estimate
Jet Grout Operator	4	wk	$7,475	$29,900	Engineer's Estimate
ISS Attachment Operator	4	wk	$7,475	$29,900	Engineer's Estimate
Labor, Foreman	4	wk	$4,550	$18,200	Engineer's Estimate
Labor, General	4	wk	$3,900	$15,600	Engineer's Estimate
ISS Superintendent	4	wk	$6,500	$26,000	Engineer's Estimate
QA/QC Manager	4	wk	$8,125	$32,500	Engineer's Estimate
Safety Manager	4	wk	$8,125	$32,500	Engineer's Estimate
Miscellaneous					
Derrick/barge/tug, 2 days+tug+plus fuel	1	ls	$100,000	$100,000	Allowance
Mob/Demob Derrick/Barge/tug	1	ls	$100,000	$100,000	Allowance
Crane Mat Purchase	30	ls	$2,500	$75,000	Engineer's Estimate
Miscellaneous Tools and Supplies	1	ls	$12,500	$12,500	Engineer's Estimate
Per Diem	308	day	$129	$39,732	Standard Per Diem Rate = Washington
			Subtotal:	**$1,181,432**	
JET GROUTING NORTH UNIT					
Equipment					
Jet Grout Rig	31	wk	$15,000	$465,000	Engineer's Estimate
Hose, Connectors, Whip Checks	31	wk	$1,600	$49,600	Engineer's Estimate
Wash Down Tank	31	wk	$1,500	$46,500	Engineer's Estimate
Excavator, CAT 336D L	31	wk	$6,000	$186,000	Engineer's Estimate
Forklift, CAT 1255 12k#	31	wk	$3,500	$108,500	Engineer's Estimate
Crew Truck	31	wk	$1,200	$37,200	Engineer's Estimate
Batch Plant and Silo(s)	31	wk	$3,900	$120,900	Engineer's Estimate
Horizontal Storage Silo (Pig)	31	wk	$750	$23,250	Engineer's Estimate
Generator, 350 kW	31	wk	$5,000	$155,000	Engineer's Estimate
Generator Fuel	24,800	gal	$4	$99,200	Engineer's Estimate
Tool Truck	31	wk	$1,100	$34,100	Engineer's Estimate
Personnel					
Jet Grout Operator	31	wk	$7,475	$231,725	Engineer's Estimate
Equipment Operator	31	wk	$5,525	$171,275	Engineer's Estimate
Batch Plan Operator	31	wk	$7,475	$231,725	Engineer's Estimate
Labor, Foreman	31	wk	$4,550	$141,050	Engineer's Estimate
Labor, General	31	wk	$3,900	$120,900	Engineer's Estimate
Jet Grout Superintendent	31	wk	$6,500	$201,500	Engineer's Estimate
QA/QC Manager	31	wk	$8,125	$251,875	Engineer's Estimate
Safety Manager	31	wk	$8,125	$251,875	Engineer's Estimate
Materials					
P/D Portland Cement	1,300	tn	$125	$162,500	Engineer's Estimate
P/D Bentonite	65	tn	$325	$21,125	Engineer's Estimate
Miscellaneous					
Per Diems	1,736	day	$129	$223,944	Standard Per Diem Rate = Washington
			Subtotal:	**$3,334,744**	
Install Monitoring Wells					
Mob/Demob	1	ls	$5,000	$5,000	Vendor Quote
Install MW - Alt 4	20	ea	$15,750	$315,000	70-ft bgs
Develop Wells - Alt 4	20	ea	$1,600	$32,000	Engineer's Estimate
			Subtotal:	**$352,000**	
SITE WIDE EXCAVATION (7-FT)					
Equipment					

TABLE C-4B
Cost Estimate for Alternative 4a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Excavator, CAT345D	22	wk	$7,100	$156,200	Engineer's Estimate
Loader, CAT 966H	22	wk	$4,000	$88,000	Engineer's Estimate
Water Truck	5	wk	$2,500	$12,500	Engineer's Estimate
Crew Truck	22	wk	$1,200	$26,400	Engineer's Estimate
Personnel					
Equipment Operator	44	wk	$5,525	$243,100	Engineer's Estimate
Water Truck Driver	5	wk	$4,875	$24,375	Engineer's Estimate
Labor, Foreman	22	wk	$4,550	$100,100	Engineer's Estimate
Labor, General	44	wk	$3,900	$171,600	Engineer's Estimate
Miscellaneous					
Stockpile Management	160	wk	$350	$56,000	Engineer's Estimate
Per Diems	809	day	$129	$104,297	Standard Per Diem Rate = Washington
			Subtotal:	**$982,572**	
AUGER MIX ISS					
Equipment					
ISS Rig - Manitowoc/Attacment	160	wk	$21,100	$3,376,000	Engineer's Estimate
Batch Plant and Silo(s)	160	wk	$3,900	$624,000	Engineer's Estimate
Grout Pumping System/Metering	160	wk	$3,000	$480,000	Engineer's Estimate
Hose, Connectors, Whip Checks	160	wk	$1,600	$256,000	Engineer's Estimate
Wash Down Tank	160	wk	$1,500	$240,000	Engineer's Estimate
Drill Tools	160	wk	$2,500	$400,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	160	wk	$750	$120,000	Engineer's Estimate
Teeth replacement/Tooth Packets	160	wk	$750	$120,000	Engineer's Estimate
Forklift, CAT TL1255 12k#	160	wk	$3,500	$560,000	Engineer's Estimate
Manlift	160	wk	$2,000	$320,000	Engineer's Estimate
Excavator, CAT336D	160	wk	$6,000	$960,000	Engineer's Estimate
Excavator, CAT345D	160	wk	$7,100	$1,136,000	Engineer's Estimate
Generator, 350 kW	160	wk	$5,000	$800,000	Engineer's Estimate
Generator Fuel	128,000	gal	$4	$512,000	Engineer's Estimate
Crew Truck	160	wk	$1,200	$192,000	Engineer's Estimate
Tool Truck	160	wk	$1,100	$176,000	Engineer's Estimate
Subcontractors					
Electrical	1	ls	$15,000	$15,000	Engineer's Estimate
Welders	1	ls	$25,000	$25,000	Engineer's Estimate
Personnel					
Batch Plant Operator	160	wk	$7,475	$1,196,000	Engineer's Estimate
Crane Operator	160	wk	$6,175	$988,000	Engineer's Estimate
Equipment Operator	160	wk	$5,525	$884,000	Engineer's Estimate
ISS Attachment Operator	160	wk	$7,475	$1,196,000	Engineer's Estimate
Labor, Foreman	160	wk	$4,550	$728,000	Engineer's Estimate
Labor, General	160	wk	$3,900	$624,000	Engineer's Estimate
ISS Superintendent	160	wk	$6,500	$1,040,000	Engineer's Estimate
QA/QC Manager	160	wk	$8,125	$1,300,000	Engineer's Estimate
Safety Manager	160	wk	$8,125	$1,300,000	Engineer's Estimate
Materials					
P/D Portland Cement	58,170	tn	$125	$7,271,250	Engineer's Estimate
P/D Bentonite	2,705	tn	$325	$879,125	Engineer's Estimate
Miscellaneous					
Per Diems	10,080	day	$129	$1,300,320	Standard Per Diem Rate = Washington
			Subtotal:	**$29,018,695**	
EX-SITU SOIL MIXING AND PLACEMENT					
Equipment					
Excavator, CAT 336D	30	wk	$6,000	$180,000	Engineer's Estimate
Loader, CAT 966H	30	wk	$4,000	$120,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	30	wk	$3,500	$105,000	Engineer's Estimate
Water Truck	30	wk	$2,500	$75,000	Engineer's Estimate
Personnel					
Equipment Operator	60	wk	$5,525	$331,500	Engineer's Estimate
Water Truck Driver	30	wk	$4,875	$146,250	Engineer's Estimate
Labor, Foreman	30	wk	$4,550	$136,500	Engineer's Estimate
Labor, General	60	wk	$3,900	$234,000	Engineer's Estimate
Materials					
P/D Portland Cement	14,600	TN	$125	$1,825,000	Engineer's Estimate
P/D Bentonite	730	TN	$325	$237,250	Engineer's Estimate

TABLE C-4B
Cost Estimate for Alternative 4a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Miscellaneous					
Per Diems	1,260	day	$129	$162,540	Standard Per Diem Rate = Washington
			Subtotal:	**$3,553,040**	
DEMOBILIZATION					
Equipment Costs (Transportation)					
ISS Crane	1	ea	$30,000	$30,000	Engineer's Estimate
Jet Grout Rig - Casa Grande C-7	1	ea	$12,500	$12,500	Engineer's Estimate
Drilling Attachment	1	ea	$19,000	$19,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$14,000	$14,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$1,600	$1,600	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$17,250	$17,250	Engineer's Estimate
Crane Mats	1	ea	$1,600	$1,600	Engineer's Estimate
Crew Truck	1	ea	$750	$750	Engineer's Estimate
Tool Truck	1	ea	$750	$750	Engineer's Estimate
Project Trailer and Generator	1	ea	$2,000	$2,000	Engineer's Estimate
Forklift, CAT TL1255 12k#	1	ea	$1,000	$1,000	Engineer's Estimate
Manlift	1	ea	$1,000	$1,000	Engineer's Estimate
Excavator, CAT336D	1	ea	$1,250	$1,250	Engineer's Estimate
Excavator, CAT345D	1	ea	$1,250	$1,250	Engineer's Estimate
Loader, CAT 966H	1	ea	$1,000	$1,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	1	ea	$1,000	$1,000	Engineer's Estimate
Equipment Costs (2 week demob)					
ISS Rig - Manitowoc/Attachment	2	wk	$21,100	$42,200	Engineer's Estimate
Jet Grout Rig - CasaGrande C-7	2	wk	$15,000	$30,000	Engineer's Estimate
Batch Plant and Silo(s)	2	wk	$3,900	$7,800	Engineer's Estimate
Grout Pumping System/Metering	2	wk	$3,000	$6,000	Engineer's Estimate
Hose, Connectors, Whip Checks	2	wk	$1,600	$3,200	Engineer's Estimate
Wash Down Tank	2	wk	$1,500	$3,000	Engineer's Estimate
Drill Tools	2	wk	$2,500	$5,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	2	wk	$750	$1,500	Engineer's Estimate
Forklift, CAT TL1255 12k#	2	wk	$3,500	$7,000	Engineer's Estimate
Manlift	2	wk	$2,000	$4,000	Engineer's Estimate
Excavator, CAT 336D	2	wk	$6,000	$12,000	Engineer's Estimate
Excavator, CAT 345D	2	wk	$7,100	$14,200	Engineer's Estimate
Loader, CAT 966H	2	wk	$4,000	$8,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	2	wk	$3,500	$7,000	Engineer's Estimate
Crew Trucks	2	wk	$1,200	$2,400	Engineer's Estimate
Tool Truck	2	wk	$1,100	$2,200	Engineer's Estimate
Personnel					
Batch Plan Operator	2	wk	$7,475	$14,950	Engineer's Estimate
Crane Operator	2	wk	$6,175	$12,350	Engineer's Estimate
Equipment Operator	2	wk	$5,525	$11,050	Engineer's Estimate
Jet Grout Superintendent	2	wk	$6,500	$13,000	Engineer's Estimate
Jet Grout Operator	2	wk	$7,475	$14,950	Engineer's Estimate
ISS Attachment Operator	2	wk	$7,475	$14,950	Engineer's Estimate
Labor, General	2	wk	$3,900	$7,800	Engineer's Estimate
Labor, Foreman	2	wk	$3,900	$7,800	Engineer's Estimate
ISS Superintendent	2	wk	$6,500	$13,000	Engineer's Estimate
QA/QC Manager	2	wk	$8,125	$16,250	Engineer's Estimate
Safety Manager	2	wk	$8,125	$16,250	Engineer's Estimate
Miscellaneous					
Derrick/barge/tug, 2 days+tug+plus fuel	1	ls	$50,000	$50,000	Allowance
Mob/Demob Derrick/Barge/tug	1	ls	$50,000	$50,000	Allowance
Per Diems	154	day	$129	$19,866	Standard Per Diem Rate = Washington
			Subtotal:	**$523,666**	
PROJECT MANAGEMENT	5%		$39,201,149	$1,960,057	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$39,201,149	$2,352,069	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$39,201,149	$2,352,069	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$6,764,195**	
CONTINGENCY (10% scope + 15% bid)	25%		$45,965,344	$11,491,336	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS FOR ISS				**$57,457,000**	

TABLE C-4B
Cost Estimate for Alternative 4a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
OPERATIONAL & MAINTENANCE COSTS					
ANNUAL OPERATION & MAINTENANCE COSTS OF GWTP (through 2021)					
Operator(s)	4,160	hr	$80	$332,800	2 FTEs Operating GWTP
Electrical Usage	1	ls	$60,000	$60,000	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Waste Disposal	1	ls	$100,000	$100,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$20,000	$20,000	Allowance
Maintenance	10%		$512,800	$51,280	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Undefined Scope Allowance	10%		$654,080	$65,408	
PROJECT MANAGEMENT	6%		$719,488	$43,169	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS OF GWTP				**$788,000**	
OPERATION & MAINTENANCE COSTS OF PASSIVE TREATMENT SYSTEM (YR2022 thru YR2029)					
Operator(s)	1,040	hr	$80	$83,200	0.5 FTEs
Maintenance	10%		$83,200	$8,320	Allowance
GAC Filled Storm Filter Changeout	420	ea	$200	$84,000	Quarterly changeout/recycle
T&D of Spent GAC Filters	40	drum	$400	$16,000	1 drum/manhole/event
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Undefined Scope Allowance	10%		$84,000	$8,400	
PROJECT MANAGEMENT	8%		$289,920	$23,194	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	10%		$198,400	$19,840	Based on EPA 540-R-00-002
TOTAL O&M COSTS				**$333,000**	
PERIODIC COSTS					
Maintain Onsite Roads	1	ls	$25,000	$25,000	Allowance - regrade/repair onsite roads
GWTP Demolition	1	ls	$1,000,000	$1,000,000	Allowance
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS

Base Year: 2014 | 1.9% Discount Rate | OMB - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value
0	Annual O&M Costs	$0	1.00	$ -
1	Annual O&M Costs	$0	0.98	$ -
2	Capital Costs (2016)	$9,753,000	0.96	$ 9,392,687
2	Annual O&M Costs (2016)	$788,000	0.96	$ 758,888
3	Capital Costs (2017)	$12,055,000	0.95	$ 11,393,172
3	Annual O&M Costs (2017)	$788,000	0.95	$ 744,738
3	5-yr Review (2017)	$20,000	0.95	$ 18,902
4	Capital Costs (2018)	$9,489,958	0.93	$ 8,801,720
4	Annual O&M Costs (2018)	$788,000	0.93	$ 730,852
5	Capital Costs (2019)	$16,011,257	0.91	$ 14,573,186
5	Annual O&M Costs (2019)	$788,000	0.91	$ 717,225
6	Construction Costs (2020)	$15,715,899	0.89	$ 14,037,641
6	Annual O&M Costs (2020)	$788,000	0.89	$ 703,852
7	Construction Costs (2021)	$16,239,565	0.88	$ 14,234,923
7	Annual O&M Costs (2021)	$788,000	0.88	$ 690,728
8	Construction Costs (2022)	$13,334,000	0.86	$ 11,470,094

TABLE C-4B
Cost Estimate for Alternative 4a

DRAFT

	Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)		NOTES
8	Annual O&M Costs (2022)				$333,000	0.86	$ 286,451
8	5 Year Review (2022)				$20,000	0.86	$ 17,204
9	Annual O&M Costs (2023)				$333,000	0.84	$ 281,110
10	Annual O&M Costs (2024)				$333,000	0.83	$ 275,869
11	Capital Costs (2025)				$1,000,000	0.81	$ 812,988
11	Annual O&M Costs (2025)				$333,000	0.81	$ 270,725
12	Annual O&M Costs (2026)				$333,000	0.80	$ 265,677
13	Annual O&M Costs (2027)				$333,000	0.78	$ 260,723
13	5 Year Review (2027)				$20,000	0.78	$ 15,659
14	Annual O&M Costs (2028)				$333,000	0.77	$ 255,862
15	Annual O&M Costs (2029)				$333,000	0.75	$ 251,091
18	5 Year Review (2032)				$20,000	0.71	$ 14,253
23	5 Year Review (2037)				$20,000	0.65	$ 12,973
25	Capital Costs (2039)				$25,000	0.62	$ 15,617
28	5 Year Review (2042)				$20,000	0.59	$ 11,807
33	5 Year Review (2047)				$20,000	0.54	$ 10,747
38	5 Year Review (2052)				$20,000	0.49	$ 9,782
43	5 Year Review (2057)				$20,000	0.45	$ 8,903
48	5 Year Review (2062)				$20,000	0.41	$ 8,103
53	5 Year Review (2067)				$20,000	0.37	$ 7,376
58	5 Year Review (2072)				$20,000	0.34	$ 6,713
63	5 Year Review (2077)				$20,000	0.31	$ 6,110
68	5 Year Review (2082)				$20,000	0.28	$ 5,561
73	5 Year Review (2087)				$20,000	0.25	$ 5,062
78	5 Year Review (2092)				$20,000	0.23	$ 4,607
83	5 Year Review (2097)				$20,000	0.21	$ 4,193
88	5 Year Review (2102)				$20,000	0.19	$ 3,817
93	5 Year Review (2107)				$20,000	0.17	$ 3,474
98	5 Year Review (2112)				$20,000	0.16	$ 3,162
102	Final Completion Report (2116)				$150,000	0.15	$ 21,995
TOTAL VALUE ANALYSIS					**$101,566,000**		**$91,430,000**

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%. It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

TABLE C-5a
Cost Estimate for Alternative 5

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
GENERAL SITE ACTIVITIES					
Pre-construction Activities - Common Elements (2016)					
Permitting	1	LS	$21,000	$21,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$117,000	$117,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$552,000	$33,120	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$552,000	$44,160	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$552,000	$66,240	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$695,520	$173,880	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$869,000**	
Access Roads (2016)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$3	$4,133	
Project Management	8%		$173,533	$13,883	USEPA 540-R-00-002 Guidance Document
Construction Management	10%		$173,533	$17,353	USEPA 540-R-00-002 Guidance Document
Remedial Design	15%		$173,533	$26,030	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$230,798	$57,700	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$288,000**	
Demolition - Concrete Structures (2016)					
Surface Decontamination	7,200	SY	$10	$72,000	
Concrete Demolition - Easy	2,010	CY	$40	$80,400	
Concrete Demolition - Difficult	6,020	CY	$70	$421,400	
Concrete Crushing	8,030	CY	$60	$481,800	
Spread Crushed Concrete Oniste	8,030	CY	$20	$160,600	
Recycle Rebar	650	TN	-$290	-$188,500	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$250,900	$250,900	Allowance
Project Management	6%		$1,393,800	$83,628	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$1,393,800	$111,504	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$1,393,800	$167,256	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$1,756,188	$439,047	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$2,195,000**	
Debris Removal - Site Wide (2016)					
Excavation/Debris Removal (5-ft)	66,578	CY	$10	$665,780	
Odor Control	12	WK	$9,600	$115,200	
Backfill - Site Wide	66,578	CY	$2	$133,156	
T&D Debris - Hazardous	900	TN	$1,000	$900,000	
Level C PPE Upgrade	1	LS	$332,890	$332,890	Allowance
Project Management	5%		$2,147,026	$107,351	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,147,026	$128,822	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,147,026	$171,762	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,554,961	$638,740	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$3,194,000**	
Rock/Soil/Bulkhead Removal (2016)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	
Crush Rock	16,857	CY	$10	$168,570	

TABLE C-5a
Cost Estimate for Alternative 5

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	Allowance
Project Management	5%		$5,890,725	$294,536	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$5,890,725	$353,444	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$5,890,725	$471,258	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$7,009,963	$1,752,491	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$8,762,000**	
Miscellaneous Demolition (2016)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose Pilot Plant SP	24,300	SF	$30	$729,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$116,000	$116,000	HCSS Estimate
Odor Control	4	WK	$9,600	$38,400	Allowance
Level C PPE Upgrade	1	LS	$575,350	$575,350	Allowance
Project Management	6%		$1,900,450	$114,027	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$1,900,450	$152,036	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$1,900,450	$228,054	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,394,567	$598,642	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$2,993,000**	
Storm Water Infiltration Trench (2016)					
Excavation	2,800	CY	$17	$47,600	
P/D Drain Gravel	4,536	TN	$24	$108,864	
Spread Drain Gravel	6,400	TN	$9	$57,600	
Project Management	8%		$214,064	$17,125	USEPA 540-R-00-002 Guidance Document
Construction Management	10%		$214,064	$21,406	USEPA 540-R-00-002 Guidance Document
Remedial Design	15%		$214,064	$32,110	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$284,705	$71,176	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$214,000**	
Install New Perimeter SP Wall, Non ISS (2017)					
P/D AZ50 Sheet Pile	3,700	TN	$1,900	$7,030,000	Vendor Quote
Unload Sheet Pile	169	LD	$2,000	$338,000	
Install Perimeter SP Wall (AZ50)	142,200	SF	$11	$1,564,200	
Project Management	5%		$8,932,200	$446,610	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$8,932,200	$535,932	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$8,932,200	$714,576	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$10,629,318	$2,657,330	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$13,287,000**	
Non-ISS Concrete Perimeter Wall (2026)					
Excavation - Non-ISS Perimeter Wall	14,646	CY	$62	$908,052	
Install Concrete Plug	1,475	CY	$220	$324,500	
Odor Control	8	WK	$9,600	$76,800	Allowance
P/D/I Rebar	1,100	TN	$3,000	$3,300,000	
P/D/I Concrete	13,201	CY	$220	$2,904,220	
Project Management	5%		$7,513,572	$375,679	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$7,513,572	$450,814	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$7,513,572	$601,086	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$8,941,151	$2,235,288	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$11,176,000**	
Construct Outfall (2017)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	
Unload Sheet Pile	5	LD	$2,000	$10,000	

TABLE C-5a
Cost Estimate for Alternative 5

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Install Sheet Pile	3,500	SF	$10	$35,000	
Dewatering	20	DY	$800	$16,000	
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	Allowance
Project Management	5%		$2,214,036	$110,702	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,214,036	$132,842	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,214,036	$177,123	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,634,703	$658,676	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$3,293,000**	
Final Site Cap (2026)					
Subgrade Preparation	39,150	SY	$3.00	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20.00	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$6.75	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2.25	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30.00	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60.00	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900.00	$63,800	HCSS Estimate
Restoration	13	AC	$3,200.00	$41,600	Engineer's Estimate
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$4,100,000**	
Non-ISS Passive Drainage System (2026)					
MH Excavations, Non-ISS PWT	1,500	CY	$35	$52,500	
P/D Manholes & Bases	10	EA	$12,000	$120,000	
Install Manholes & Bases	10	EA	$4,000	$40,000	
Install Contech GAC Storm Filters	1	LS	$15,000	$15,000	
Discharge Line Penetration/Install	10	EA	$7,000	$70,000	
Backfill Manholes	1,500	CY	$30	$45,000	
Excavate French Drains	4,750	CY	$18	$85,500	
P/D/I 12", Slotted HDPE	2,000	LF	$54	$108,000	
Backfill French Drains	4,750	CY	$24	$114,000	
Repair Cap	1,000	SY	$67	$67,000	
Project Management	6%		$717,000	$43,020	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$717,000	$57,360	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$717,000	$86,040	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$903,420	$225,855	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$1,129,000**	
REMEDIAL ACTION ALTERNATIVE					
Alternative 5 - North Unit Jet Grouting					
Pre-construction Activities					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	
Survey (Throughout Project)	50	DY	$2,900	$145,000	
			Subtotal:	**$255,000**	
MOBILIZATION					
Equipment Costs (Transportation)					
Jet Grout Rig - Casa Grande C-7	1	ea	$25,000	$25,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$28,000	$28,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$3,200	$3,200	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$34,500	$34,500	Engineer's Estimate
Crane Mats	1	ea	$3,200	$3,200	Engineer's Estimate
Crew Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Tool Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Project Trailer and Generator	1	ea	$4,000	$4,000	Engineer's Estimate
Forklift, CAT 1255 12k#	1	ea	$2,000	$2,000	Engineer's Estimate
Excavator, CAT 336D	1	ea	$2,500	$2,500	Engineer's Estimate

TABLE C-5a
Cost Estimate for Alternative 5

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Equipment Costs (2 week Mob)					
Jet Grout Rig	2	wk	$15,000	$30,000	Engineer's Estimate
Batch Plant and Silo(s)	2	wk	$3,900	$7,800	Engineer's Estimate
Grout Pumping System/Metering	2	wk	$3,000	$6,000	Engineer's Estimate
Hose, Connectors, Whip Checks	2	wk	$1,600	$3,200	Engineer's Estimate
Wash Down Tank	2	wk	$1,500	$3,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	2	wk	$750	$1,500	Engineer's Estimate
Forklift, CAT 1255 12k#	2	wk	$3,500	$7,000	Engineer's Estimate
Excavator, CAT 336D	2	wk	$6,000	$12,000	Engineer's Estimate
Crew Truck	2	wk	$1,200	$2,400	Engineer's Estimate
Tool Truck	2	wk	$1,100	$2,200	Engineer's Estimate
Subcontractors					
Electrical	1	LS	$15,000	$15,000	Engineer's Estimate
Welders	1	LS	$25,000	$25,000	Engineer's Estimate
Personnel					
Batch Plan Operator	2	wk	$7,475	$14,950	Engineer's Estimate
Equipment Operator	2	wk	$5,525	$11,050	Engineer's Estimate
Jet Grout Superintendent	2	wk	$6,500	$13,000	Engineer's Estimate
Jet Grout Operator	2	wk	$7,475	$14,950	Engineer's Estimate
Labor, General	2	wk	$4,550	$9,100	Engineer's Estimate
Labor, Foreman	2	wk	$3,900	$7,800	Engineer's Estimate
QA/QC Manager	2	wk	$8,125	$16,250	Engineer's Estimate
Safety Manager	2	wk	$8,125	$16,250	Engineer's Estimate
Miscellaneous					
Per Diem	112	day	$129	$14,448	Standard Per Diem Rate = Washington
			Subtotal:	**$338,298**	
JET GROUTING NORTH UNIT					
Equipment					
Jet Grout Rig	31	wk	$15,000	$465,000	Engineer's Estimate
Hose, Connectors, Whip Checks	31	wk	$1,600	$49,600	Engineer's Estimate
Wash Down Tank	31	wk	$1,500	$46,500	Engineer's Estimate
Excavator, CAT 336D L	31	wk	$6,000	$186,000	Engineer's Estimate
Forklift, CAT 1255 12k#	31	wk	$3,500	$108,500	Engineer's Estimate
Crew Truck	31	wk	$1,200	$37,200	Engineer's Estimate
Batch Plant and Silo(s)	31	wk	$3,900	$120,900	Engineer's Estimate
Horizontal Storage Silo (Pig)	31	wk	$750	$23,250	Engineer's Estimate
Generator, 350 kW	31	wk	$5,000	$155,000	Engineer's Estimate
Generator Fuel	24,800	gal	$4	$99,200	Engineer's Estimate
Tool Truck	31	wk	$1,100	$34,100	Engineer's Estimate
Personnel					
Jet Grout Operator	31	wk	$7,475	$231,725	Engineer's Estimate
Equipment Operator	31	wk	$5,525	$171,275	Engineer's Estimate
Batch Plan Operator	31	wk	$7,475	$231,725	Engineer's Estimate
Labor, Foreman	31	wk	$4,550	$141,050	Engineer's Estimate
Labor, General	31	wk	$3,900	$120,900	Engineer's Estimate
Jet Grout Superintendent	31	wk	$6,500	$201,500	Engineer's Estimate
QA/QC Manager	31	wk	$8,125	$251,875	Engineer's Estimate
Safety Manager	31	wk	$8,125	$251,875	Engineer's Estimate
Materials					
P/D Portland Cement	1,300	tn	$125	$162,500	Engineer's Estimate
P/D Bentonite	65	tn	$325	$21,125	Engineer's Estimate
Miscellaneous					
Per Diems	1,736	day	$129	$223,944	Standard Per Diem Rate = Washington
			Subtotal:	**$3,334,744**	
DEMOBILIZATION					
Equipment Costs (Transportation)					
Jet Grout Rig - Casa Grande C-7	1	ea	$12,500	$12,500	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$14,000	$14,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$1,600	$1,600	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$17,250	$17,250	Engineer's Estimate
Crane Mats	1	ea	$1,600	$1,600	Engineer's Estimate
Crew Truck	1	ea	$750	$750	Engineer's Estimate
Tool Truck	1	ea	$750	$750	Engineer's Estimate
Project Trailer and Generator	1	ea	$2,000	$2,000	Engineer's Estimate
Forklift	1	ea	$1,000	$1,000	Engineer's Estimate
Excavator, CAT 336D	1	ea	$1,250	$1,250	Engineer's Estimate

TABLE C-5a
Cost Estimate for Alternative 5

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Equipment Costs (1 week Demob)					
Jet Grout Rig	1	wk	$15,000	$15,000	Engineer's Estimate
Batch Plant and Silo(s)	1	wk	$3,900	$3,900	Engineer's Estimate
Grout Pumping System/Metering	1	wk	$3,000	$3,000	Engineer's Estimate
Hose, Connectors, Whip Checks	1	wk	$1,600	$1,600	Engineer's Estimate
Wash Down Tank	1	wk	$1,500	$1,500	Engineer's Estimate
Horizontal Storage Silo (Pig)	1	wk	$750	$750	Engineer's Estimate
Forklift, CAT 1255 12k#	1	wk	$3,500	$3,500	Engineer's Estimate
Excavator, CAT 336D	1	wk	$6,000	$6,000	Engineer's Estimate
Crew Truck	1	wk	$1,200	$1,200	Engineer's Estimate
Tool Truck	1	wk	$1,100	$1,100	Engineer's Estimate
Personnel					
Batch Plan Operator	1	wk	$7,475	$7,475	Engineer's Estimate
Equipment Operator	1	wk	$5,525	$5,525	Engineer's Estimate
Jet Grout Superintendent	1	wk	$6,500	$6,500	Engineer's Estimate
Jet Grout Operator	1	wk	$7,475	$7,475	Engineer's Estimate
Labor, General	1	wk	$3,900	$3,900	Engineer's Estimate
Labor, Foreman	1	wk	$4,550	$4,550	Engineer's Estimate
QA/QC Manager	1	wk	$8,125	$8,125	Engineer's Estimate
Safety Manager	1	wk	$8,125	$8,125	Engineer's Estimate
Miscellaneous					
Per Diem	56	day	$129	$7,224	Standard Per Diem Rate = Washington
			Subtotal:	**$149,149**	
PROJECT MANAGEMENT	5%		$4,077,191	$203,860	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$4,077,191	$244,631	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$4,077,191	$244,631	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$793,122**	
CONTINGENCY (10% scope + 15% bid)	25%		$4,870,313	$1,217,578	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS JET GROUTING				**$6,088,000**	
Alternative 5 - Thermal (Midpoint 2018)					
Pre-construction Activities					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	
			Subtotal:	**$110,000**	
Mob/Demob					
P/D AZ36-700N Sheet Pile	2,509	TN	$1,700	$4,266,304	Vendor Quote
Unload Sheet Pile	114	LD	$2,000	$228,000	Engineer's Estimate
Install AZ36-700N Sheet Pile	145,043	SF	$10	$1,450,430	Engineer's Estimate
Install Dewatering Wells	27	ea	$25,000	$675,000	Engineer's Estimate
Dewatering Well Completions	27	ea	$350	$9,450	Engineer's Estimate
Install Steam Injection Wells	172	ea	$15,000	$2,580,000	Engineer's Estimate
Injection Well Completions	172	ea	$450	$77,400	Engineer's Estimate
Steam Injection Well Piping/System	1	ls	$460,000	$460,000	Engineer's Estimate
Install Extraction Wells	147	ea	$5,700	$837,900	Engineer's Estimate
Extraction Well Completions	147	ea	$450	$66,150	Engineer's Estimate
Install Extraction Well Head System	49	ea	$2,500	$122,500	Engineer's Estimate
Allowance to Relocate Well Heads	197	ea	$1,500	$295,500	Engineer's Estimate
Install Biosparge Wells	31	ea	$5,000	$155,000	Engineer's Estimate
Biosparge Well Completions	31	ea	$350	$10,850	Engineer's Estimate
Install Biosparge Wellhead and Header Piping/Valves	31	ea	$2,500	$77,500	Engineer's Estimate
Install Thermocouple Borings	201	ea	$2,800	$562,800	Engineer's Estimate
Purchase Thermocouples	589	ea	$1,500	$883,500	Engineer's Estimate
Install Thermocouples	7,068	ft	$25	$176,700	Engineer's Estimate
Thermocouple Completions	201	ea	$350	$70,350	Engineer's Estimate
Install Vapor Collection Layer	8,985	tn	$20	$179,700	Engineer's Estimate
Install Vapor Collection Piping	462	ft	$25	$11,550	Engineer's Estimate
Install Select Fill Below Vapor Cap	6,739	tn	$25	$168,475	Engineer's Estimate
Temp Geomembrane over VC	28,881	sy	$7	$202,167	Engineer's Estimate
Temp VC Pipe Penetrations	84	ea	$500	$42,000	Engineer's Estimate
Install Cushion Geotextile	28,881	sy	$2	$57,762	Engineer's Estimate
Install Fill Above VC (18")	20,217	tn	$25	$505,425	Engineer's Estimate
Surface Top Coarse (6")	6,739	tn	$25	$168,475	Engineer's Estimate

TABLE C-5a
Cost Estimate for Alternative 5

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Steam Supply Header Materials	8,550	ft	$45	$384,750	Engineer's Estimate
Allowance for Steam Valves/I&C	1	ls	$75,000	$75,000	Engineer's Estimate
Air Supply Piping Header	10,645	ft	$20	$212,900	Engineer's Estimate
Vapor Extraction Piping	8,550	ft	$55	$470,250	Engineer's Estimate
Extracted Water Piping	10,645	ft	$20	$212,900	Engineer's Estimate
Install Air/Vapor/Extraction Piping	38,390	ft	$7	$268,730	Engineer's Estimate
Installation of 6' Pipe Rack	940	ea	$400	$376,000	Engineer's Estimate
Installation of 15' Pipe Rack	127	ea	$750	$95,250	Engineer's Estimate
Allowance for Extraction Valves/I&C	1	ls	$100,000	$100,000	Engineer's Estimate
Corrosion Protection for wells	377	ls	$500	$188,500	Engineer's Estimate
			Subtotal:	**$16,725,168**	
Vapor and GW Treatment System					
Site Preparation	1	ls	$30,000	$30,000	Engineer's Estimate
Concrete Slab on Grade	1,400	cy	$350	$490,000	Engineer's Estimate
Secondary Containment Walls	13	CY	$350	$4,550	Engineer's Estimate
P/D Diesel Generators	2	ea	$600,000	$1,200,000	Engineer's Estimate
P/D Direct Contact Condenser	1	ea	$415,000	$415,000	Engineer's Estimate
P/D VLS, LRVP, Therm-OX Package	1	ea	$100,000	$100,000	Engineer's Estimate
P/D Solids Dewater Screw Conveyor	2	ea	$135,000	$270,000	Engineer's Estimate
P/D Cooling Tower	1	ea	$41,000	$41,000	Engineer's Estimate
Cooling Water Chemical/Makeup Treatment Systems	1	ls	$150,000	$150,000	Allowance
P/D Heat Exchanger H-1	2	ea	$11,500	$23,000	Engineer's Estimate
P/D Heat Exchanger H-2	2	ea	$15,000	$30,000	Engineer's Estimate
P/D Accumulation Tank	1	ea	$97,000	$97,000	Engineer's Estimate
P/D Oil/Water Separator	1	ea	$310,000	$310,000	Engineer's Estimate
P/D Solids NAPL Holding Tank	1	ea	$92,000	$92,000	Engineer's Estimate
P/D Air Compressor	1	ea	$11,000	$11,000	Engineer's Estimate
P/D Pumps	20	ea	$10,000	$200,000	Engineer's Estimate
P/D DAF	1	ea	$357,000	$357,000	Engineer's Estimate
P/D Walnut Filter	1	ea	$300,000	$300,000	Engineer's Estimate
Equipment Installation (15% of equipment cost)	1	ls	$400,000	$400,000	Allowance
Process Piping (5% of equip cost)	1	ls	$132,000	$132,000	Allowance
I&C (15% of equipment cost)	1	ls	$400,000	$400,000	Allowance
Electrical (20% of equipment cost)	1	ls	$530,000	$530,000	Allowance
Solids Handling Rain Shelter	600	sf	$200	$120,000	Allowance
Electrical/I&C Building	1	ls	$36,000	$36,000	Allowance
			Subtotal:	**$5,738,550**	
Boiler Propane System					
Site Preparation	1	ls	$15,000	$15,000	Engineer's Estimate
Concrete Slab on Grade	125	cy	$350	$43,750	Engineer's Estimate
Install Propane Tank	1	ls	$30,000	$30,000	Allowance
Install Vaporizer	1	ls	$30,000	$30,000	Allowance
Setup Boiler System	1	ls	$75,000	$75,000	Allowance
Monthly Rental of Boiler System	60	mo	$17,500	$1,050,000	Nationwide Boiler Quote. Includes softener and feed water pump.
			Subtotal:	**$1,243,750**	
PROJECT MANAGEMENT	5%		$23,817,468	$1,190,873	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$23,817,468	$1,429,048	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$23,817,468	$1,429,048	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$4,148,969**	
CONTINGENCY (10% scope + 15% bid)	25%		$27,966,437	$6,991,609	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS THERMAL				**$34,958,000**	

REMEDIAL ACTION ALTERNATIVE

OPERATION & MAINTENANCE COSTS OF GWTP (through 2024)

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Annual O&M					
Operator(s)	4,160	hr	$80	$332,800	2 FTEs Operating GWTP
Electrical Usage	1	ls	$60,000	$60,000	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Waste Disposal	1	ls	$100,000	$100,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$20,000	$20,000	Allowance
Maintenance	10%		$512,800	$51,280	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	

TABLE C-5a
Cost Estimate for Alternative 5

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Undefined Scope Allowance	10%		$654,080	$65,408	
PROJECT MANAGEMENT	6%		$719,488	$43,169	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL O&M COSTS - GWTP				**$788,000**	
OPERATION & MAINTENANCE COSTS OF NAPL RECOVERY (20219 through 2021)					
Annual O&M					
Disposal - NAPL Waste	47,000	gal	$7	$329,000	Vendor Quote; 140,000-gal over 3 yrs
Transportation - NAPL Waste	22	load	$6,400	$140,800	Vendor Quote
Well field Analysis&Sampling Team	1,040	hr	$80	$83,200	Engineer's Estimate
Laboratory Analysis	260	ls	$300	$78,000	Engineer's Estimate
PPE Allowance	1,040	hr	$15	$15,600	Allowance
Maintenance	10%		$646,600	$64,660	Allowance
Undefined Scope Allowance	10%		$711,260	$71,126	
PROJECT MANAGEMENT	6%		$782,386	$46,943	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - NAPL RECOVERY				**$854,000**	
OPERATION & MAINTENANCE COSTS OF EAB (2021 through 2026)					
EAB					
Operator(s)	1,040	hr	$80	$83,200	1/2 yr running EAB System
Supervisor	208	hr	$100	$20,800	20% of operator time
Electrical	1	ls	$16,000	$16,000	Engineer's Estimate
Nutrient Chemicals/Media	1	ls	$11,000	$11,000	
System Maintenance	5%		$131,000	$6,550	Allowance
Undefined Scope Allowance	10%		$137,550	$13,755	
PROJECT MANAGEMENT	8%		$151,305	$12,104	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - EAB RECOVERY				**$188,000**	
OPERATION & MAINTENANCE COSTS OF THERMAL (2019 through 2024)					
Annual O&M					
Operator(s)	16,640	hr	$80	$1,331,200	8 FTEs running system 24/7
Supervisor	4,160	hr	$100	$416,000	2 FTE
Electrical Usage	1	ls	$103,385	$103,385	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Diesel Generator	12	mo	$20,600	$247,200	5150 gal/mo @ $4/gal
Propane	12	mo	$266,600	$3,199,200	86,000-gal/mo@$3.10/gal
Disposal - NAPL Waste	13,000	gal	$7	$91,000	Vendor Quote; 14,000-gal/yr
Transportation - NAPL Waste	6	load	$6,400	$38,400	Vendor Quote
Disposal - Naphthalene Waste	264	tn	$660	$174,240	Engineer's Estimate
Transportation - Naphthalene Waste	12	ld	$1,360	$16,320	22 tn/load => 16 hrs/load haul time
Waste Disposal - Carbon/Filter Media	1	ls	$86,000	$86,000	Allowance
Well field Analysis&Sampling Team	1,040	hr	$80	$83,200	Engineer's Estimate
Laboratory Analysis	260	ls	$300	$78,000	Engineer's Estimate
PPE Allowance	16,640	hr	$0.75	$12,480	Allowance - hard hats, boots, work gloves, safety glasses, Tyvek and other consumables
Maintenance	10%		$5,876,625	$587,663	Allowance
Undefined Scope Allowance	10%		$6,464,288	$646,429	
PROJECT MANAGEMENT	5%		$7,110,716	$355,536	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - THERMAL				**$7,491,000**	

TABLE C-5a
Cost Estimate for Alternative 5

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
OPERATION & MAINTENANCE COSTS OF PASSIVE GROUNDWATER TREATMENT SYSTEM (2025 through 2035)					
Operator(s)	520	hr	$80	$41,600	0.25 FTEs
Maintenance	10%		$41,600	$4,160	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Contech GAC Filled Storm Filter Change	280	ea	$200	$56,000	Quarterly change out/recycle
T&D of Spent GAC Filters	40	drum	$400	$16,000	1 drum/manhole/event
Undefined Scope Allowance	10%		$191,760	$19,176	
PROJECT MANAGEMENT	8%		$226,936	$18,155	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	15%		$91,176	$13,676	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	
TOTAL PASSIVE WATER TREATMENT SYSTEM:				**$284,000**	
PERIODIC COSTS					
GWTP Periodic Costs					
GWTP Demolition	1	ls	$1,000,000	$1,000,000	Allowance
Well Abandonment (2025)					
Driller Mobilization/Demob	1	ls	$5,000	$5,000	Vendor Quote
Abandon 2-in Wells	195	ea	$1,300	$253,500	Vendor Quote
Abandon 4-in Wells	357	ea	$2,550	$910,350	Vendor Quote
PROJECT MANAGEMENT	6%		$1,168,850	$70,131	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	8%		$1,168,850	$93,508	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	
			Subtotal:	**$1,357,489**	
Maintain Onsite Roads	1	ls	$25,000	$25,000	Allowance - regrade/repair onsite roads
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS

Base Year: 2014 1.9% Discount Rate — OMB - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value
0	Annual O&M Costs (2014)	$0	1.00	$ -
1	Annual O&M Costs (2015)	$0	0.98	$ -
2	Capital Costs (2016)	$18,515,000	0.96	$ 17,830,986
2	Capital Costs (2016)	$6,088,000	0.96	$ 5,863,086
2	Annual O&M Costs	$788,000	0.96	$ 758,888
3	Capital Costs (2017)	$27,756,000	0.95	$ 26,232,177
3	Annual O&M Costs	$788,000	0.95	$ 744,738
3	5 Year Review (2017)	$20,000	0.95	$ 18,902
4	Capital Costs Thermal (midpoint 2018)	$34,958,000	0.93	$ 32,422,750
4	Annual O&M Costs	$788,000	0.93	$ 730,852
5	Annual O&M Costs	$1,642,000	0.91	$ 1,494,522
6	Annual O&M Costs	$9,133,000	0.89	$ 8,157,712
7	Annual O&M Costs	$9,321,000	0.88	$ 8,170,398
8	Annual O&M Costs	$8,467,000	0.86	$ 7,283,432
8	5 Year Review (2022)	$20,000	0.86	$ 17,204
9	Annual O&M Costs	$8,467,000	0.84	$ 7,147,627
10	Annual O&M Costs	$8,467,000	0.83	$ 7,014,355
11	Capital Costs (Passive GWT System)	$1,129,000	0.81	$ 917,863
11	Periodic Cost - Well Abandonment	$1,357,489	0.81	$ 1,103,622
11	Annual O&M Costs	$472,000	0.81	$ 383,730
12	Annual O&M Costs	$472,000	0.80	$ 376,575
12	Capital Costs (Final Cap)	$4,100,000	0.80	$ 3,271,099
13	Annual O&M Costs	$284,000	0.78	$ 222,359
13	5 Year Review (2027)	$20,000	0.78	$ 15,659

TABLE C-5a
Cost Estimate for Alternative 5

DRAFT

	Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)		NOTES
14	Annual O&M Costs				$284,000	0.77	$ 218,213
15	Annual O&M Costs				$284,000	0.75	$ 214,144
16	Annual O&M Costs				$284,000	0.74	$ 210,151
17	Annual O&M Costs				$284,000	0.73	$ 206,233
17	Periodic Cost - GWTP Demolition				$1,000,000	0.73	$ 726,171
18	Annual O&M Costs				$284,000	0.71	$ 202,387
18	5 Year Review (2032)				$20,000	0.71	$ 14,253
19	Annual O&M Costs				$284,000	0.70	$ 198,614
20	Annual O&M Costs				$284,000	0.69	$ 194,910
21	Annual O&M Costs				$284,000	0.67	$ 191,276
22	Annual O&M Costs				$284,000	0.66	$ 187,710
23	Annual O&M Costs				$284,000	0.65	$ 184,210
23	5 Year Review (2037)				$20,000	0.65	$ 12,973
24	Annual O&M Costs				$284,000	0.64	$ 180,775
25	Capital Costs (Road Maintenance)				$25,000	0.62	$ 15,617
25	Annual O&M Costs				$284,000	0.62	$ 177,404
26	Annual O&M Costs				$284,000	0.61	$ 174,096
27	Annual O&M Costs				$284,000	0.60	$ 170,850
28	Annual O&M Costs				$284,000	0.59	$ 167,665
28	5 Year Review (2042)				$20,000	0.59	$ 11,807
29	Annual O&M Costs				$284,000	0.58	$ 164,538
33	5 Year Review (2047)				$20,000	0.54	$ 10,747
38	5 Year Review (2052)				$20,000	0.49	$ 9,782
43	5 Year Review (2057)				$20,000	0.45	$ 8,903
48	5 Year Review (2062)				$20,000	0.41	$ 8,103
53	5 Year Review (2067)				$20,000	0.37	$ 7,376
58	5 Year Review (2072)				$20,000	0.34	$ 6,713
63	5 Year Review (2077)				$20,000	0.31	$ 6,110
68	5 Year Review (2082)				$20,000	0.28	$ 5,561
73	5 Year Review (2087)				$20,000	0.25	$ 5,062
78	5 Year Review (2092)				$20,000	0.23	$ 4,607
83	5 Year Review (2097)				$20,000	0.21	$ 4,193
88	5 Year Review (2102)				$20,000	0.19	$ 3,817
93	5 Year Review (2107)				$20,000	0.17	$ 3,474
98	5 Year Review (2112)				$20,000	0.16	$ 3,162
102	Final Completion Report (2116)				$150,000	0.15	$ 21,995
TOTAL VALUE ANALYSIS					**$149,111,000**		**$134,110,000**

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%. It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

TABLE C-5b
Cost Estimate for Alternative 5a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
GENERAL SITE ACTIVITIES					
Pre-construction Activities - Common Elements (2016)					
Permitting	1	LS	$21,000	$21,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$117,000	$117,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$552,000	$33,120	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$552,000	$44,160	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$552,000	$66,240	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$695,520	$173,880	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$869,000**	
Access Roads (2016)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$3	$4,133	
Project Management	8%		$173,533	$13,883	USEPA 540-R-00-002 Guidance Document
Construction Management	10%		$173,533	$17,353	USEPA 540-R-00-002 Guidance Document
Remedial Design	15%		$173,533	$26,030	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$230,798	$57,700	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$288,000**	
Demolition - Concrete Structures (2016)					
Surface Decontamination	7,200	SY	$10	$72,000	
Concrete Demolition - Easy	2,010	CY	$40	$80,400	
Concrete Demolition - Difficult	6,020	CY	$70	$421,400	
Concrete Crushing	8,030	CY	$60	$481,800	
Spread Crushed Concrete Oniste	8,030	CY	$20	$160,600	
Recycle Rebar	650	TN	-$290	-$188,500	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$250,900	$250,900	Allowance
Project Management	6%		$1,393,800	$83,628	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$1,393,800	$111,504	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$1,393,800	$167,256	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$1,756,188	$439,047	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$2,195,000**	
Debris Removal - Site Wide (2016)					
Excavation/Debris Removal (5-ft)	66,578	CY	$10	$665,780	
Odor Control	12	WK	$9,600	$115,200	
Backfill - Site Wide	66,578	CY	$2	$133,156	
T&D Debris - Hazardous	900	TN	$1,000	$900,000	
Level C PPE Upgrade	1	LS	$332,890	$332,890	Allowance
Project Management	5%		$2,147,026	$107,351	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,147,026	$128,822	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,147,026	$171,762	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,554,961	$638,740	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$3,194,000**	
Miscellaneous Demolition (2016)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose Pilot Plant SP	24,300	SF	$30	$729,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$116,000	$116,000	HCSS Estimate
Odor Control	4	WK	$9,600	$38,400	Allowance
Level C PPE Upgrade	1	LS	$575,350	$575,350	Allowance

TABLE C-5b
Cost Estimate for Alternative 5a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Project Management	6%		$1,900,450	$114,027	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$1,900,450	$152,036	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$1,900,450	$228,054	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,394,567	$598,642	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$2,993,000**	
Storm Water Infiltration Trench (2016)					
Excavation	2,800	CY	$17	$47,600	
P/D Drain Gravel	4,536	TN	$24	$108,864	
Spread Drain Gravel	6,400	TN	$9	$57,600	
Project Management	8%		$214,064	$17,125	USEPA 540-R-00-002 Guidance Document
Construction Management	10%		$214,064	$21,406	USEPA 540-R-00-002 Guidance Document
Remedial Design	15%		$214,064	$32,110	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$284,705	$71,176	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$214,000**	
Rock/Soil/Bulkhead Removal (2017)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	
Crush Rock	16,857	CY	$10	$168,570	
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	Allowance
Project Management	5%		$5,890,725	$294,536	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$5,890,725	$353,444	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$5,890,725	$471,258	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$7,009,963	$1,752,491	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$8,762,000**	
Install New Perimeter SP Wall, Non ISS (2018)					
P/D AZ50 Sheet Pile	3,700	TN	$1,900	$7,030,000	Vendor Quote
Unload Sheet Pile	169	LD	$2,000	$338,000	
Install Perimeter SP Wall (AZ50)	142,200	SF	$11	$1,564,200	
Project Management	5%		$8,932,200	$446,610	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$8,932,200	$535,932	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$8,932,200	$714,576	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$10,629,318	$2,657,330	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$13,287,000**	
Non-ISS Concrete Perimeter Wall (2019)					
Excavation - Non-ISS Perimeter Wall	14,646	CY	$62	$908,052	
Install Concrete Plug	1,475	CY	$220	$324,500	
Odor Control	8	WK	$9,600	$76,800	Allowance
P/D/I Rebar	1,100	TN	$3,000	$3,300,000	
P/D/I Concrete	13,201	CY	$220	$2,904,220	
Project Management	5%		$7,513,572	$375,679	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$7,513,572	$450,814	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$7,513,572	$601,086	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$8,941,151	$2,235,288	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$11,176,000**	
Construct Outfall (2019)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	
Unload Sheet Pile	5	LD	$2,000	$10,000	

TABLE C-5b
Cost Estimate for Alternative 5a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Install Sheet Pile	3,500	SF	$10	$35,000	
Dewatering	20	DY	$800	$16,000	
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	Allowance
Project Management	5%		$2,214,036	$110,702	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,214,036	$132,842	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,214,036	$177,123	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,634,703	$658,676	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$3,293,000**	
Non-ISS Passive Drainage System (2027)					
MH Excavations, Non-ISS PWT	1,500	CY	$35	$52,500	
P/D Manholes & Bases	10	EA	$12,000	$120,000	
Install Manholes & Bases	10	EA	$4,000	$40,000	
Install Contech GAC Storm Filters	1	LS	$15,000	$15,000	
Discharge Line Penetration/Install	10	EA	$7,000	$70,000	
Backfill Manholes	1,500	CY	$30	$45,000	
Excavate French Drains	4,750	CY	$18	$85,500	
P/D/I 12", Slotted HDPE	2,000	LF	$54	$108,000	
Backfill French Drains	4,750	CY	$24	$114,000	
Repair Cap	1,000	SY	$67	$67,000	
Project Management	6%		$717,000	$43,020	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$717,000	$57,360	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$717,000	$86,040	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$903,420	$225,855	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$1,129,000**	
Final Site Cap (2029)					
Subgrade Preparation	39,150	SY	$3	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$7	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900	$63,800	HCSS Estimate
Restoration	13	AC	$3,200	$41,600	Engineer's Estimate
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$4,100,000**	

REMEDIAL ACTION ALTERNATIVE

Alternative 5 - North Unit Jet Grouting (2017)

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Pre-construction Activities					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	
Survey (Throughout Project)	50	DY	$2,900	$145,000	
			Subtotal:	**$255,000**	
MOBILIZATION					
Equipment Costs (Transportation)					
Jet Grout Rig - Casa Grande C-7	1	ea	$25,000	$25,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$28,000	$28,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$3,200	$3,200	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$34,500	$34,500	Engineer's Estimate
Crane Mats	1	ea	$3,200	$3,200	Engineer's Estimate
Crew Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Tool Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Project Trailer and Generator	1	ea	$4,000	$4,000	Engineer's Estimate
Forklift, CAT 1255 12k#	1	ea	$2,000	$2,000	Engineer's Estimate
Excavator, CAT 336D	1	ea	$2,500	$2,500	Engineer's Estimate

TABLE C-5b
Cost Estimate for Alternative 5a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Equipment Costs (2 week Mob)					
Jet Grout Rig	2	wk	$15,000	$30,000	Engineer's Estimate
Batch Plant and Silo(s)	2	wk	$3,900	$7,800	Engineer's Estimate
Grout Pumping System/Metering	2	wk	$3,000	$6,000	Engineer's Estimate
Hose, Connectors, Whip Checks	2	wk	$1,600	$3,200	Engineer's Estimate
Wash Down Tank	2	wk	$1,500	$3,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	2	wk	$750	$1,500	Engineer's Estimate
Forklift, CAT 1255 12k#	2	wk	$3,500	$7,000	Engineer's Estimate
Excavator, CAT 336D	2	wk	$6,000	$12,000	Engineer's Estimate
Crew Truck	2	wk	$1,200	$2,400	Engineer's Estimate
Tool Truck	2	wk	$1,100	$2,200	Engineer's Estimate
Subcontractors					
Electrical	1	LS	$15,000	$15,000	Engineer's Estimate
Welders	1	LS	$25,000	$25,000	Engineer's Estimate
Personnel					
Batch Plan Operator	2	wk	$7,475	$14,950	Engineer's Estimate
Equipment Operator	2	wk	$5,525	$11,050	Engineer's Estimate
Jet Grout Superintendent	2	wk	$6,500	$13,000	Engineer's Estimate
Jet Grout Operator	2	wk	$7,475	$14,950	Engineer's Estimate
Labor, General	2	wk	$3,900	$7,800	Engineer's Estimate
Labor, Foreman	2	wk	$4,550	$9,100	Engineer's Estimate
QA/QC Manager	2	wk	$8,125	$16,250	Engineer's Estimate
Safety Manager	2	wk	$8,125	$16,250	Engineer's Estimate
Miscellaneous					
Per Diem	112	day	$129	$14,448	Standard Per Diem Rate = Washington
			Subtotal:	**$338,298**	
JET GROUTING NORTH UNIT					
Equipment					
Jet Grout Rig	31	wk	$15,000	$465,000	Engineer's Estimate
Hose, Connectors, Whip Checks	31	wk	$1,600	$49,600	Engineer's Estimate
Wash Down Tank	31	wk	$1,500	$46,500	Engineer's Estimate
Excavator, CAT 336D L	31	wk	$6,000	$186,000	Engineer's Estimate
Forklift, CAT 1255 12k#	31	wk	$3,500	$108,500	Engineer's Estimate
Crew Truck	31	wk	$1,200	$37,200	Engineer's Estimate
Batch Plant and Silo(s)	31	wk	$3,900	$120,900	Engineer's Estimate
Horizontal Storage Silo (Pig)	31	wk	$750	$23,250	Engineer's Estimate
Generator, 350 kW	31	wk	$5,000	$155,000	Engineer's Estimate
Generator Fuel	24,800	gal	$4	$99,200	Engineer's Estimate
Tool Truck	31	wk	$1,100	$34,100	Engineer's Estimate
Personnel					
Jet Grout Operator	31	wk	$7,475	$231,725	Engineer's Estimate
Equipment Operator	31	wk	$5,525	$171,275	Engineer's Estimate
Batch Plan Operator	31	wk	$7,475	$231,725	Engineer's Estimate
Labor, Foreman	31	wk	$4,550	$141,050	Engineer's Estimate
Labor, General	31	wk	$3,900	$120,900	Engineer's Estimate
Jet Grout Superintendent	31	wk	$6,500	$201,500	Engineer's Estimate
QA/QC Manager	31	wk	$8,125	$251,875	Engineer's Estimate
Safety Manager	31	wk	$8,125	$251,875	Engineer's Estimate
Materials					
P/D Portland Cement	1,300	tn	$125	$162,500	Engineer's Estimate
P/D Bentonite	65	tn	$325	$21,125	Engineer's Estimate
Miscellaneous					
Per Diems	1,736	day	$129	$223,944	Standard Per Diem Rate = Washington
			Subtotal:	**$3,334,744**	
DEMOBILIZATION					
Equipment Costs (Transportation)					
Jet Grout Rig - Casa Grande C-7	1	ea	$12,500	$12,500	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$14,000	$14,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$1,600	$1,600	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$17,250	$17,250	Engineer's Estimate
Crane Mats	1	ea	$1,600	$1,600	Engineer's Estimate
Crew Truck	1	ea	$750	$750	Engineer's Estimate
Tool Truck	1	ea	$750	$750	Engineer's Estimate
Project Trailer and Generator	1	ea	$2,000	$2,000	Engineer's Estimate
Forklift	1	ea	$1,000	$1,000	Engineer's Estimate
Excavator, CAT 336D	1	ea	$1,250	$1,250	Engineer's Estimate

TABLE C-5b
Cost Estimate for Alternative 5a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Equipment Costs (1 week Demob)					
Jet Grout Rig	1	wk	$15,000	$15,000	Engineer's Estimate
Batch Plant and Silo(s)	1	wk	$3,900	$3,900	Engineer's Estimate
Grout Pumping System/Metering	1	wk	$3,000	$3,000	Engineer's Estimate
Hose, Connectors, Whip Checks	1	wk	$1,600	$1,600	Engineer's Estimate
Wash Down Tank	1	wk	$1,500	$1,500	Engineer's Estimate
Horizontal Storage Silo (Pig)	1	wk	$750	$750	Engineer's Estimate
Forklift, CAT 1255 12k#	1	wk	$3,500	$3,500	Engineer's Estimate
Excavator, CAT 336D	1	wk	$6,000	$6,000	Engineer's Estimate
Crew Truck	1	wk	$1,200	$1,200	Engineer's Estimate
Tool Truck	1	wk	$1,100	$1,100	Engineer's Estimate
Personnel					
Batch Plan Operator	1	wk	$7,475	$7,475	Engineer's Estimate
Equipment Operator	1	wk	$5,525	$5,525	Engineer's Estimate
Jet Grout Superintendent	1	wk	$6,500	$6,500	Engineer's Estimate
Jet Grout Operator	1	wk	$7,475	$7,475	Engineer's Estimate
Labor, General	1	wk	$4,550	$4,550	Engineer's Estimate
Labor, Foreman	1	wk	$3,900	$3,900	Engineer's Estimate
QA/QC Manager	1	wk	$8,125	$8,125	Engineer's Estimate
Safety Manager	1	wk	$8,125	$8,125	Engineer's Estimate
Miscellaneous					
Per Diem	56	day	$129	$7,224	Standard Per Diem Rate = Washington
			Subtotal:	**$149,149**	
PROJECT MANAGEMENT	5%		$4,077,191	$203,860	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$4,077,191	$244,631	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$4,077,191	$244,631	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$793,122**	
CONTINGENCY (10% scope + 15% bid)	25%		$4,870,313	$1,217,578	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS JET GROUTING				**$6,088,000**	
Alternative 5 - Thermal (2020-2022)					
Pre-construction Activities					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	
			Subtotal:	**$110,000**	
Mob/Demob					
P/D AZ36-700N Sheet Pile	2,509	TN	$1,700	$4,266,304	Vendor Quote
Unload Sheet Pile	114	LD	$2,000	$228,000	Engineer's Estimate
Install AZ36-700N Sheet Pile	145,043	SF	$10	$1,450,430	Engineer's Estimate
Install Dewatering Wells	27	ea	$25,000	$675,000	Engineer's Estimate
Dewatering Well Completions	27	ea	$350	$9,450	Engineer's Estimate
Install Steam Injection Wells	172	ea	$15,000	$2,580,000	Engineer's Estimate
Injection Well Completions	172	ea	$450	$77,400	Engineer's Estimate
Steam Injection Well Piping/System	1	ls	$460,000	$460,000	Engineer's Estimate
Install Extraction Wells	147	ea	$5,700	$837,900	Engineer's Estimate
Extraction Well Completions	147	ea	$450	$66,150	Engineer's Estimate
Install Extraction Well Head System	49	ea	$2,500	$122,500	Engineer's Estimate
Allowance to Relocate Well Heads	197	ea	$1,500	$295,500	Engineer's Estimate
Install Biosparge Wells	31	ea	$5,000	$155,000	Engineer's Estimate
Biosparge Well Completions	31	ea	$350	$10,850	Engineer's Estimate
Install Biosparge Wellhead and Header Piping/Valves	31	ea	$2,500	$77,500	Engineer's Estimate
Install Thermocouple Borings	201	ea	$2,800	$562,800	Engineer's Estimate
Purchase Thermocouples	589	ea	$1,500	$883,500	Engineer's Estimate
Install Thermocouples	7,068	ft	$25	$176,700	Engineer's Estimate
Thermocouple Completions	201	ea	$350	$70,350	Engineer's Estimate
Install Vapor Collection Layer	8,985	tn	$20	$179,700	Engineer's Estimate
Install Vapor Collection Piping	462	ft	$25	$11,550	Engineer's Estimate
Install Select Fill Below Vapor Cap	6,739	tn	$25	$168,475	Engineer's Estimate
Temp Geomembrane over VC	28,881	sy	$7	$202,167	Engineer's Estimate
Temp VC Pipe Penetrations	84	ea	$500	$42,000	Engineer's Estimate
Install Cushion Geotextile	28,881	sy	$2	$57,762	Engineer's Estimate
Install Fill Above VC (18")	20,217	tn	$25	$505,425	Engineer's Estimate
Surface Top Coarse (6")	6,739	tn	$25	$168,475	Engineer's Estimate
Steam Supply Header Materials	8,550	ft	$45	$384,750	Engineer's Estimate

TABLE C-5b
Cost Estimate for Alternative 5a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Allowance for Steam Valves/I&C	1	ls	$75,000	$75,000	Engineer's Estimate
Air Supply Piping Header	10,645	ft	$20	$212,900	Engineer's Estimate
Vapor Extraction Piping	8,550	ft	$55	$470,250	Engineer's Estimate
Extracted Water Piping	10,645	ft	$20	$212,900	Engineer's Estimate
Install Air/Vapor/Extraction Piping	38,390	ft	$7	$268,730	Engineer's Estimate
Installation of 6' Pipe Rack	940	ea	$400	$376,000	Engineer's Estimate
Installation of 15' Pipe Rack	127	ea	$750	$95,250	Engineer's Estimate
Allowance for Extraction Valves/I&C	1	ls	$100,000	$100,000	Engineer's Estimate
Corrosion Protection for wells	377	ls	$500	$188,500	Engineer's Estimate
			Subtotal:	**$16,725,168**	
Vapor and GW Treatment System					
Site Preparation	1	ls	$30,000	$30,000	Engineer's Estimate
Concrete Slab on Grade	1,400	cy	$350	$490,000	Engineer's Estimate
Secondary Containment Walls	13	CY	$350	$4,550	Engineer's Estimate
P/D Diesel Generators	2	ea	$600,000	$1,200,000	Engineer's Estimate
P/D Direct Contact Condenser	1	ea	$415,000	$415,000	Engineer's Estimate
P/D VLS, LRVP, Therm-OX Package	1	ea	$100,000	$100,000	Engineer's Estimate
P/D Solids Dewater Screw Conveyor	2	ea	$135,000	$270,000	Engineer's Estimate
P/D Cooling Tower	1	ea	$41,000	$41,000	Engineer's Estimate
Cooling Water Chemical/Makeup Treatment Systems	1	ls	$150,000	$150,000	Allowance
P/D Heat Exchanger H-1	2	ea	$11,500	$23,000	Engineer's Estimate
P/D Heat Exchanger H-2	2	ea	$15,000	$30,000	Engineer's Estimate
P/D Accumulation Tank	1	ea	$97,000	$97,000	Engineer's Estimate
P/D Oil/Water Separator	1	ea	$310,000	$310,000	Engineer's Estimate
P/D Solids NAPL Holding Tank	1	ea	$92,000	$92,000	Engineer's Estimate
P/D Air Compressor	1	ea	$11,000	$11,000	Engineer's Estimate
P/D Pumps	20	ea	$10,000	$200,000	Engineer's Estimate
P/D DAF	1	ea	$357,000	$357,000	Engineer's Estimate
P/D Walnut Filter	1	ea	$300,000	$300,000	Engineer's Estimate
Equipment Installation (15% of equipment cost)	1	ls	$400,000	$400,000	Allowance
Process Piping (5% of equip cost)	1	ls	$132,000	$132,000	Allowance
I&C (15% of equipment cost)	1	ls	$400,000	$400,000	Allowance
Electrical (20% of equipment cost)	1	ls	$530,000	$530,000	Allowance
Solids Handling Rain Shelter	600	sf	$200	$120,000	Allowance
Electrical/I&C Building (30% of cost)	1	ls	$36,000	$36,000	Allowance
			Subtotal:	**$5,738,550**	
Boiler Propane System					
Site Preparation	1	ls	$15,000	$15,000	Engineer's Estimate
Concrete Slab on Grade	125	cy	$350	$43,750	Engineer's Estimate
Install Propane Tank	1	ls	$30,000	$30,000	Allowance
Install Vaporizer	1	ls	$30,000	$30,000	Allowance
Setup Boiler System	1	ls	$75,000	$75,000	Allowance
Monthly Rental of Boiler System	60	mo	$17,500	$1,050,000	Nationwide Boiler Quote. Includes softener and feed water pump.
			Subtotal:	**$1,243,750**	
PROJECT MANAGEMENT	5%		$23,817,468	$1,190,873	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$23,817,468	$1,429,048	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$23,817,468	$1,429,048	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$4,148,969**	
CONTINGENCY (10% scope + 15% bid)	25%		$27,966,437	$6,991,609	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS THERMAL				**$34,958,000**	

OPERATION & MAINTENANCE COSTS

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
OPERATION & MAINTENANCE COSTS OF GWTP (through 2027)					
Annual O&M					
Operator(s)	4,160	hr	$80	$332,800	2 FTEs Operating GWTP
Electrical Usage	1	ls	$60,000	$60,000	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Waste Disposal	1	ls	$100,000	$100,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$20,000	$20,000	Allowance
Maintenance	10%		$512,800	$51,280	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	

TABLE C-5b
Cost Estimate for Alternative 5a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
Undefined Scope Allowance	10%		$654,080	$65,408	
PROJECT MANAGEMENT	6%		$719,488	$43,169	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL O&M COSTS - GWTP				**$788,000**	
OPERATION & MAINTENANCE COSTS OF NAPL RECOVERY (2022 through 2024)					
Annual O&M					
Disposal - NAPL Waste	47,000	gal	$7	$329,000	Vendor Quote; 140,000-gal over 3 yrs
Transportation - NAPL Waste	22	load	$6,400	$140,800	Vendor Quote
Well field Analysis&Sampling Team	1,040	hr	$80	$83,200	Engineer's Estimate
Laboratory Analysis	260	ls	$300	$78,000	Engineer's Estimate
PPE Allowance	1,040	hr	$15	$15,600	Allowance
Maintenance	10%		$646,600	$64,660	Allowance
Undefined Scope Allowance	10%		$711,260	$71,126	
PROJECT MANAGEMENT	6%		$782,386	$46,943	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - NAPL RECOVERY				**$854,000**	
OPERATION & MAINTENANCE COSTS OF EAB (2024 through 2029)					
EAB					
Operator(s)	1,040	hr	$80	$83,200	1/2 yr running EAB System
Supervisor	208	hr	$100	$20,800	20% of operator time
Electrical	1	ls	$16,000	$16,000	Engineer's Estimate
Nutrient Chemicals/Media	1	ls	$11,000	$11,000	
System Maintenance	5%		$131,000	$6,550	Allowance
Undefined Scope Allowance	10%		$137,550	$13,755	
PROJECT MANAGEMENT	8%		$151,305	$12,104	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - EAB RECOVERY				**$188,000**	
OPERATION & MAINTENANCE COSTS OF THERMAL (2023 through 2027)					
Annual O&M					
Operator(s)	16,640	hr	$80	$1,331,200	8 FTEs running system 24/7
Supervisor	4,160	hr	$100	$416,000	2 FTE
Electrical Usage	1	ls	$103,385	$103,385	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Diesel Generator	12	mo	$20,600	$247,200	5150 gal/mo @ $4/gal
Propane	12	mo	$266,600	$3,199,200	86,000-gal/mo@$3.10/gal
Disposal - NAPL Waste	13,000	gal	$7	$91,000	Vendor Quote; 14,000-gal/yr
Transportation - NAPL Waste	6	load	$6,400	$38,400	Vendor Quote
Disposal - Naphthalene Waste	264	tn	$660	$174,240	Engineer's Estimate
Transportation - Naphthalene Waste	12	ld	$1,360	$16,320	22 tn/load => 16 hrs/load haul time
Waste Disposal - Carbon/Filter Media	1	ls	$86,000	$86,000	Allowance
Well field Analysis&Sampling Team	1,040	hr	$80	$83,200	Engineer's Estimate
Laboratory Analysis	260	ls	$300	$78,000	Engineer's Estimate
PPE Allowance	16,640	hr	$0.75	$12,480	Allowance - hard hats, boots, work gloves, safety glasses, Tyvek and other consumables
Maintenance	10%		$5,876,625	$587,663	Allowance
Undefined Scope Allowance	10%		$6,464,288	$646,429	
PROJECT MANAGEMENT	5%		$7,110,716	$355,536	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - THERMAL				**$7,491,000**	

TABLE C-5b
Cost Estimate for Alternative 5a

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
OPERATION & MAINTENANCE COSTS OF PASSIVE GROUNDWATER TREATMENT SYSTEM (2028 through 2043)					
Operator(s)	520	hr	$80	$41,600	0.25 FTEs
Maintenance	10%		$41,600	$4,160	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Contech GAC Filled Storm Filter Change	280	ea	$200	$56,000	Quarterly change out/recycle
T&D of Spent GAC Filters	40	drum	$400	$16,000	1 drum/manhole/event
Undefined Scope Allowance	10%		$191,760	$19,176	
PROJECT MANAGEMENT	8%		$226,936	$18,155	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	15%		$91,176	$13,676	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	
TOTAL O&M COSTS - PASSIVE WATER TREATMENT SYSTEM:				**$284,000**	
PERIODIC COSTS					
GWTP Periodic Costs					
GWTP Demolition	1	ls	$1,000,000	$1,000,000	Allowance
Well Abandonment (2029)					
Driller Mobilization/Demob	1	ls	$5,000	$5,000	Vendor Quote
Abandon 2-in Wells	195	ea	$1,300	$253,500	Vendor Quote
Abandon 4-in Wells	357	ea	$2,550	$910,350	Vendor Quote
PROJECT MANAGEMENT	6%		$1,168,850	$70,131	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	8%		$1,168,850	$93,508	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	
			Subtotal:	**$1,357,489**	
Maintain Onsite Roads	1	ls	$25,000	$25,000	Allowance - regrade/repair onsite roads
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS

Base Year: 2014 1.9% Discount Rate — OMB - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value
0	Annual O&M Costs (2014)	$0	1.00	$ -
1	Annual O&M Costs (2015)	$0	0.98	$ -
2	Capital Costs (2016)	$9,753,000	0.96	$ 9,392,687
2	Annual O&M Costs (2016)	$788,000	0.96	$ 758,888
3	Capital Costs (2017)	$14,850,000	0.95	$ 14,034,725
3	Annual O&M Costs (2017)	$788,000	0.95	$ 744,738
3	5 Year Review (2017)	$20,000	0.95	$ 18,902
4	Capital Costs (2018)	$13,287,000	0.93	$ 12,323,390
4	Annual O&M Costs (2018)	$788,000	0.93	$ 730,852
5	Capital Costs (2019)	$14,469,000	0.91	$ 13,169,449
5	Annual O&M Costs (2019)	$788,000	0.91	$ 717,225
6	Capital Costs (2020)	$11,652,667	0.89	$ 10,408,310
6	Annual O&M Costs (2020)	$788,000	0.89	$ 703,852
7	Capital Costs (2021)	$11,652,667	0.88	$ 10,214,239
7	Annual O&M Costs (2021)	$788,000	0.88	$ 690,728
8	Capital Costs (2022)	$11,652,667	0.86	$ 10,023,788
8	Annual O&M Costs (2022)	$1,642,000	0.86	$ 1,412,471
8	5 Year Review (2022)	$20,000	0.86	$ 17,204
9	Annual O&M Costs (2023)	$9,133,000	0.84	$ 7,709,848
10	Annual O&M Costs (2024)	$9,321,000	0.83	$ 7,721,838
11	Annual O&M Costs (2025)	$8,467,000	0.81	$ 6,883,567
12	Annual O&M Costs (2026)	$8,467,000	0.80	$ 6,755,218

TABLE C-5b
Cost Estimate for Alternative 5a

DRAFT

	Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)		NOTES
13	Capital Costs (2027)				$1,129,000	0.78	$ 883,954
13	Capital Costs (2027)				$1,357,489	0.78	$ 1,062,850
13	Annual O&M Costs (2027)				$8,467,000	0.78	$ 6,629,262
13	5 Year Review (2027)				$20,000	0.78	$ 15,659
14	Annual O&M Costs (2028)				$472,000	0.77	$ 362,663
15	Capital Costs (2029)				$4,100,000	0.75	$ 3,091,513
15	Annual O&M Costs (2029)				$472,000	0.75	$ 355,901
16	Annual O&M Costs (2030)				$284,000	0.74	$ 210,151
17	Capital Cost (2031)				$1,000,000	0.73	$ 726,171
17	Annual O&M Costs (2031)				$284,000	0.73	$ 206,233
18	Annual O&M Costs (2032)				$284,000	0.71	$ 202,387
18	5 Year Review (2032)				$20,000	0.71	$ 14,253
19	Annual O&M Costs (2033)				$284,000	0.70	$ 198,614
20	Annual O&M Costs (2034)				$284,000	0.69	$ 194,910
21	Annual O&M Costs (2035)				$284,000	0.67	$ 191,276
22	Annual O&M Costs (2036)				$284,000	0.66	$ 187,710
23	Annual O&M Costs (2037)				$284,000	0.65	$ 184,210
23	5 Year Review (2037)				$20,000	0.65	$ 12,973
24	Annual O&M Costs (2038)				$284,000	0.64	$ 180,775
25	Capital Costs (2039)				$25,000	0.62	$ 15,617
25	Annual O&M Costs (2039)				$284,000	0.62	$ 177,404
26	Annual O&M Costs (2040)				$284,000	0.61	$ 174,096
27	Annual O&M Costs (2041)				$284,000	0.60	$ 170,850
28	Annual O&M Costs (2042)				$284,000	0.59	$ 167,665
28	5 Year Review (2042)				$20,000	0.59	$ 11,807
29	Annual O&M Costs (2043)				$284,000	0.58	$ 164,538
30	Annual O&M Costs (2044)				$284,000	0.57	$ 161,470
31	Annual O&M Costs (2045)				$284,000	0.56	$ 158,460
32	Annual O&M Costs (2046)				$284,000	0.55	$ 155,505
33	5 Year Review (2047)				$20,000	0.54	$ 10,747
38	5 Year Review (2052)				$20,000	0.49	$ 9,782
43	5 Year Review (2057)				$20,000	0.45	$ 8,903
48	5 Year Review (2062)				$20,000	0.41	$ 8,103
53	5 Year Review (2067)				$20,000	0.37	$ 7,376
58	5 Year Review (2072)				$20,000	0.34	$ 6,713
63	5 Year Review (2077)				$20,000	0.31	$ 6,110
68	5 Year Review (2082)				$20,000	0.28	$ 5,561
73	5 Year Review (2087)				$20,000	0.25	$ 5,062
78	5 Year Review (2092)				$20,000	0.23	$ 4,607
83	5 Year Review (2097)				$20,000	0.21	$ 4,193
88	5 Year Review (2102)				$20,000	0.19	$ 3,817
93	5 Year Review (2107)				$20,000	0.17	$ 3,474
98	5 Year Review (2112)				$20,000	0.16	$ 3,162
102	Final Completion Report (2116)				$150,000	0.15	$ 21,995
TOTAL VALUE ANALYSIS					**$151,475,000**		**$130,810,000**

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%. It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

Alternative 6 - MTTD and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
GENERAL SITE ACTIVITIES					
Pre-construction Activites - Common Elements (2016)					
Permitting	1	LS	$21,000	$21,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$117,000	$117,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$552,000	$33,120	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$552,000	$44,160	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$552,000	$66,240	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$695,520	$173,880	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$869,000**	
Access Roads (2016)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$3	$4,133	
Project Management	8%		$173,533	$13,883	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$173,533	$17,353	USEPA 540-R-00-002 Guidence Document
Remedial Design	15%		$173,533	$26,030	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$230,798	$57,700	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$288,000**	
Demolition - Concrete Structures (2016)					
Surface Decontamination	7,200	SY	$10	$72,000	
Concrete Demolition - Easy	2,010	CY	$40	$80,400	
Concrete Demolition - Difficult	6,020	CY	$70	$421,400	
Concrete Crushing	8,030	CY	$60	$481,800	
Spread Crushed Concrete Oniste	8,030	CY	$20	$160,600	
Recycle Rebar	650	TN	-$290	-$188,500	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$250,900	$250,900	Allowance
Project Management	6%		$1,393,800	$83,628	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$1,393,800	$111,504	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$1,393,800	$167,256	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$1,756,188	$439,047	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$2,195,000**	
Debris Removal - Site Wide (2016)					
Excavation/Debris Removal (5-ft)	66,578	CY	$10	$665,780	
Odor Control	12	WK	$9,600	$115,200	
Backfill - Site Wide	66,578	CY	$2	$133,156	
T&D Debris - Hazardous	900	TN	$1,000	$900,000	
Level C PPE Upgrade	1	LS	$332,890	$332,890	Allowance
Project Management	5%		$2,147,026	$107,351	USEPA 540-R-00-002 Guidence Document

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Construction Management	6%		$2,147,026	$128,822	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,147,026	$171,762	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,554,961	$638,740	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,194,000**	
Rock/Soil/Bulkhead Removal (2016)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	
Crush Rock	16,857	CY	$10	$168,570	
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	Allowance
Project Management	5%		$5,890,725	$294,536	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$5,890,725	$353,444	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$5,890,725	$471,258	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$7,009,963	$1,752,491	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$8,762,000**	
Miscellaneous Demolition (2016)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose Pilot Plant SP	24,300	SF	$30	$729,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$116,000	$116,000	HCSS Estimate
Odor Control	4	WK	$9,600	$38,400	Allowance
Level C PPE Upgrade	1	LS	$575,350	$575,350	Allowance
Project Management	6%		$1,900,450	$114,027	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$1,900,450	$152,036	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$1,900,450	$228,054	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,394,567	$598,642	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$2,993,000**	
Storm Water Infiltration Trench (2016)					
Excavation	2,800	CY	$17	$47,600	
P/D Drain Gravel	4,536	TN	$24	$108,864	
Spread Drain Gravel	6,400	TN	$9	$57,600	
Project Management	8%		$214,064	$17,125	USEPA 540-R-00-002 Guidence Document
Construction Management	10%		$214,064	$21,406	USEPA 540-R-00-002 Guidence Document
Remedial Design	15%		$214,064	$32,110	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$284,705	$71,176	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$214,000**	
Install New Perimeter SP Wall, Non ISS (2017)					

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
P/D AZ50 Sheet Pile	3,700	TN	$1,900	$7,030,000	Vendor Quote
Unload Sheet Pile	169	LD	$2,000	$338,000	
Install Perimeter SP Wall (AZ50)	142,200	SF	$11	$1,564,200	
Project Management	5%		$8,932,200	$446,610	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$8,932,200	$535,932	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$8,932,200	$714,576	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$10,629,318	$2,657,330	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$13,287,000**	
Construct Outfall (2017)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	HCSS Estimate
Unload Sheet Pile	5	LD	$2,000	$10,000	HCSS Estimate
Install Sheet Pile	3,500	SF	$10	$35,000	HCSS Estimate
Dewatering	20	DY	$800	$16,000	HCSS Estimate
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	HCSS Estimate
Project Management	5%		$2,214,036	$110,702	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,214,036	$132,842	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,214,036	$177,123	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$2,634,703	$658,676	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$3,293,000**	
Non-ISS Passive Drainage System (2025)					
MH Excavations, Non-ISS PWT	1,500	CY	$35	$52,500	
P/D Manholes & Bases	10	EA	$12,000	$120,000	
Install Manholes & Bases	10	EA	$4,000	$40,000	
Install Contech GAC Storm Filters	1	LS	$15,000	$15,000	
Discharge Line Penetration/Install	10	EA	$7,000	$70,000	
Backfill Manholes	1,500	CY	$30	$45,000	
Excavate French Drains	4,750	CY	$18	$85,500	
P/D/I 12", Slotted HDPE	2,000	LF	$54	$108,000	
Backfill French Drains	4,750	CY	$24	$114,000	
Repair Cap	1,000	SY	$67	$67,000	
Project Management	6%		$717,000	$43,020	USEPA 540-R-00-002 Guidence Document
Construction Management	8%		$717,000	$57,360	USEPA 540-R-00-002 Guidence Document
Remedial Design	12%		$717,000	$86,040	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$903,420	$225,855	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$1,129,000**	
Final Site Cap (2028)					
Subgrade Preparation	39,150	SY	$3.00	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$6.75	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2.25	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900	$63,800	HCSS Estimate
Restoration	13	AC	$3,200.00	$41,600	Engineer's Estimate

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$4,100,000**	
Non-ISS Concrete Perimeter Wall (2028)					
Excavation - Non-ISS Perimeter Wall	14,646	CY	$62	$908,052	
Install Concrete Plug	1,475	CY	$220	$324,500	
Odor Control	8	WK	$9,600	$76,800	Allowance
P/D/I Rebar	1,100	TN	$3,000	$3,300,000	
P/D/I Concrete	13,201	CY	$220	$2,904,220	
Project Management	5%		$7,513,572	$375,679	USEPA 540-R-00-002 Guidence Document
Construction Management	6%		$7,513,572	$450,814	USEPA 540-R-00-002 Guidence Document
Remedial Design	8%		$7,513,572	$601,086	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$8,941,151	$2,235,288	USEPA 540-R-00-002 Guidence Document
			Subtotal:	**$11,176,000**	
REMEDIAL ACTION ALTERNATIVE					
Alternative 6 - Thermal (Midpoint 2019)					
Pre-construction Activities					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	
			Subtotal:	**$110,000**	
Mob/Demob					
P/D AZ36-700N Sheet Pile	4,331	TN	$1,600	$6,929,600	Vendor Quote
Unload Sheet Pile	114	LD	$1,200	$136,800	Engineer's Estimate
Install AZ36-700N Sheet Pile	189,255	SF	$10	$1,892,550	Engineer's Estimate
Install Dewatering Wells	27	ea	$25,000	$675,000	Engineer's Estimate
Dewatering Well Completions	27	ea	$350	$9,450	Engineer's Estimate
Install Steam Injection Wells	183	ea	$15,000	$2,745,000	Engineer's Estimate
Injection Well Completions	183	ea	$450	$82,350	Engineer's Estimate
Steam Injection Well Piping/System	1	ls	$460,000	$460,000	Engineer's Estimate
Install Extraction Wells	147	ea	$5,700	$837,900	Engineer's Estimate
Extraction Well Completions	147	ea	$450	$66,150	Engineer's Estimate
Install Extraction Well Head System	49	ea	$2,500	$122,500	Engineer's Estimate
Allowance to Relocate Well Heads	220	ea	$1,500	$330,000	Engineer's Estimate
Install Biosparge Wells	31	ea	$5,000	$155,000	Engineer's Estimate
Biosparge Well Completions	31	ea	$350	$10,850	Engineer's Estimate
Install Biosparge Wellhead and Header Piping/Valves	31	ea	$2,500	$77,500	Engineer's Estimate
Install Thermocouple Borings	238	ea	$2,800	$666,400	Engineer's Estimate
Purchase Thermocouples	589	ea	$1,500	$883,500	Engineer's Estimate
Install Thermocouples	7,068	ft	$25	$176,700	Engineer's Estimate
Thermocouple Completions	238	ea	$350	$83,300	Engineer's Estimate
Install Vapor Collection Layer	8,168	tn	$20	$163,360	Engineer's Estimate
Install Vapor Collection Piping	3,420	ft	$25	$85,500	Engineer's Estimate
Install Select Fill Below Vapor Cap	6,126	tn	$25	$153,150	Engineer's Estimate
Temp Geomembrane over VC	26,255	SY	$7	$183,785	Engineer's Estimate

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Temp VC Pipe Penetrations	76	ea	$500	$38,000	Engineer's Estimate
Install Cushion Geotextile	26,255	SY	$2	$52,510	Engineer's Estimate
Install Fill Above VC (18")	18,379	tn	$25	$459,475	Engineer's Estimate
Surface Top Coarse (6")	6,126	tn	$25	$153,150	Engineer's Estimate
Steam Supply Header Materials	10,645	ft	$45	$479,025	Engineer's Estimate
Allowance for Steam Valves/I&C	1	ls	$75,000	$75,000	Engineer's Estimate
Air Supply Piping Header	10,645	ft	$20	$212,900	Engineer's Estimate
Vapor Extraction Piping	10,645	ft	$55	$585,475	Engineer's Estimate
Extracted Water Piping	10,645	ft	$20	$212,900	Engineer's Estimate
Install Air/Vapor/Extraction Piping	42,580	ft	$7	$298,060	Engineer's Estimate
Installation of 6' Pipe Rack	940	ea	$400	$376,000	Engineer's Estimate
Installation of 15' Pipe Rack	127	ea	$750	$95,250	Engineer's Estimate
Allowance for Extraction Valves/I&C	1	ls	$100,000	$100,000	Engineer's Estimate
Corrosion Protection for wells	388	ls	$500	$194,000	Engineer's Estimate
			Subtotal:	**$20,258,090**	
Vapor and GW Treatment System					
Site Preparation	1	ls	$30,000	$30,000	Engineer's Estimate
Concrete Slab on Grade	1,400	cy	$350	$490,000	Engineer's Estimate
Secondary Containment Walls	13	CY	$350	$4,550	Engineer's Estimate
P/D Diesel Generators	2	ea	$600,000	$1,200,000	Engineer's Estimate
P/D Direct Contact Condenser	1	ea	$415,000	$415,000	Engineer's Estimate
P/D VLS, LRVP, Therm-OX Package	1	ea	$100,000	$100,000	Engineer's Estimate
P/D Solids Dewater Screw Conveyor	2	ea	$135,000	$270,000	Engineer's Estimate
P/D Cooling Tower	1	ea	$41,000	$41,000	Engineer's Estimate
Cooling Water Chemical/Makeup Treatment Systems	1	ls	$150,000	$150,000	Allowance
P/D Heat Exchanger H-1	2	ea	$11,500	$23,000	Engineer's Estimate
P/D Heat Exchanger H-2	2	ea	$15,000	$30,000	Engineer's Estimate
P/D Accumulation Tank	1	ea	$97,000	$97,000	Engineer's Estimate
P/D Oil/Water Separator	1	ea	$310,000	$310,000	Engineer's Estimate
P/D Solids NAPL Holding Tank	1	ea	$92,000	$92,000	Engineer's Estimate
P/D Air Compressor	1	ea	$11,000	$11,000	Engineer's Estimate
P/D Pumps	20	ea	$10,000	$200,000	Engineer's Estimate
P/D DAF	1	ea	$357,000	$357,000	Engineer's Estimate
P/D Walnut Filter	1	ea	$300,000	$300,000	Engineer's Estimate
Equipment Installation (15% of equipment cost)	1	ls	$400,000	$400,000	Allowance
Process Piping (5% of equip cost)	1	ls	$132,000	$132,000	Allowance
I&C (15% of equipment cost)	1	ls	$400,000	$400,000	Allowance
Electrical (20% of equipment cost)	1	ls	$530,000	$530,000	Allowance
Solids Handling Rain Shelter	600	sf	$200	$120,000	Allowance
Electrical/I&C Building (30% of cost)	1	ls	$36,000	$36,000	Allowance
			Subtotal:	**$5,738,550**	
Boiler Propane System					
Site Preparation	1	ls	$15,000	$15,000	Engineer's Estimate
Concrete Slab on Grade	125	cy	$350	$43,750	Engineer's Estimate
Install Propane Tank	1	ls	$30,000	$30,000	Allowance
Install Vaporizor	1	ls	$30,000	$30,000	Allowance
Setup Boiler System	1	ls	$75,000	$75,000	Allowance
Monthly Rental of Boiler System	60	mo	$17,500	$1,050,000	Nationwide Boiler Quote. Includes softener and feedwater pump.
			Subtotal:	**$1,243,750**	
PROJECT MANAGEMENT	5%		$27,350,390	$1,367,520	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$27,350,390	$1,641,023	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$27,350,390	$1,641,023	Based on EPA 540-R-00-002

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$4,749,566**	
CONTINGENCY (10% scope + 15% bid)	25%		$32,099,956	$8,024,989	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS - THERMAL				**$40,125,000**	
Alternative 6 - MTTD (Midpoint 2018)					
Sheet Pile, Whalers, and Struts					
P/D AZ50 Sheet Pile	3,186	TN	$1,900	$6,053,400	Vendor Quote
P/D AZ36-700N Sheet Pile	1,148	TN	$2,000	$2,296,000	Vendor Quote
P/D Whalers	302	TN	$1,400	$422,800	Vendor Quote
P/D Struts	500	TN	$1,500	$750,000	Vendor Quote
Unload Sheet Pile, Whalers, struts	241	LD	$2,000	$482,000	Engineer's Estimate
Install AZ50 Sheet Pile	123,000	SF	$20	$2,460,000	HCSS Estimate
Install AZ36-700N Sheet Pile	66,349	SF	$10	$663,490	HCSS Estimate
P/D Controlled Density Fill (CDF)	2,110	cy	$220	$464,200	HCSS Estimate
Derrick barge, 2 days+tug+plus fuel	1	ls	$100,000	$100,000	Engineer's Estimate
Demobilize GC Derrick Barge+tug	1	ls	$100,000	$100,000	Engineer's Estimate
Demobilize MTTD Equipment	1	ls	$96,000	$96,000	Engineer's Estimate
Holding Cell (124' x 120')					
P/D/P Ecology Blocks	200	ea	$400	$80,000	Vendor Quote
Subgrade Preparation	1,500	sy	$3	$4,500	HCSS Estimate
Geotextile	1,600	sy	$7	$10,800	Engineer's Estimate
P/D/P Structural Fill (6")	230	cy	$20	$4,600	HCSS Estimate
P/D/P Agg Base (3")	184	tn	$10	$1,840	HCSS Estimate
P/D/P/Seal AC Pavement	230	tn	$190	$43,700	HCSS Estimate
Material Handling Building (100' x 300')					
Sprung Structure (or similar)	30,000	sf	$40	$1,200,000	Enclosed/Insulated Metal Frame Structure
Subgrade Preparation	3,111	sy	$3	$9,333	HCSS Estimate
P/D/P Geotextile	2,700	sy	$7	$18,225	Engineer's Estimate
P/D/P Structural Fill (6")	450	cy	$20	$9,000	HCSS Estimate
P/D/P Agg Base (3")	360	tn	$10	$3,600	HCSS Estimate
P/D/P/Seal AC Pavement	450	ton	$190	$85,500	HCSS Estimate
Perimeter Foundation	170	cy	$350	$59,500	HCSS Estimate
Interior Lighting	1	ls	$20,000	$20,000	Allowance
Construct Dump Ramp	40	ea	$400	$16,000	Ecology Blocks
Weather Station	1	ls	$4,000	$4,000	Allowance
Building Protection	300	ea	$400	$120,000	Ecology Blocks
MHB Operating Costs	12	mo	$78,500	$942,000	2 operators, Loader, skid steer, mixer/tiller
Sheet Pile Cell Excavation	12	mo	$135,000	$1,620,000	Long reach excavator/clamshell; two off road haul trucks; dozer; H2O truck; four operators
Propane Tank					
Subgrade Preparation	284	sy	$3	$853	
P/D/P Structural Fill (6")	35	cy	$20	$700	HCSS Estimate
P/D/P Agg Base (3")	24	tn	$10	$240	HCSS Estimate
P/D/P Ecology Blocks	40	ea	$400	$16,000	
P/D/I Propane Piping - SS	50	lf	$50	$2,500	1" line, fittings
Trench - HDPE Pipe	75	cy	$6	$413	2'x2'x500' trench
Trench - Backfill (by hand)	75	cy	$58	$4,350	2'x2'x500' trench
P/D/I Propane Piping - HDPE	500	lf	$2	$1,000	2" line
Generator MTTD					

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
750kW Generators - Rental	28	mo	$13,500	$378,000	Vendor Quote
20-30kW Generators - Rental	56	mo	$1,050	$58,800	Vendor Quote-Bldg; wheel wash; extraction wells (2)
Parralling Gear and Cables	1	ls	$70,000	$70,000	Vendor Quote
Adder for 65 dBA @ 23' (non-refund)	1	ls	$50,000	$50,000	Vendor Quote
16k-gal Diesel Tank	1	ea	$75,000	$75,000	Budgetary Quote from Western Global
Buried/armored cable	400	lf	$13	$5,000	
Fuel Consumption					
Propane for MTTD	3,017,600	gal	$1.70	$5,129,920	
Diesel for MTTD	450,000	gal	$4	$1,800,000	Engineer's Estimate
Diesel for Building Gensets	42,048	gal	$4	$168,192	Engineer's Estimate
Diesel for Wheel Wash Genset	20,160	gal	$4	$80,640	Engineer's Estimate
Diesel for Extraction Well Gensets	14,400	gal	$4	$57,600	Engineer's Estimate
Decon Pad					
Decon Trailer	14	mo	$5,000	$70,000	Engineer's Estimate
Powered Wheel Wash	14	mo	$2,700	$37,800	Engineer's Estimate
Excavation for Buried Wheel Wash	10	cy	$15	$150	
Water Supply Connection	1	ls	$5,000	$5,000	Engineer's Estimate
P/D/P Concrete Ramp	12	cy	$350	$4,200	HCSS Estimate
P/D/I Chain-link Fencing	1,000	lf	$5	$5,000	HCSS Estimate
Road Along Beach Soil Stockpile					
Subgrade Preparation	267	sf	$3	$800	
P/D/P Geotextile	2,700	sy	$7	$18,900	
P/D/P Crushed Gravel	890	cy	$30	$26,700	
Maintenance (2 yrs)	200	cy	$30	$6,000	
Delineators, flexible	1	ls	$1,000	$1,000	
Excavate Storm Water Trench	555	cy	$6	$3,053	
P/D Vaults	3	ea	$1,200	$3,600	4' dia x 4' deep precast storm drain
P/D Pumps	3	ea	$350	$1,050	1/2 hp submersible RSMeans
Install Vaults w/ Pumps	3	ea	$3,000	$9,000	Set vault, backfill, piping connections
Fractionation Tanks MTTD and Decon Pad					
22k-gal, trailer mount tanks rental	32	mo	$15,000	$480,000	Based on vendor quote (verbal) - 2 tanks
Subgrade Preparation	244	sy	$3	$733	
P/D/P Crushed Gravel	30	cy	$30	$900	
Tank Piping	1	ls	$2,500	$2,500	Allowance
Excavate Water Supply Line Trench	1,800	lf	$15	$27,000	300'x3'x2'
Dust Control and Wheel Wash Supply Tank					
Trailer Mounted Fractionation Tank	16	mo	$15,000	$240,000	Based on vendor quote (verbal)
P/D Flocculant	5	totes	$1,600	$8,000	
Subgrade Preparation	125	sy	$3	$375	
P/D/P Crushed Gravel	14	cy	$30	$420	
Water Truck Fill Stand Pipe	200	lf	$50	$10,000	
Water Supply Connection	1	ls	$5,000	$5,000	
Fire Hose for Dust Suppresion	16	ea	$175	$2,800	50-ft sections
Soils and Water Analysis (3-day TAT)					
PAH and PCB SIM Soil	1,640	ea	$475	$779,000	Engineer's Estimate
MTTD Feed Soil	410	ea	$475	$194,750	Engineer's Estimate
Water Analysis	100	ea	$475	$47,500	
Sampling Tech	2,496	hrs	$75	$187,200	1 FTE for 1.2 yrs
Data Validation	500	hrs	$120	$60,000	
Test Burn	1	ls	$50,000	$50,000	Allowance

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Stockpile Management	12	mo	$55,800	$669,600	1 Loader/Oper, 12 hrs/day
Water Supply Well					
Trenching Excavation	350	cy	$6	$2,100	6-in HDPE, buried
P/D/I Conveyance Piping	1,600	lf	$2.50	$4,000	6-in HDPE, buried
P/D Bedding Sand	300	tn	$15	$4,500	
Trench - Backfill (by hand)	175	cy	$58	$10,150	
MTTD Operations					
Treatment Costs	131,000	tn	$70	$9,170,000	Includes equipment costs
Miscellaneous Equip Costs	12	mo	$7,500	$90,000	radial stacker
MTTD Footprint (110'x100')					
Subgrage Preparation	1,333	sy	$3	$4,000	
P/D/P Geotextile	1,450	sy	$7	$9,788	Engineer's Estimate
P/D/P Crushed Gravel	200	cy	$30	$6,000	
P/D/P Agg Base	135	cy	$10	$1,350	HCSS Estimate
P/D/P/Seal AC Pavement	200	ton	$190	$38,000	HCSS Estimate
Treated Soil Stockpile					
P/D/P Ecology Blocks	400	ea	$400	$160,000	
Subgrade Preparation	4,444	sy	$3	$13,333	
P/D/P Geotextile	40,000	sy	$7	$270,000	Engineer's Estimate
P/D/P Crushed Gravel	1,110	cy	$30	$33,300	
P/D/P Agg Base	370	cy	$10	$3,700	HCSS Estimate
P/D/P/Seal AC Pavement	750	ton	$190	$142,500	HCSS Estimate
P/D/I Chain Link Fence	400	lf	$29	$11,600	10' O.C., 6' high, 9 ga. wire, set in concrete
Operating Cost	12	mo	$98,000	$1,176,000	1 Loader/oper; 2 haul trucks/oper.; H2O truck; for 1 yr, 12 hrs/day
Granular Activated Carbon					
Pickup Plenum Inside Bldg	1	ls	$10,000	$10,000	
P/D/I GAC Units	6	ea	$40,000	$240,000	20' x 8' x 8' GAC Siemens containers w/ 20,000# GAC/each
GAC Changeouts	200,000	lbs	$1.20	$240,000	Engineer's Estimate
Hoses	1	ls	$10,000	$10,000	Allowance
P/D/I Blower, Motor, Control Skid	1	ls	$50,000	$50,000	
Odor Control Foam					
Odor Control Foam	1	ls	$100,000	$100,000	Allowance
			Subtotal:	**$40,798,048**	
PROJECT MANAGEMENT	5%		$40,798,048	$2,039,902	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$40,798,048	$2,447,883	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$40,798,048	$2,447,883	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$7,035,668**	
CONTINGENCY (10% scope + 15% bid)	25%		$47,833,716	$11,958,429	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS - MTTD				**$59,792,000**	

REMEDIAL ACTION ALTERNATIVE

OPERATION & MAINTENANCE COSTS OF GWTP (through 2024)

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Annual O&M					
Operator(s)	4,160	hr	$80	$332,800	2 FTEs Operating GWTP

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Electrical Usage	1	ls	$60,000	$60,000	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Waste Disposal	1	ls	$100,000	$100,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$20,000	$20,000	Allowance
Maintenance	10%		$512,800	$51,280	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Undefined Scope Allowance	10%		$654,080	$65,408	
PROJECT MANAGEMENT	6%		$719,488	$43,169	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL O&M COSTS GWTP				**$788,000**	
OPERATION & MAINTENANCE COSTS OF NAPL RECOVERY (20219 through 2021)					
Annual O&M					
Disposal - NAPL Waste	47,000	gal	$7	$329,000	Vendor Quote; 140,000-gal over 3 yrs
Transportation - NAPL Waste	22	ld	$6,400	$140,800	Vendor Quote
Well field Analysis&Sampling Team	1,040	hr	$80	$83,200	Engineer's Estimate
Laboratory Analysis	260	ls	$300	$78,000	Engineer's Estimate
PPE Allowance	1,040	hr	$15	$15,600	Allowance
Maintenance	10%		$646,600	$64,660	Allowance
Undefined Scope Allowance	10%		$711,260	$71,126	
PROJECT MANAGEMENT	6%		$782,386	$46,943	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - NAPL RECOVERY				**$854,000**	
OPERATION & MAINTENANCE COSTS OF EAB (2021 through 2026)					
EAB					
Operator(s)	1,040	hr	$80	$83,200	1/2 yr running EAB System
Supervisor	208	hr	$100	$20,800	20% of operator time
Electrical	1	ls	$16,000	$16,000	Engineer's Estimate
Nutrient Chemicals/Media	1	ls	$11,000	$11,000	
System Maintenance	5%		$131,000	$6,550	Allowance
Undefined Scope Allowance	10%		$137,550	$13,755	
PROJECT MANAGEMENT	8%		$151,305	$12,104	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - EAB RECOVERY				**$188,000**	
OPERATION & MAINTENANCE COSTS OF THERMAL (2019 through 2023)					
Annual O&M					
Operator(s)	16,640	hr	$80	$1,331,200	8 FTEs running system 24/7
Supervisor	4,160	hr	$100	$416,000	2 FTE
Electrical Usage	1	ls	$103,385	$103,385	Current usage is $4k/mo to pump 65 gpm, scaled up to pump 140 gpm
Diesel Generator	12	mo	$20,600	$247,200	5150 gal/mo @ $4/gal

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Propane	12	mo	$266,600	$3,199,200	86,000-gal/mo@$3.10/gal
Disposal - NAPL Waste	14,000	gal	$7	$98,000	Vendor Quote; 14,000-gal/yr
Transportation - NAPL Waste	13	ld	$6,400	$83,200	Vendor Quote
Disposal - Naphthalene Waste	258	tn	$660	$170,360	Engineer's Estimate
Transportation - Naphthalene Waste	12	ld	$1,360	$16,320	22 tn/load => 16 hrs/load haul time
Waste Disposal - Carbon/Filter Media	1	ls	$86,000	$86,000	Allowance
Well field Analysis&Sampling Team	1,040	hr	$80	$83,200	Engineer's Estimate
Laboratory Analysis	260	ls	$300	$78,000	Engineer's Estimate
PPE Allowance	16,640	hr	$0.75	$12,480	Allowance - hard hats, boots, work gloves, safety glasses, Tyvek and other consumables
Maintenance	10%		$5,924,545	$592,455	Allowance
Undefined Scope Allowance	10%		$6,517,000	$651,700	
PROJECT MANAGEMENT	5%		$7,168,700	$358,435	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - THERMAL				**$7,552,000**	
OPERATION & MAINTENANCE COSTS OF PASSIVE GROUNDWATER TREATMENT SYSTEM (2026 through 2035)					
Operator(s)	520	hr	$80	$41,600	0.25 FTE
Maintenance	10%		$41,600	$4,160	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Contech GAC Filled Storm Filter Change	280	ea	$200	$56,000	Quarterly change out/recycle
T&D of Spent GAC Filters	40	drum	$400	$16,000	1 drum/manhole/event
Undefined Scope Allowance	10%		$191,760	$19,176	
PROJECT MANAGEMENT	8%		$226,936	$18,155	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	15%		$91,176	$13,676	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	
TOTAL O&M COSTS PASSIVE GWT				**$284,000**	
PERIODIC COSTS					
GWTP Periodic Costs					
GWTP Demolition	1	ls	$1,000,000	$1,000,000	Allowance
Well Abandonment (2025)					
Driller Mobilization/Demob	1	ls	$5,000	$5,000	Vendor Quote
Abandon 2-in Wells	232	ea	$1,300	$301,600	Vendor Quote
Abandon 4-in Wells	357	ea	$2,550	$910,350	Vendor Quote
PROJECT MANAGEMENT	6%		$1,216,950	$73,017	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	8%		$1,216,950	$97,356	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	
			Subtotal:	**$1,412,323**	

Alternative 6 - MTTD and Thermal
Wyckoff/Eagle Harbor Soil and Groundwater OUs, Focused Feasibility Study

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)	NOTES
Maintain Onsite Roads	1	ls	$25,000	$25,000	Allowance - re-grade/repair onsite roads
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS

1.9% Discount Rate — OMB - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value
0	Annual O&M Costs (2014)	$0	1.00	$ -
1	Annual O&M Costs (2015)	$0	0.98	$ -
2	Capital Costs (2016)	$18,515,000	0.96	$ 17,830,986
2	Annual O&M Costs	$788,000	0.96	$ 758,888
3	Capital Costs (2017)	$16,580,000	0.95	$ 15,669,747
3	Annual O&M Costs	$788,000	0.95	$ 744,738
3	5 Year Review (2017)	$20,000	0.95	$ 18,902
4	Capital Costs MTTD (midpoint 2018)	$59,792,000	0.93	$ 55,455,720
4	Annual O&M Costs	$788,000	0.93	$ 730,852
5	Capital Costs Thermal (midpoint 2019)	$40,125,000	0.91	$ 36,521,123
5	Annual O&M Costs	$788,000	0.91	$ 717,225
6	Annual O&M Costs	$1,642,000	0.89	$ 1,466,655
7	Annual O&M Costs	$9,194,000	0.88	$ 8,059,075
8	Annual O&M Costs	$9,382,000	0.86	$ 8,070,528
8	5 Year Review (2022)	$20,000	0.86	$ 17,204
9	Annual O&M Costs	$8,528,000	0.84	$ 7,199,122
10	Annual O&M Costs	$8,528,000	0.83	$ 7,064,889
11	Capital Costs (Passive GWT System)	$1,129,000	0.81	$ 917,863
11	Annual O&M Costs	$8,528,000	0.81	$ 6,933,159
12	Annual O&M Costs	$472,000	0.80	$ 376,575
13	Annual O&M Costs	$284,000	0.78	$ 222,359
13	5 Year Review (2027)	$20,000	0.78	$ 15,659
14	Periodic Cost - Well Abandonment	$1,412,323	0.77	$ 1,085,164
14	Capital Costs (Final Cap + Concrete Perimeter Wall)	$15,276,000	0.77	$ 11,737,378
14	Annual O&M Costs	$284,000	0.77	$ 218,213
15	Annual O&M Costs	$284,000	0.75	$ 214,144
16	Annual O&M Costs	$284,000	0.74	$ 210,151
17	Annual O&M Costs	$284,000	0.73	$ 206,233
18	Annual O&M Costs	$284,000	0.71	$ 202,387
18	5 Year Review (2032)	$20,000	0.71	$ 14,253
19	Annual O&M Costs	$284,000	0.70	$ 198,614
20	Periodic Cost - GWTP Demolition	$1,000,000	0.69	$ 686,304
20	Annual O&M Costs	$284,000	0.69	$ 194,910
21	Annual O&M Costs	$284,000	0.67	$ 191,276
22	Annual O&M Costs	$284,000	0.66	$ 187,710
23	Annual O&M Costs	$284,000	0.65	$ 184,210
23	Annual O&M Costs	$284,000	0.65	$ 184,210
23	5 Year Review (2037)	$20,000	0.65	$ 12,973
24	Annual O&M Costs	$284,000	0.64	$ 180,775
25	Maintain Onsite Roads	$25,000	0.62	$ 15,617
25	Annual O&M Costs	$284,000	0.62	$ 177,404
26	Annual O&M Costs	$284,000	0.61	$ 174,096
27	Annual O&M Costs	$284,000	0.60	$ 170,850
28	Annual O&M Costs	$284,000	0.59	$ 167,665
28	5 Year Review (2042)	$20,000	0.59	$ 11,807
29	Annual O&M Costs	$284,000	0.58	$ 164,538
33	5 Year Review (2047)	$20,000	0.54	$ 10,747

TABLE C-6
Cost Estimate for Alternative 6

DRAFT

	Item Description	Qty	Units	Unit Cost ($)	Total Cost ($)			NOTES
38	5 Year Review (2052)				$20,000	0.49	$	9,782
43	5 Year Review (2057)				$20,000	0.45	$	8,903
48	5 Year Review (2062)				$20,000	0.41	$	8,103
53	5 Year Review (2067)				$20,000	0.37	$	7,376
58	5 Year Review (2072)				$20,000	0.34	$	6,713
63	5 Year Review (2077)				$20,000	0.31	$	6,110
68	5 Year Review (2082)				$20,000	0.28	$	5,561
73	5 Year Review (2087)				$20,000	0.25	$	5,062
78	5 Year Review (2092)				$20,000	0.23	$	4,607
83	5 Year Review (2097)				$20,000	0.21	$	4,193
88	5 Year Review (2102)				$20,000	0.19	$	3,817
93	5 Year Review (2107)				$20,000	0.17	$	3,474
98	5 Year Review (2112)				$20,000	0.16	$	3,162
102	Final Completion Report (2116)				$150,000	0.15	$	21,995
TOTAL VALUE ANALYSIS					**$208,942,000**			**$185,690,000**

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%. It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

TABLE C-7
Cost Estimate for Alternative 7

DRAFT

Item Description	Qty	Units	Unit Cost ($$)	Total Cost ($$)	NOTES
			GENERAL SITE ACTIVITIES		
Pre-construction Activities - Common Elements (2016)					
Permitting	1	LS	$21,000	$21,000	Excavation/Grading/Drilling/Ecological
Precon Submittals	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Mobilization/Demobilization	1	LS	$117,000	$117,000	
Community Relations	1	LS	$169,000	$169,000	
Site Preparation	1	LS	$50,000	$50,000	WP/H&SP/AHAs/Schedule
Surveying - General	50	DY	$2,900	$145,000	
Project Management	6%		$552,000	$33,120	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$552,000	$44,160	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$552,000	$66,240	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$695,520	$173,880	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$869,000**	
Access Roads (2016)					
Erosion Controls	1,500	LF	$10	$15,000	
Roadway Grading	1,955	CY	$50	$97,750	
P/D/P 3" Agg Base	725	TN	$10	$7,250	
P/D/P/Seal 4" AC Pavement	260	TN	$190	$49,400	
Erosion Control Matting	1,445	sy	$3	$4,133	
Project Management	8%		$173,533	$13,883	USEPA 540-R-00-002 Guidance Document
Construction Management	10%		$173,533	$17,353	USEPA 540-R-00-002 Guidance Document
Remedial Design	15%		$173,533	$26,030	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$230,798	$57,700	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$288,000**	
Demolition - Concrete Structures (2016)					
Surface Decontamination	7,200	SY	$10	$72,000	
Concrete Demolition - Easy	2,010	CY	$40	$80,400	
Concrete Demolition - Difficult	6,020	CY	$70	$421,400	
Concrete Crushing	8,030	CY	$60	$481,800	
Spread Crushed Concrete Oniste	8,030	CY	$20	$160,600	
Recycle Rebar	650	TN	-$290	-$188,500	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$250,900	$250,900	Allowance
Project Management	6%		$1,393,800	$83,628	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$1,393,800	$111,504	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$1,393,800	$167,256	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$1,756,188	$439,047	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$2,195,000**	
Debris Removal - Site Wide (2016)					
Excavation/Debris Removal (5-ft)	22,193	CY	$10	$221,927	
Odor Control	4	WK	$9,600	$38,400	
Backfill - Site Wide	22,193	CY	$2	$44,385	
T&D Debris - Hazardous	300	TN	$1,000	$300,000	
Level C PPE Upgrade	1	LS	$110,963	$110,963	Allowance
Project Management	6%		$715,675	$42,941	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$715,675	$57,254	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$715,675	$85,881	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$901,751	$225,438	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$1,127,000**	
Rock/Soil/Bulkhead Removal (2016)					
Rock Removal	16,857	CY	$50	$842,850	
Excavate Behind Exist SP Wall	28,393	CY	$30	$851,790	
Bulkhead Removal	2,696	CY	$20	$53,920	
T&D Bulkhead Debris - Hazardous	2,022	TN	$1,000	$2,022,000	
T&D Bulkhead Debris - Non Haz	2,022	TN	$250	$505,500	
Backfill Existing Sheet Pile Wall	28,393	CY	$20	$567,860	
Crush Rock	16,857	CY	$10	$168,570	
Spread Crushed Material Onsite	16,857	CY	$20	$337,140	
Odor Control	12	WK	$9,600	$115,200	Allowance
Level C PPE Upgrade	1	LS	$425,895	$425,895	Allowance

TABLE C-7
Cost Estimate for Alternative 7

Project Management	5%		$5,890,725	$294,536	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$5,890,725	$353,444	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$5,890,725	$471,258	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$7,009,963	$1,752,491	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$8,762,000**	
Miscellaneous Demolition (2016)					
Remove/Dispose Asphalt	233	CY	$100	$23,300	HCSS Estimate
Remove/Dispose of Pilot Plant Pipe	1	LS	$20,000	$20,000	Engineer's Estimate
Remove/Dispose Pilot Plant SP	24,300	SF	$30	$729,000	Engineer's Estimate
Remove/Dispose NW Beach SP	13,280	SF	$30	$398,400	HCSS Estimate
Remove/Dispose Tanks & Equip	1	LS	$116,000	$116,000	HCSS Estimate
Odor Control	4	WK	$9,600	$38,400	Allowance
Level C PPE Upgrade	1	LS	$575,350	$575,350	Allowance
Project Management	6%		$1,900,450	$114,027	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$1,900,450	$152,036	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$1,900,450	$228,054	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,394,567	$598,642	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$2,993,000**	
Storm Water Infiltration Trench (2016)					
Excavation	2,800	CY	$17	$47,600	
P/D Drain Gravel	4,536	TN	$24	$108,864	
Spread Drain Gravel	6,400	TN	$9	$57,600	
Project Management	8%		$214,064	$17,125	USEPA 540-R-00-002 Guidance Document
Construction Management	10%		$214,064	$21,406	USEPA 540-R-00-002 Guidance Document
Remedial Design	15%		$214,064	$32,110	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$284,705	$71,176	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$214,000**	
Install New Perimeter SP Wall, Non ISS (2018)					
P/D AZ50 Sheet Pile	3,700	TN	$1,900	$0	Vendor Quote
Unload Sheet Pile	169	LD	$2,000	$0	
Install Perimeter SP Wall (AZ50)	142,200	SF	$11	$0	
Project Management	5%		$0	$0	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$0	$0	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$0	$0	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$0	$0	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$0**	
Non-ISS Concrete Perimeter Wall (2018)					
Excavation - Non-ISS Perimeter Wall	14,646	CY	$62	$0	
Install Concrete Plug	1,475	CY	$220	$0	
Odor Control	8	WK	$9,600	$0	Allowance
P/D/I Rebar	1,100	TN	$3,000	$0	
P/D/I Concrete	13,201	CY	$220	$0	
Project Management	5%		$0	$0	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$0	$0	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$0	$0	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$0	$0	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$0**	
Construct Outfall (2018)					
P/D AZ36-700N Sheet Pile	90	TN	$1,700	$153,036	
Unload Sheet Pile	5	LD	$2,000	$10,000	
Install Sheet Pile	3,500	SF	$10	$35,000	
Dewatering	20	DY	$800	$16,000	
HDD, Pipe, and Marine	1	LS	$1,500,000	$1,500,000	Vendor Quote
Onshore Construction	1	LS	$500,000	$500,000	
Project Management	5%		$2,214,036	$110,702	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,214,036	$132,842	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,214,036	$177,123	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$2,634,703	$658,676	USEPA 540-R-00-002 Guidance Document

TABLE C-7
Cost Estimate for Alternative 7

			Subtotal:	**$3,293,000**	
ISS Concrete Perimeter Wall (2026)					
Excavation - ISS Perimeter Wall	10,007	CY	$34	$340,238	
Install Concrete Plug	1,475	CY	$220	$324,500	
P/D/I Rebar	930	TN	$3,000	$2,790,000	
P/D/P Concrete	8,532	CY	$220	$1,877,040	
Project Management	5%		$5,331,778	$266,589	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$5,331,778	$319,907	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$5,331,778	$426,542	USEPA 540-R-00-002 Guidence Document
Contingency (10% Scope+15% Bid)	25%		$6,344,816	$1,586,204	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$7,931,020**	
Final Site Cap (2027)					
Subgrade Preparation	39,150	SY	$3	$117,450	HCSS Estimate
P/D/P Embankment Fill	13,917	CY	$20	$278,340	HCSS Estimate
Geomembrane Cover	39,150	SY	$7	$264,263	Engineer's Estimate
Geomembrane Penetrations	13	EA	$500	$6,500	Engineer's Estimate
Cushion Geotextile	39,150	SY	$2	$88,088	Engineer's Estimate
P/D/P Granular Drain Mat'l	21,000	TN	$30	$630,000	HCSS Estimate
P/D/P Topsoil Layer	21,100	TN	$60	$1,266,000	HCSS Estimate
Survey	22	DY	$2,900	$63,800	HCSS Estimate
Restoration	13	AC	$3,200	$41,600	Engineer's Estimate
Project Management	5%		$2,756,040	$137,802	USEPA 540-R-00-002 Guidance Document
Construction Management	6%		$2,756,040	$165,362	USEPA 540-R-00-002 Guidance Document
Remedial Design	8%		$2,756,040	$220,483	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$3,279,688	$819,922	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$4,100,000**	
Non-ISS Passive Drainage System (2026)					
MH Excavations, Non-ISS PWT	1,500	CY	$35	$52,500	
P/D Manholes & Bases	10	EA	$12,000	$120,000	
Install Manholes & Bases	10	EA	$4,000	$40,000	
Install Contech GAC Storm Filters	1	LS	$15,000	$15,000	
Discharge Line Penetration/Install	10	EA	$7,000	$70,000	
Backfill Manholes	1,500	CY	$30	$45,000	
Excavate French Drains	4,750	CY	$18	$85,500	
P/D/I 12", Slotted HDPE	2,000	LF	$54	$108,000	
Backfill French Drains	4,750	CY	$24	$114,000	
Repair Cap	1,000	SY	$67	$67,000	
Project Management	6%		$717,000	$43,020	USEPA 540-R-00-002 Guidance Document
Construction Management	8%		$717,000	$57,360	USEPA 540-R-00-002 Guidance Document
Remedial Design	12%		$717,000	$86,040	USEPA 540-R-00-002 Guidance Document
Contingency (10% Scope+15% Bid)	25%		$903,420	$225,855	USEPA 540-R-00-002 Guidance Document
			Subtotal:	**$1,129,275**	

REMEDIAL ACTION ALTERNATIVE

Alternative 7 - ISS CORE (Midpoint = 2017)

Pre-construction Activities (ISS Subcontractor)					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	Erosion Controls, Staging/Stockpile Areas
Survey (Throughout Project)	50	DY	$2,900	$145,000	
			Subtotal:	**$255,000**	
MOBILIZATION					
Equipment Costs (Transportation)					
ISS Crane	1	ea	$60,000	$60,000	Engineer's Estimate
Jet Grout Rig - Casa Grande C-7	1	ea	$25,000	$25,000	Engineer's Estimate
Drilling Attachment	1	ea	$38,000	$38,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$28,000	$28,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$3,200	$3,200	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$34,500	$34,500	Engineer's Estimate
Crane Mats	2	ea	$3,200	$6,400	Engineer's Estimate
Crew Truck	2	ea	$1,500	$3,000	Engineer's Estimate
Tool Truck	1	ea	$1,500	$1,500	Engineer's Estimate
Project Trailer and Generator	2	ea	$4,000	$8,000	Engineer's Estimate
Forklift	1	ea	$2,000	$2,000	Engineer's Estimate
Manlift	1	ea	$2,000	$2,000	Engineer's Estimate
Excavator, CAT 336D	1	ea	$2,500	$2,500	Engineer's Estimate

TABLE C-7
Cost Estimate for Alternative 7

Excavator, CAT 345D	1	ea	$2,500	$2,500	Engineer's Estimate
Loader, CAT 966H	1	ea	$2,000	$2,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	1	ea	$2,000	$2,000	Engineer's Estimate
Equipment Costs (4 week Mob)					
ISS Rig - Manitowoc/Attachment	4	wk	$21,100	$84,400	Engineer's Estimate
Jet Grout Rig	4	wk	$15,000	$60,000	Engineer's Estimate
Batch Plant and Silo(s)	4	wk	$3,900	$15,600	Engineer's Estimate
Grout Pumping System/Metering	4	wk	$3,000	$12,000	Engineer's Estimate
Hose, Connectors, Whip Checks	4	wk	$1,600	$6,400	Engineer's Estimate
Wash Down Tank	4	wk	$1,500	$6,000	Engineer's Estimate
Drill Tools	4	wk	$2,500	$10,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	4	wk	$750	$3,000	Engineer's Estimate
Forklift, CAT 1255 12k#	4	wk	$3,500	$14,000	Engineer's Estimate
Manlift, 60-ft	4	wk	$2,000	$8,000	Engineer's Estimate
Excavator, CAT 336D	4	wk	$6,000	$24,000	Engineer's Estimate
Excavator, CAT 345D	4	wk	$7,100	$28,400	Engineer's Estimate
Loader, CAT 966H	4	wk	$4,000	$16,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	4	wk	$3,500	$14,000	Engineer's Estimate
Crew Truck	12	wk	$1,200	$14,400	Engineer's Estimate
Tool Truck	4	wk	$1,100	$4,400	Engineer's Estimate
Subcontractors					
Electrical	1	LS	$15,000	$15,000	Engineer's Estimate
Welders	1	LS	$25,000	$25,000	Engineer's Estimate
Personnel (based on 5-day week)					
Batch Plan Operator	4	wk	$7,475	$29,900	Engineer's Estimate
Crane Operator	4	wk	$6,175	$24,700	Engineer's Estimate
Equipment Operator	8	wk	$5,525	$44,200	Engineer's Estimate
Jet Grout Superintendent	4	wk	$6,500	$26,000	Engineer's Estimate
Jet Grout Operator	4	wk	$7,475	$29,900	Engineer's Estimate
ISS Attachment Operator	4	wk	$7,475	$29,900	Engineer's Estimate
Labor, Foreman	4	wk	$4,550	$18,200	Engineer's Estimate
Labor, General	8	wk	$3,900	$31,200	Engineer's Estimate
ISS Superintendent	4	wk	$6,500	$26,000	Engineer's Estimate
QA/QC Manager	8	wk	$8,125	$65,000	Engineer's Estimate
Safety Manager	4	wk	$8,125	$32,500	Engineer's Estimate
Miscellaneous					
Derrick/barge/tug, 2 days+tug+plus fuel	1	ls	$100,000	$100,000	Allowance
Mob/Demob Derrick/Barge/tug	1	ls	$100,000	$100,000	Allowance
Crane Mat Purchase	30	ls	$2,500	$75,000	Engineer's Estimate
Miscellaneous Tools and Supplies	1	ls	$12,500	$12,500	Engineer's Estimate
Per Diem	392	day	$129	$50,568	Standard Per Diem Rate = Washington
			Subtotal:	**$1,276,768**	
CORE AREA EXCAVATION (7-FT)					
Equipment					
Excavator, CAT345D	4	wk	$7,100	$28,400	Engineer's Estimate
Loader, CAT 966H	4	wk	$4,000	$16,000	Engineer's Estimate
Water Truck	1	wk	$2,500	$2,500	Engineer's Estimate
Crew Truck	4	wk	$1,200	$4,800	Engineer's Estimate
Personnel					
Equipment Operator	8	wk	$5,525	$44,200	Engineer's Estimate
Water Truck Driver	1	wk	$4,875	$4,875	Engineer's Estimate
Labor, Foreman	4	wk	$4,550	$18,200	Engineer's Estimate
Labor, General	8	wk	$3,900	$31,200	Engineer's Estimate
Miscellaneous					
Stockpile Management	20	wk	$350	$7,000	Engineer's Estimate
Per Diems	28	day	$129	$3,612	Standard Per Diem Rate = Washington
			Subtotal:	**$160,787**	
AUGER MIX ISS - CORE AREA and CRUST ON					
Equipment					
ISS Rig - Manitowoc/Attacment	38	wk	$21,100	$801,800	Engineer's Estimate
Batch Plant and Silo(s)	38	wk	$3,900	$148,200	Engineer's Estimate
Grout Pumping System/Metering	38	wk	$3,000	$114,000	Engineer's Estimate
Hose, Connectors, Whip Checks	38	wk	$1,600	$60,800	Engineer's Estimate
Wash Down Tank	38	wk	$1,500	$57,000	Engineer's Estimate
Drill Tools	38	wk	$2,500	$95,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	38	wk	$750	$28,500	Engineer's Estimate
Teeth replacement/Tooth Packets	38	wk	$750	$28,500	Engineer's Estimate
Forklift, CAT TL1255 12k#	38	wk	$3,500	$133,000	Engineer's Estimate
Manlift	38	wk	$2,000	$76,000	Engineer's Estimate
Excavator, CAT336D	38	wk	$6,000	$228,000	Engineer's Estimate
Excavator, CAT345D	-	wk	$7,100	$0	Engineer's Estimate
Generator, 350 kW	38	wk	$5,000	$190,000	Engineer's Estimate
Generator Fuel	30,400	gal	$4	$121,600	Engineer's Estimate

TABLE C-7
Cost Estimate for Alternative 7

Crew Truck	76	wk	$1,200	$91,200	Engineer's Estimate
Tool Truck	38	wk	$1,100	$41,800	Engineer's Estimate
Subcontractors					
Electrical	1	ls	$15,000	$15,000	Engineer's Estimate
Welders	1	ls	$25,000	$25,000	Engineer's Estimate
Personnel					
Batch Plant Operator	38	wk	$7,475	$284,050	Engineer's Estimate
Crane Operator	38	wk	$6,175	$234,650	Engineer's Estimate
Equipment Operator	38	wk	$5,525	$209,950	Engineer's Estimate
ISS Attachment Operator	38	wk	$7,475	$284,050	Engineer's Estimate
Labor, Foreman	38	wk	$4,550	$172,900	Engineer's Estimate
Labor, General	38	wk	$3,900	$148,200	Engineer's Estimate
ISS Superintendent	38	wk	$6,500	$247,000	Engineer's Estimate
QA/QC Manager	38	wk	$8,125	$308,750	Engineer's Estimate
Safety Manager	38	wk	$8,125	$308,750	Engineer's Estimate
Materials					
P/D Portland Cement	21,630	tn	$125	$2,703,776	Engineer's Estimate
P/D Bentonite	879	tn	$325	$285,539	Engineer's Estimate
Miscellaneous					
Per Diems	3,724	day	$129	$480,396	Standard Per Diem Rate = Washington
			Subtotal:	**$7,923,410**	
JET GROUT ISS					
Equipment					
Jet Grout Rig	31	wk	$15,000	$465,000	Engineer's Estimate
Hose, Connectors, Whip Checks	31	wk	$1,600	$49,600	Engineer's Estimate
Wash Down Tank	31	wk	$1,500	$46,500	Engineer's Estimate
Excavator, CAT 336D	31	wk	$6,000	$186,000	Engineer's Estimate
Crew Truck	31	wk	$1,200	$37,200	Engineer's Estimate
Personnel					
Jet Grout Operator	31	wk	$7,475	$231,725	Engineer's Estimate
Equipment Operator	31	wk	$5,525	$171,275	Engineer's Estimate
Labor, Foreman	31	wk	$4,550	$141,050	Engineer's Estimate
Labor, General	31	wk	$3,900	$120,900	Engineer's Estimate
Jet Grout Superintendent	31	wk	$6,500	$201,500	Engineer's Estimate
QA/QC Manager	-	wk	$8,125	$0	Engineer's Estimate
Safety Manager	-	wk	$8,125	$0	Engineer's Estimate
Materials					
P/D Portland Cement	1,300	tn	$125	$162,500	Engineer's Estimate
P/D Bentonite	65	tn	$325	$21,125	Engineer's Estimate
Miscellaneous					
Per Diems	1,519	day	$129	$195,951	Standard Per Diem Rate = Washington
			Subtotal:	**$2,030,326**	
EX-SITU SOIL MIXING AND PLACEMENT					
Equipment					
Excavator, CAT 336D	6	wk	$6,000	$36,000	Engineer's Estimate
Loader, CAT 966H	6	wk	$4,000	$24,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	6	wk	$3,500	$21,000	Engineer's Estimate
Water Truck	6	wk	$2,500	$15,000	Engineer's Estimate
Personnel					
Equipment Operator	12	wk	$6,175	$74,100	Engineer's Estimate
Water Truck Driver	6	wk	$4,875	$29,250	Engineer's Estimate
Labor, Foreman	6	wk	$4,550	$27,300	Engineer's Estimate
Labor, General	12	wk	$3,900	$46,800	Engineer's Estimate
Materials					
P/D Portland Cement	3,479	TN	$125	$434,911	Engineer's Estimate
P/D Bentonite	174	TN	$325	$56,538	Engineer's Estimate
Miscellaneous					
Per Diems	42	day	$129	$5,418	Standard Per Diem Rate = Washington
			Subtotal:	**$770,317**	
DEMOBILIZATION					
Equipment Costs (Transportation)					
ISS Crane	1	ea	$30,000	$30,000	Engineer's Estimate
Jet Grout Rig - Casa Grande C-7	1	ea	$12,500	$12,500	Engineer's Estimate
Drilling Attachment	1	ea	$19,000	$19,000	Engineer's Estimate
Grout Pump, Hose, Washout Tank	1	ea	$14,000	$14,000	Engineer's Estimate
Storage Silo (Pig)	1	ea	$1,600	$1,600	Engineer's Estimate
Batch Plan and Silo(s)	1	ea	$17,250	$17,250	Engineer's Estimate
Crane Mats	2	ea	$1,600	$3,200	Engineer's Estimate
Crew Truck	2	ea	$750	$1,500	Engineer's Estimate
Tool Truck	1	ea	$750	$750	Engineer's Estimate

TABLE C-7
Cost Estimate for Alternative 7

Project Trailer and Generator	2	ea	$2,000	$4,000	Engineer's Estimate
Forklift, CAT TL1255 12k#	1	ea	$1,000	$1,000	Engineer's Estimate
Manlift	1	ea	$1,000	$1,000	Engineer's Estimate
Excavator, CAT336D	1	ea	$1,250	$1,250	Engineer's Estimate
Excavator, CAT345D	1	ea	$1,250	$1,250	Engineer's Estimate
Loader, CAT 966H	1	ea	$1,000	$1,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	1	ea	$1,000	$1,000	Engineer's Estimate
Equipment Costs (2 week demob)					
ISS Rig - Manitowoc/Attachment	2	wk	$21,100	$42,200	Engineer's Estimate
Jet Grout Rig - CasaGrande C-7	2	wk	$15,000	$30,000	Engineer's Estimate
Batch Plant and Silo(s)	2	wk	$3,900	$7,800	Engineer's Estimate
Grout Pumping System/Metering	2	wk	$3,000	$6,000	Engineer's Estimate
Hose, Connectors, Whip Checks	2	wk	$1,600	$3,200	Engineer's Estimate
Wash Down Tank	2	wk	$1,500	$3,000	Engineer's Estimate
Drill Tools	2	wk	$2,500	$5,000	Engineer's Estimate
Horizontal Storage Silo (Pig)	2	wk	$750	$1,500	Engineer's Estimate
Forklift, CAT TL1255 12k#	2	wk	$3,500	$7,000	Engineer's Estimate
Manlift	2	wk	$2,000	$4,000	Engineer's Estimate
Excavator, CAT 336D	2	wk	$6,000	$12,000	Engineer's Estimate
Excavator, CAT 345D	2	wk	$7,100	$14,200	Engineer's Estimate
Loader, CAT 966H	2	wk	$4,000	$8,000	Engineer's Estimate
Bulldozer, CAT D6K LGP	2	wk	$3,500	$7,000	Engineer's Estimate
Crew Trucks	4	wk	$1,200	$4,800	Engineer's Estimate
Tool Truck	2	wk	$1,100	$2,200	Engineer's Estimate
Personnel					
Batch Plan Operator	2	wk	$7,475	$14,950	Engineer's Estimate
Crane Operator	2	wk	$6,175	$12,350	Engineer's Estimate
Equipment Operator	4	wk	$5,525	$22,100	Engineer's Estimate
Jet Grout Superintendent	2	wk	$6,500	$13,000	Engineer's Estimate
Jet Grout Operator	2	wk	$7,475	$14,950	Engineer's Estimate
ISS Attachment Operator	2	wk	$7,475	$14,950	Engineer's Estimate
Labor, General	4	wk	$7,475	$29,900	Engineer's Estimate
Labor, Foreman	2	wk	$4,550	$9,100	Engineer's Estimate
ISS Superintendent	2	wk	$3,900	$7,800	Engineer's Estimate
QA/QC Manager	4	wk	$8,125	$32,500	Engineer's Estimate
Safety Manager	2	wk	$8,125	$16,250	Engineer's Estimate
Miscellaneous					
Derrick/barge/tug, 2 days+tug+plus fuel	1	ls	$50,000	$50,000	Allowance
Mob/Demob Derrick/Barge/tug	1	ls	$50,000	$50,000	Allowance
Per Diems	224	day	$129	$28,896	Standard Per Diem Rate = Washington
			Subtotal:	**$584,946**	
PROJECT MANAGEMENT	5%		$13,001,555	$650,078	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$13,001,555	$780,093	Based on EPA 540-R-00-002
REMEDIAL DESIGN	6%		$13,001,555	$780,093	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$2,310,264**	
CONTINGENCY (10% scope + 15% bid)	25%		$15,311,819	$3,827,955	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS FOR ISS				**$19,140,000**	

Alternative 5 - Thermal (Midpoint 2018)					
Pre-construction Activities					
Permitting	1	LS	$10,000	$10,000	Allowance
Precon Submittals	1	LS	$50,000	$50,000	
Site Preparation	1	LS	$50,000	$50,000	
			Subtotal:	**$110,000**	
Mob/Demob					
Install Steam Injection Wells	66	ea	$15,000	$990,000	Engineer's Estimate
Injection Well Completions	66	ea	$450	$29,700	Engineer's Estimate
Steam Injection Well Piping/System	1	ls	$204,000	$204,000	Engineer's Estimate
Install Extraction Wells	92	ea	$5,700	$524,400	Engineer's Estimate
Extraction Well Completions	92	ea	$450	$41,400	Engineer's Estimate
Install Extraction Well Head System	92	ea	$1,250	$115,000	Engineer's Estimate
Allowance to Relocate Well Heads	-	ea	$1,500	$0	Engineer's Estimate
Install Biosparge Wells	31	ea	$5,000	$155,000	Engineer's Estimate
Biosparge Well Completions	31	ea	$350	$10,850	Engineer's Estimate
Install Biosparge Wellhead and Header Piping/Valves	31	ea	$2,500	$77,500	Engineer's Estimate
Install Thermocouple Borings	92	ea	$2,800	$257,600	Engineer's Estimate
Purchase Thermocouples	293	ea	$1,500	$439,552	Engineer's Estimate
Install Thermocouples	3,000	ft	$25	$75,000	Engineer's Estimate
Thermocouple Completions	92	ea	$350	$32,200	Engineer's Estimate

TABLE C-7
Cost Estimate for Alternative 7

Surface Top Coarse (6")	6,739	tn	$10	$67,390	Engineer's Estimate
Steam Supply Header Materials	3,280.81	ft	$45	$147,637	Engineer's Estimate
Allowance for Steam Valves/I&C	1	ls	$28,779	$28,779	Engineer's Estimate
Air Supply Piping Header	5,087	ft	$20	$101,731	Engineer's Estimate
Vapor Extraction Piping	8,550	ft	$55	$0	Engineer's Estimate
Extracted Water Piping	6,662.18	ft	$20	$133,244	Engineer's Estimate
Install Air/Vapor/Extraction Piping	15,030	ft	$7	$105,207	Engineer's Estimate
Installation of 6' Pipe Rack	588.30	ea	$400	$235,320	Engineer's Estimate
Installation of 15' Pipe Rack	79.48	ea	$750	$59,612	Engineer's Estimate
Allowance for Extraction Valves/I&C	1	ls	$62,585	$62,585	Engineer's Estimate
Corrosion Protection for wells	216	ls	$500	$108,000	Engineer's Estimate
			Subtotal:	**$4,001,706**	
Vapor and GW Treatment System					
Site Preparation	1	ls	$30,000	$30,000	Engineer's Estimate
Concrete Slab on Grade	700	cy	$350	$245,000	Engineer's Estimate
Secondary Containment Walls	6.5	CY	$350	$2,275	Engineer's Estimate
P/D Diesel Generators	1	ea	$600,000	$600,000	Engineer's Estimate
P/D Cooling Tower	1	ea	$41,000	$41,000	Engineer's Estimate
Cooling Water Chemical/Makeup Treatment Systems	0.25	ls	$150,000	$37,500	Allowance
P/D Heat Exchanger H-1	1	ea	$11,500	$11,500	Engineer's Estimate
P/D Accumulation Tank	1	ea	$97,000	$97,000	Engineer's Estimate
P/D Oil/Water Separator	1	ea	$310,000	$310,000	Engineer's Estimate
P/D Solids NAPL Holding Tank	1	ea	$92,000	$92,000	Engineer's Estimate
P/D Air Compressor	1	ea	$11,000	$11,000	Engineer's Estimate
P/D Pumps	4	ea	$10,000	$40,000	Engineer's Estimate
Equipment Installation (15% of equipment cost)	1	ls	$186,000	$186,000	Allowance
Process Piping (5% of equip cost)	1	ls	$62,000	$62,000	Allowance
I&C (15% of equipment cost)	1	ls	$186,000	$186,000	Allowance
Electrical (20% of equipment cost)	1	ls	$248,000	$248,000	Allowance
Solids Handling Rain Shelter	600	sf	$200	$120,000	Allowance
Electrical/I&C Building	1	ls	$36,000	$36,000	Allowance
			Subtotal:	**$2,355,275**	
Boiler Propane System					
Site Preparation	1	ls	$15,000	$15,000	Engineer's Estimate
Concrete Slab on Grade	50	cy	$350	$17,500	Engineer's Estimate
Install Propane Tank	1	ls	$30,000	$30,000	Allowance
Install Vaporizer	1	ls	$30,000	$30,000	Allowance
Setup Boiler System	1	ls	$75,000	$75,000	Allowance
Monthly Rental of Boiler System	60	mo	$17,500	$1,050,000	Nationwide Boiler Quote. Includes softener and
			Subtotal:	**$1,217,500**	
PROJECT MANAGEMENT	5%		$7,684,481	$384,224	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	6%		$7,684,481	$461,069	Based on EPA 540-R-00-002
REMEDIAL DESIGN	8%		$7,684,481	$614,758	Based on EPA 540-R-00-002
CONSTRUCTION COMPLETION REPORT	1	LS	$100,000	$100,000	
			Subtotal:	**$1,560,051**	
CONTINGENCY (10% scope + 15% bid)	25%		$9,244,532	$2,311,133	Based on EPA 540-R-00-002
TOTAL CAPITAL COSTS THERMAL				**$11,556,000**	
OPERATION & MAINTENANCE COSTS OF GWTP (through 2026)					
Annual O&M					
Operator(s)	4,160	hr	$80	$332,800	2 FTEs Operating GWTP
Electrical Usage	1	ls	$60,000	$60,000	Current usage is $4k/mo to pump 65 gpm,
Waste Disposal	1	ls	$100,000	$100,000	Allowance: NAPL and spent carbon disposal
Chemicals/Media	1	ls	$20,000	$20,000	Allowance
Maintenance	10%		$512,800	$51,280	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Contech GAC Filled Storm Filter Change	-	ea	$200	$0	Annual change out/recycle of 7 filters in 10 MHs
Undefined Scope Allowance	10%		$654,080	$65,408	
PROJECT MANAGEMENT	6%		$719,488	$43,169	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL O&M COSTS - GWTP				**$788,000**	
OPERATION & MAINTENANCE COSTS OF NAPL RECOVERY (20- through 20-)					
Annual O&M					
Disposal - NAPL Waste	47,000	gal	$7	$329,000	Vendor Quote; 140,000-gal over 3 yrs
Transportation - NAPL Waste	22	load	$6,400	$140,800	Vendor Quote

TABLE C-7
Cost Estimate for Alternative 7

GWTP Chemicals/Media	-	ls	$20,000	$0	
Well field Analysis&Sampling Team	1,040	hr	$80	$83,200	Engineer's Estimate
Laboratory Analysis	260	ls	$300	$78,000	Engineer's Estimate
PPE Allowance	1,040	hr	$15	$15,600	Allowance
Maintenance	10%		$646,600	$64,660	Allowance
Undefined Scope Allowance	10%		$711,260	$71,126	
PROJECT MANAGEMENT	6%		$782,386	$46,943	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - NAPL RECOVERY				**$854,000**	

OPERATION & MAINTENANCE COSTS OF EAB (2019 through 2026)

EAB					
Operator(s)	1,040	hr	$80	$83,200	1/2 yr running EAB System
Supervisor	208	hr	$100	$20,800	20% of operator time
Electrical	1	ls	$16,000	$16,000	Engineer's Estimate
Nutrient Chemicals/Media	1	ls	$11,000	$11,000	
System Maintenance	5%		$131,000	$6,550	Allowance
Undefined Scope Allowance	10%		$137,550	$13,755	
PROJECT MANAGEMENT	8%		$151,305	$12,104	Based on EPA 540-R-00-002
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - EAB RECOVERY				**$188,000**	

OPERATION & MAINTENANCE COSTS OF THERMAL (Initial 2 years of operation, 2019 through 2020)

Annual O&M					
Operator(s)	6,240	hr	$80	$499,200	3 FTEs running system 24/7
Supervisor	2,080	hr	$100	$208,000	1 FTE
Electrical Usage	1	ls	$103,385	$103,385	Current usage is $4k/mo to pump 65 gpm,
Diesel Generator	12	mo	$10,300	$123,600	5150 gal/mo @ $4/gal
Propane	12	mo	$155,000	$1,860,000	86,000-gal/mo@$3.10/gal
Disposal - NAPL Waste	23,000	gal	$7	$161,000	Vendor Quote; 14,000-gal/yr
Transportation - NAPL Waste	11	load	$6,400	$70,400	Vendor Quote
Disposal - Naphthalene Waste	264	tn	$660	$0	Engineer's Estimate
Transportation - Naphthalene Waste	12	ld	$1,360	$0	22 tn/load => 16 hrs/load haul time
Waste Disposal - Carbon/Filter Media	1	ls	$43,000	$43,000	Allowance
GWTP Chemicals/Media	-	ls	$20,000	$0	
Well field Analysis&Sampling Team	520	hr	$80	$41,600	Engineer's Estimate
Laboratory Analysis	130	ls	$300	$39,000	Engineer's Estimate
PPE Allowance	6,240	hr	$0.75	$4,680	Allowance - hard hats, boots, work gloves,
Maintenance	10%		$3,153,865	$315,387	Allowance
Undefined Scope Allowance	10%		$3,469,252	$346,925	
PROJECT MANAGEMENT	5%		$3,816,177	$190,809	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - THERMAL				**$4,032,000**	

OPERATION & MAINTENANCE COSTS OF THERMAL (Additional 6 years of operation, 2021 through 2026)

Annual O&M					
Operator(s)	2,080	hr	$80	$166,400	1 FTE
Supervisor	520	hr	$100	$52,000	0.25 FTE
Electrical Usage	1	ls	$103,385	$103,385	Current usage is $4k/mo to pump 65 gpm,
Diesel Generator	12	mo	$10,300	$123,600	5150 gal/mo @ $4/gal
Propane	12	mo	$37,200	$446,400	86,000-gal/mo@$3.10/gal
Disposal - NAPL Waste	5,300	gal	$7	$37,100	Vendor Quote; 14,000-gal/yr
Transportation - NAPL Waste	3	load	$6,400	$19,200	Vendor Quote
Disposal - Naphthalene Waste	264	tn	$660	$0	Engineer's Estimate
Transportation - Naphthalene Waste	12	ld	$1,360	$0	22 tn/load => 16 hrs/load haul time
Waste Disposal - Carbon/Filter Media	1	ls	$43,000	$43,000	Allowance
GWTP Chemicals/Media	-	ls	$20,000	$0	
Well field Analysis&Sampling Team	520	hr	$80	$41,600	Engineer's Estimate
Laboratory Analysis	130	ls	$300	$39,000	Engineer's Estimate
PPE Allowance	2,080	hr	$0.75	$1,560	Allowance - hard hats, boots, work gloves,
Maintenance	10%		$1,073,245	$107,325	Allowance
Undefined Scope Allowance	10%		$1,180,570	$118,057	
PROJECT MANAGEMENT	5%		$1,298,626	$64,931	
REPORTING	1		$25,000	$25,000	
TOTAL ANNUAL O&M COSTS - THERMAL				**$1,389,000**	

TABLE C-7
Cost Estimate for Alternative 7

OPERATION & MAINTENANCE COSTS OF PASSIVE GROUNDWATER TREATMENT SYSTEM (2027 through 2036)

Operator(s)	520	hr	$80	$41,600	0.25 FTEs
Waste Disposal	-	ls	$50,000	$0	Engineer's Estimate
Chemicals/Media	-	ls	$20,000	$0	Engineer's Estimate
Maintenance	10%		$41,600	$4,160	Allowance
Quarterly GW Sampling	4	ea	$10,000	$40,000	
Annual GW Sampling	1	ls	$50,000	$50,000	
Maintain Onsite Roads	-	ls	$25,000	$0	Allowance - re-grade/repair onsite roads
Contech GAC Filled Storm Filter Change	280	ea	$200	$56,000	Quarterly change out/recycle
T&D of Spent GAC Filters	40	drum	$400	$16,000	1 drum/manhole/event
Undefined Scope Allowance	10%		$191,760	$19,176	
PROJECT MANAGEMENT	8%		$226,936	$18,155	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	15%		$91,176	$13,676	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	

TOTAL O&M COSTS - PASSIVE WATER TREATMENT SYSTEM: $284,000

PERIODIC COSTS

GWTP Periodic Costs					
GWTP Mech/Elec Replacement	-	ls	$4,000,000	$0	Allowance: Every 25 years
GWTP Demolition (2031)	1	ls	$1,000,000	$1,000,000	Allowance
Well Abandonment (2027)					
Driller Mobilization/Demob	1	ls	$5,000	$5,000	Vendor Quote
Abandon 2-in Wells	195	ea	$1,300	$253,500	Vendor Quote
Abandon 4-in Wells	357	ea	$2,550	$910,350	Vendor Quote
PROJECT MANAGEMENT	6%		$1,168,850	$70,131	Based on EPA 540-R-00-002
CONSTRUCTION MANAGEMENT	8%		$1,168,850	$93,508	Based on EPA 540-R-00-002
REPORTING	1	ls	$25,000	$25,000	
			Subtotal:	**$1,357,489**	
Maintain Onsite Roads (2039)	1	ls	$25,000	$25,000	Allowance - regrade/repair onsite roads
5 Yr Reviews (last completed 2012)	1	ls	$20,000	$20,000	
Final Completion Report	1	ls	$150,000	$150,000	

PRESENT VALUE ANALYSIS — 1.9% Discount Rate — OMB - Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis, 12/2013

Year	Cost Type	Cost	Discount Rate	Present Value
0	Annual O&M Costs (2014)	$0	1.00	$ -
1	Annual O&M Costs (2015)	$0	0.98	$ -
2	Capital Costs (2016)	$16,448,000	0.96	$ 15,840,348
2	Annual O&M Costs	$788,000	0.96	$ 758,888
3	Capital Costs (2017)	$19,140,000	0.95	$ 18,089,201
3	Annual O&M Costs	$788,000	0.95	$ 744,738
3	5 Year Review (2017)	$20,000	0.95	$ 18,902
4	Capital Costs (2018)	$3,293,000	0.93	$ 3,054,183
4	Annual O&M Costs	$788,000	0.93	$ 730,852
4	Capital Costs Thermal (midpoint 2018)	$11,556,000	0.93	$ 10,717,927
5	Annual O&M Costs	$5,008,000	0.91	$ 4,558,200
6	Annual O&M Costs	$5,008,000	0.89	$ 4,473,209
7	Annual O&M Costs	$2,365,000	0.88	$ 2,073,060
8	Annual O&M Costs	$2,365,000	0.86	$ 2,034,406
8	5 Year Review (2022)	$20,000	0.86	$ 17,204
9	Annual O&M Costs	$2,365,000	0.84	$ 1,996,473
10	Annual O&M Costs	$2,365,000	0.83	$ 1,959,248
11	Annual O&M Costs	$2,365,000	0.81	$ 1,922,716
12	Annual O&M Costs	$2,365,000	0.80	$ 1,886,865
12	Capital Costs (Passive GWT System)	$1,129,275	0.80	$ 900,968
13	Periodic Cost - Well Abandonment	$1,357,489	0.78	$ 1,062,850
13	Capital Costs (ISS Perimeter Wall)	$7,931,020	0.78	$ 6,209,615
13	Annual O&M Costs	$284,000	0.78	$ 222,359
13	5 Year Review (2027)	$20,000	0.78	$ 15,659
14	Capital Costs (Final Cap)	$4,100,000	0.77	$ 3,150,252
14	Annual O&M Costs	$284,000	0.77	$ 218,213

TABLE C-7
Cost Estimate for Alternative 7

15	Annual O&M Costs	$284,000	0.75	$	214,144
16	Annual O&M Costs	$284,000	0.74	$	210,151
17	Annual O&M Costs	$284,000	0.73	$	206,233
17	Periodic Cost - GWTP Demolition	$1,000,000	0.73	$	726,171
18	Annual O&M Costs	$284,000	0.71	$	202,387
18	5 Year Review (2032)	$20,000	0.71	$	14,253
19	Annual O&M Costs	$284,000	0.70	$	198,614
20	Annual O&M Costs	$284,000	0.69	$	194,910
21	Annual O&M Costs	$284,000	0.67	$	191,276
22	Annual O&M Costs	$284,000	0.66	$	187,710
23	Annual O&M Costs	$0	0.65	$	-
23	5 Year Review (2037)	$20,000	0.65	$	12,973
24	Annual O&M Costs	$0	0.64	$	-
25	Capital Costs (Road Maintenance)	$25,000	0.62	$	15,617
25	Annual O&M Costs	$0	0.62	$	-
26	Annual O&M Costs	$0	0.61	$	-
27	Annual O&M Costs	$0	0.60	$	-
28	Annual O&M Costs	$0	0.59	$	-
28	5 Year Review (2042)	$20,000	0.59	$	11,807
29	Annual O&M Costs	$0	0.58	$	-
30	Annual O&M Costs	$0	0.57	$	-
31	Annual O&M Costs	$0	0.56	$	-
32	Annual O&M Costs	$0	0.55	$	-
33	Annual O&M Costs	$0	0.54	$	-
33	5 Year Review (2047)	$20,000	0.54	$	10,747
34	Annual O&M Costs	$0	0.53	$	-
35	Annual O&M Costs	$0	0.52	$	-
36	Annual O&M Costs	$0	0.51	$	-
37	Annual O&M Costs	$0	0.50	$	-
38	Annual O&M Costs	$0	0.49	$	-
38	5 Year Review (2052)	$20,000	0.49	$	9,782
39	Annual O&M Costs	$0	0.48	$	-
40	Annual O&M Costs	$0	0.47	$	-
41	Annual O&M Costs	$0	0.46	$	-
42	Annual O&M Costs	$0	0.45	$	-
43	Annual O&M Costs	$0	0.45	$	-
43	5 Year Review (2057)	$20,000	0.45	$	8,903
44	Annual O&M Costs	$0	0.44	$	-
45	Annual O&M Costs	$0	0.43	$	-
46	Annual O&M Costs	$0	0.42	$	-
47	Annual O&M Costs	$0	0.41	$	-
48	Annual O&M Costs	$0	0.41	$	-
48	5 Year Review (2062)	$20,000	0.41	$	8,103
49	Annual O&M Costs	$0	0.40	$	-
50	Annual O&M Costs	$0	0.39	$	-
51	Annual O&M Costs	$0	0.38	$	-
52	Annual O&M Costs	$0	0.38	$	-
53	Annual O&M Costs	$0	0.37	$	-
53	5 Year Review (2067)	$20,000	0.37	$	7,376
54	Annual O&M Costs	$0	0.36	$	-
55	Annual O&M Costs	$0	0.36	$	-
56	Annual O&M Costs	$0	0.35	$	-
57	Annual O&M Costs	$0	0.34	$	-
58	Annual O&M Costs	$0	0.34	$	-
58	5 Year Review (2072)	$20,000	0.34	$	6,713
59	Annual O&M Costs	$0	0.33	$	-
60	Annual O&M Costs	$0	0.32	$	-
61	Annual O&M Costs	$0	0.32	$	-
62	Annual O&M Costs	$0	0.31	$	-
63	Annual O&M Costs	$0	0.31	$	-
63	5 Year Review (2077)	$20,000	0.31	$	6,110
64	Annual O&M Costs	$0	0.30	$	-
65	Annual O&M Costs	$0	0.29	$	-
66	Annual O&M Costs	$0	0.29	$	-
67	Annual O&M Costs	$0	0.28	$	-
68	Annual O&M Costs	$0	0.28	$	-
68	5 Year Review (2082)	$20,000	0.28	$	5,561
69	Annual O&M Costs	$0	0.27	$	-
70	Annual O&M Costs	$0	0.27	$	-
71	Annual O&M Costs	$0	0.26	$	-
72	Annual O&M Costs	$0	0.26	$	-
73	Annual O&M Costs	$0	0.25	$	-
73	5 Year Review (2087)	$20,000	0.25	$	5,062
74	Annual O&M Costs	$0	0.25	$	-
75	Annual O&M Costs	$0	0.24	$	-
76	Annual O&M Costs	$0	0.24	$	-
77	Annual O&M Costs	$0	0.23	$	-
78	Annual O&M Costs	$0	0.23	$	-
78	5 Year Review (2092)	$20,000	0.23	$	4,607
79	Annual O&M Costs	$0	0.23	$	-

TABLE C-7

Cost Estimate for Alternative 7

80	Annual O&M Costs	$0	0.22	$ -
81	Annual O&M Costs	$0	0.22	$ -
82	Annual O&M Costs	$0	0.21	$ -
83	Annual O&M Costs	$0	0.21	$ -
83	5 Year Review (2097)	$20,000	0.21	$ 4,193
84	Annual O&M Costs	$0	0.21	$ -
85	Annual O&M Costs	$0	0.20	$ -
86	Annual O&M Costs	$0	0.20	$ -
87	Annual O&M Costs	$0	0.19	$ -
88	Annual O&M Costs	$0	0.19	$ -
88	5 Year Review (2102)	$20,000	0.19	$ 3,817
89	Annual O&M Costs	$0	0.19	$ -
90	Annual O&M Costs	$0	0.18	$ -
91	Annual O&M Costs	$0	0.18	$ -
92	Annual O&M Costs	$0	0.18	$ -
93	Annual O&M Costs	$0	0.17	$ -
93	5 Year Review (2107)	$20,000	0.17	$ 3,474
94	Annual O&M Costs	$0	0.17	$ -
95	Annual O&M Costs	$0	0.17	$ -
96	Annual O&M Costs	$0	0.16	$ -
97	Annual O&M Costs	$0	0.16	$ -
98	Annual O&M Costs	$0	0.16	$ -
98	5 Year Review (2112)	$20,000	0.16	$ 3,162
99	Annual O&M Costs	$0	0.16	$ -
100	Annual O&M Costs	$0	0.15	$ -
101	Annual O&M Costs	$0	0.15	$ -
102	Final Completion Report (2116)	$150,000	0.15	$ 21,995
TOTAL VALUE ANALYSIS		**$95,940,000**		**$85,150,000**

This construction cost estimate is not an offer for construction and/or project execution. The construction cost estimate for this Design is an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate and is assumed to represent the actual total installed cost. The estimate above is considered control-level cost estimating, suitable for use in project budgeting and planning. This estimate has been prepared with partial design and engineering calculations. The level of accuracy for the class of estimate defines the upper and lower ranges of the cost estimate. It is based upon the level of design detail and uncertainty associate with that level of detail. For a Class 4 estimate, the accuracy range is +50% to -30%. It would appear prudent that internal budget allowances account for the highest cost indicated by this range as well as other site specific allowances. The cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

Appendix D
Remedial Action Alternative Timeframe Projections

APPENDIX D

Remedial Action Alternative Timeframe Projections

Note: This appendix will be submitted with the next submittal.

Appendix E
Wyckoff NAPL Composition

TABLE E-1

Upper Aquifer Production Well NAPL SVOC Analysis Results

Wyckoff /Eagle Harbor Groundwater Operable Unit

Bainbridge Island, WA

	Well ID :	RPW1	RPW1	RPW2	RPW2	RPW4	RPW5	RPW6	RPW6	PW8	PW9
	Screen Elevation :	5 to 38	5 to 38	5 to 55	5 to 55	5 to 49.4	5 to 54	4.1 to 35.6	4.1 to 35.6	5 to 48	4 to 34
	Compartment Number :	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3
	CH2M HILL SampleID :	RPW1-0514-L	RPW1-0514-D	RPW2-0514-L	RPW2-0514-D	RPW4-0514-L	RPW5-0514-D	RPW6-0514-D	FD1-0514	PW8-0514-D	PW9-0514-D
	CLP SampleID :	14174100	14174101	14174106	14174107	14174102	14174103	14174104	14174105	14174108	14174109
	Date Collected :	5/1/2014	5/1/2014	5/2/2014	5/2/2014	5/1/2014	5/1/2014	5/1/2014	5/1/2014	5/2/2014	5/2/2014
	Sample Type :	N	N	N	N	N	N	N	FD	N	N
Analyte	**Units**										
SVOC-Total PAH [a]											
Total PAHs	ug/L	206,785	320,705	215,420	304,405	223,330	287,770	258,425	243,655	245,820	320,940
Total LPAHs	ug/L	174,340	271,690	188,780	254,370	201,370	230,440	208,980	196,750	198,810	278,170
Total HPAHs	ug/L	32,445	49,015	26,640	50,035	21,960	57,330	49,445	46,905	47,010	42,770
SVOC-Low Molecular Weight PAHs											
9H-Fluorene	mg/Kg	16,000	26,000	14,000	24,000	12,000	26,000	25,000	24,000	21,000	25,000
Acenaphthene	mg/Kg	19,000	27,000	20,000	28,000	21,000	30,000	27,000	26,000	26,000	30,000
Acenaphthylene	mg/Kg	540	590	580	670	770	640	680	650	610	570
Anthracene	mg/Kg	5,800	7,100	5,200	7,700	4,600	7,800	7,300	7,100	6,200	7,600
Naphthalene	mg/Kg	100,000	140,000	120,000	140,000	140,000	110,000	92,000	86,000	99,000	150,000
Phenanthrene	mg/Kg	33,000	71,000	29,000	54,000	23,000	56,000	57,000	53,000	46,000	65,000
SVOC-Other Creosote Related											
9H-Carbazole	mg/Kg	1,600	3,200	810	2,500	600	2,900	1,900	1,900	2,100	3,000
Dibenzofuran	mg/Kg	13,000	23,000	13,000	20,000	12,000	21,000	20,000	20,000	18,000	24,000
Naphthalene, 1-methyl-	mg/Kg	20,000	21,000	28,000	25,000	35,000	23,000	22,000	21,000	22,000	30,000
Naphthalene, 2-methyl-	mg/Kg	35,000	41,000	46,000	48,000	60,000	35,000	29,000	29,000	33,000	58,000
SVOC-High Molecular Weight PAHs											
Benzo(a)anthracene	mg/Kg	2,600	3,800	2,000	4,600	1,700	5,000	4,100	3,900	4,100	2,900
Benzo(a)pyrene	mg/Kg	810	900	760	1,300	710	1,500	1,200	1,100	1,300	720
Benzo(g,h,i)perylene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Benzo[b]Fluoranthene	mg/Kg	1,300	1,300	1,000	2,200	930	2,400	1,800	1,700	2,100	930
Benzo[k]fluoranthene	mg/Kg	460	640	560	1,000	500	1,100	840	830	920	530
Chrysene	mg/Kg	1,900	2,700	1,500	3,200	1,400	3,400	2,800	2,700	2,900	2,000
Dibenzo[a,h]anthracene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Indeno(1,2,3-cd)pyrene	mg/Kg	450 U	450 U	480 U	490 U	480 U	470	470 U	450 U	460 U	460 U
Fluoranthene	mg/Kg	15,000	24,000	12,000	22,000	9,600	26,000	23,000	22,000	21,000	21,000
Pyrene	mg/Kg	9,700	15,000	8,100	15,000	6,400	17,000	15,000	14,000	14,000	14,000
SVOC-Other											
Pentachlorophenol	mg/Kg	1,600	450 U	480 U	490 U	1,900	460 U	470 U	450 U	460 U	460 U
1,1'-Biphenyl	mg/Kg	5,200	7,800	6,000	8,100	7,500	7,500	7,500	7,300	7,100	10,000
1,2,4,5-Tetrachlorobenzene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
1,2,4-Trichlorobenzene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,3,4,6-Tetrachlorophenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,4,5-Trichlorophenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,4,6-Trichlorophenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,4-Dichlorophenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,4-Dimethylphenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2,4-Dinitrophenol	mg/Kg	1,800 UJ	1,800 UJ	1,900 UJ	1,900 UJ	1,900 UJ	1,800 UJ	1,900 UJ	1,800 UJ	1,900 UJ	1,800 UJ
2,4-Dinitrotoluene	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
2,6-Dinitrotoluene	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
2-Chloronaphthalene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2-Chlorophenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
2-Nitroaniline	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
2-Nitrophenol	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
3,3'-Dichlorobenzidine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
3-Nitroaniline	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
4,6-Dinitro-2-methylphenol	mg/Kg	910 UJ	890 UJ	960 UJ	970 UJ	950 UJ	920 UJ	940 UJ	900 UJ	930 UJ	920 UJ
4-Bromophenyl-Phenylether	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
4-Chloro-3-methylphenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
4-Chloroaniline	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
4-Chlorophenyl-Phenylether	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
4-Methylphenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
4-Nitroaniline	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
4-Nitrophenol	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
Atrazine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Benzaldehyde	mg/Kg	910 UJ	890 UJ	960 UJ	970 UJ	950 UJ	920 UJ	940 UJ	900 UJ	930 UJ	920 UJ
bis(2-Chloroethyl)ether	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Bis(2-Chloroisopropyl)ether	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Bis(2-ethylhexyl) phthalate	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U

TABLE E-1

Upper Aquifer Production Well NAPL SVOC Analysis Results

Wyckoff /Eagle Harbor Groundwater Operable Unit

Bainbridge Island, WA

	Well ID :	RPW1	RPW1	RPW2	RPW2	RPW4	RPW5	RPW6	RPW6	PW8	PW9
	Screen Elevation :	5 to 38	5 to 38	5 to 55	5 to 55	5 to 49.4	5 to 54	4.1 to 35.6	4.1 to 35.6	5 to 48	4 to 34
	Compartment Number :	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3
	CH2M HILL SampleID :	RPW1-0514-L	RPW1-0514-D	RPW2-0514-L	RPW2-0514-D	RPW4-0514-L	RPW5-0514-D	RPW6-0514-D	FD1-0514	PW8-0514-D	PW9-0514-D
	CLP SampleID :	14174100	14174101	14174106	14174107	14174102	14174103	14174104	14174105	14174108	14174109
	Date Collected :	5/1/2014	5/1/2014	5/2/2014	5/2/2014	5/1/2014	5/1/2014	5/1/2014	5/1/2014	5/2/2014	5/2/2014
	Sample Type :	N	N	N	N	N	N	N	FD	N	N
Analyte	**Units**										
Butylbenzylphthalate	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
Caffeine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Caprolactam	mg/Kg	910 UJ	890 UJ	960 UJ	970 UJ	950 UJ	920 UJ	940 UJ	900 UJ	930 UJ	920 UJ
Diethyl phthalate	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Dimethylphthalate	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Di-n-Butylphthalate	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Di-n-octylphthalate	mg/Kg	910 U	890 U	960 U	970 U	950 U	920 U	940 U	900 U	930 U	920 U
Ethanone, 1-phenyl-	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Hexachlorobenzene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Hexachlorobutadiene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Hexachlorocyclopentadiene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Hexachloroethane	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Isophorone	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Methane, bis(2-chloroethoxy)-	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Nitrobenzene	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
N-Nitrosodimethylamine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
N-Nitrosodinpropylamine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
n-Nitrosodiphenylamine	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Phenol	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U
Phenol, 2-methyl-	mg/Kg	450 U	450 U	480 U	490 U	480 U	460 U	470 U	450 U	460 U	460 U

Notes:

[a] Total PAH, Total LPAH, and Total HPAR are calculated results using detected constituents and 1/2 reporting limit for non-detect constituents.

mg/kg = milligrams per kilogram

U - The analyte was not detected at or above the reported value.

J - The identification of the analyte is acceptable; however the reported value is an estimate.

N = normal sample

FD = field duplicate

TABLE E-2
Production Well NAPL VOC Analysis Results
Wyckoff /Eagle Harbor Groundwater Operable Unit Upper Aquifer Results
Bainbridge Island, WA

	Well ID :	RPW1	RPW1	RPW2	RPW2	RPW4	RPW5	RPW6	RPW6	PW8	PW9
	Screen Elevation :	5 to 38	5 to 38	5 to 55	5 to 55	5 to 49.4	5 to 54	4.1 to 35.6	4.1 to 35.6	5 to 48	4 to 34
	Compartment Number :	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3
	CH2M HILL SampleID :	RPW1-0514-L	RPW1-0514-D	RPW2-0514-L	RPW2-0514-D	RPW4-0514-L	RPW5-0514-D	RPW6-0514-D	FD1-0514	PW8-0514-D	PW9-0514-D
	CLP SampleID :	14174100	14174101	14174106	14174107	14174102	14174103	14174104	14174105	14174108	14174109
	Date Collected :	5/1/2014	5/1/2014	5/2/2014	5/2/2014	5/1/2014	5/1/2014	5/1/2014	5/1/2014	5/2/2014	5/2/2014
	Sample Type :	N	N	N	N	N	N	N	FD	N	N
Analyte	**Units**										
BTEX											
Benzene	mg/kg	48 U	36 U	46 U	40 U	47 U	48 U	46 U	42 U	44 U	44
Ethylbenzene	mg/kg	440	380	1,300	740	430	480	280	280	590	1,300
MP-Xylene	mg/kg	1,000	800	2,400	860	1,400	530	450	430	680	2,800
o-Xylene	mg/kg	490	350	1,100	590	720	360	250	240	440	1,200
Toluene	mg/kg	71	180	160	180	47 U	130	46 U	42 U	74	630

Notes:
mg/kg = milligrams per kilogram
U - The analyte was not detected at or above the reported value.

TABLE E-3

Production Well NAPL TPH Analysis Results and Physical Properties

Wyckoff /Eagle Harbor Groundwater Operable Unit Upper Aquifer Results

Bainbridge Island, WA

		Well ID :	RPW1	RPW1	RPW2	RPW2	RPW4	RPW5	RPW6	RPW6	PW8	PW9
		Screen Elevation :	5 to 38	5 to 38	5 to 55	5 to 55	5 to 49.4	5 to 54	4.1 to 35.6	4.1 to 35.6	5 to 48	4 to 34
		Compartment Number :	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3	1B/2/3
		CH2M HILL SampleID [a] :	RPW1-0514-L	RPW1-0514-D	RPW4-0514-L	RPW5-0514-D*	RPW6-0514-D*	FD1-0514	RPW2-0514-L	RPW2-0514-D	PW8-0514-D*	PW9-0514-D*
		CLP SampleID :	14174100	14174101	14174102	14174103	14174104	14174105	14174106	14174107	14174108	14174109
		Date Collected :	5/1/2014	5/1/2014	5/1/2014	5/1/2014	5/1/2014	5/1/2014	5/2/2014	5/2/2014	5/2/2014	5/2/2014
		Sample Type :	N	N	N	N	N	FD	N	N	N	N
	Analyte	**Units**										
TPH												
TPH-Dx	TPH-GC/Diesel Range Organics	mg/kg	980,000	940,000	99,000	930,000	920,000	920,000	870,000	900,000	910,000	970,000
TPH-Dx	TPH-GC/Motor Oil Range Organics	mg/kg	19,000 U	20,000 U	20,000 U	19,000 U	19,000 U	18,000 U	20,000 U	18,000 U	20,000 U	19,000 U
TPH-Gx	TPH-Gx Gasoline Range Organics	mg/kg	280,000	430,000	740,000	290,000	360,000	450,000	620,000	600,000	440,000	640,000
General Chemistry												
General	Sulfide	ug/L	154	6,040	72.6	4,200	1,700	640	67.3	354	413	1,110
Physical [b]												
	Interfacial Tension-NAPL to Air	cent	29.9	27.1	26.5	30.8	30.6	31	28.4	33.4	30.2	34.1
	Interfacial Tension-GW to Air	cent	59	--	68.6	51.9	54.3	--	47.8	--	48	58
	Interfacial Tension-GW to NAPL	cent	72.7	8.94	68.6	ND	1.22	--	75.1	ND	ND	14.1
	Density - NAPL	g/mL	0.97	1.04	0.96	1.02	1.02	1.01	0.98	1.02	1.01	1.03
	Density - Groundwater	g/mL	1	--	1	1	1	--	1	--	1.01	1
	Viscosity - NAPL	cP	6	13.1	4.2	8	20.1	8.6	5.8	10.3	8.4	6.9
	Viscosity - Groundwater	cP	1.01	--	1.01	1	1.07	--	0.99	--	0.99	1

Notes:

[a] -D appended to sample ID indicates DNAPL; -L appended to sample ID indicates LNAPL

[b] Density, Viscosity and Interfacial Tension Groundwater samples were collected on 5/12/2014 for comparison with NAPL samples

mg/kg = milligrams per kilogram

ug/L = micrograms per liter

g/ml = grams per milliliters

cP = centipose

Cent = Dynes/centimeter

U - The analyte was not detected at or above the reported value.

J - The identification of the analyte is acceptable; however the reported value is an estimate.