REMEDIATION SYSTEM EVALUATION

WYCKOFF/EAGLE HARBOR SUPERFUND SITE
SOIL AND GROUND WATER OPERABLE UNITS
BAINBRIDGE ISLAND, WASHINGTON

Report of the Remediation System Evaluation,
Site Visit Conducted at the Wyckoff/Eagle Harbor Superfund Site
October 8, 2003

Final Report
March 1, 2005

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Office of Solid Waste and
Emergency Response
(5102G)

EPA 542-R-05-013
March 2005
www.epa.gov/tio
www.clu-in.org/optimization

Remediation System Evaluation (RSE)
Wyckoff/Eagle Harbor Superfund Site
Soil and Ground Water Operable Units
Bainbridge Island, Washington

NOTICE

Work described herein was performed by GeoTrans, Inc. (GeoTrans) for the U.S. Environmental Protection Agency (U.S. EPA). Work conducted by GeoTrans, including preparation of this report, was performed under Dynamac Corporation Prime Contract No. 68-C-02-092, Work Service Requests No. ST-1-20 and ST-1-15. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

A Remediation System Evaluation (RSE) involves a team of expert hydrogeologists and engineers, independent of the site, conducting a third-party evaluation of site operations. It is a broad evaluation that considers the goals of the remedy, site conceptual model, above-ground and subsurface performance, and site exit strategy. The evaluation includes reviewing site documents, visiting the site for up to 1.5 days, and compiling a report that includes recommendations to improve the system. Recommendations with cost and cost savings estimates are provided in the following four categories:

- improvements in remedy effectiveness
- reductions in operation and maintenance costs
- technical improvements
- gaining site closeout

The recommendations are intended to help the site team identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation by the RSE team, and represent the opinions of the RSE team.

The Wyckoff/Eagle Harbor Superfund site is located on the eastern side of Bainbridge Island, in central Puget Sound, Washington along Eagle Harbor. The site includes the inactive 57-acre Wyckoff wood-treating facility, contaminated sediments in adjacent Eagle Harbor, and other upland sources of contamination to the harbor, including a former shipyard. The wood-treating facility operated from the early 1900s through 1988, when the plant shut down. The site consists of four operable units, but this RSE pertains only to the soil and ground water operable units (OU2 and OU4). A P&T system has operated at the site as an interim remedy for over a decade, and a pilot study of steam enhanced contaminant recovery was attempted at the site between late October 2002 and April 2003. Technical problems were encountered during the steam injection pilot test, and the site team is now faced with a decision as to how to proceed with the remedy given both technical and fiscal considerations. The RSE team was specifically asked by EPA Region 10 and OSRTI to consider options for moving forward, ranging from containment only through full-scale steam injection.

Rather than providing recommendations for the operating interim P&T system in the four above-mentioned categories, the RSE team is providing recommendations or ideas to consider as the final remedy is chosen, designed, and implemented. In Section 6.0 of this report, the RSE team outlines a road map for a final remedy and highlights what the RSE team believes are high priority items.

The RSE team believes that the best approach for this site is to initially focus efforts on hydraulically isolating the contamination underlying the Former Process Area, including the installation of an upgradient barrier wall and low permeability cap to minimize the amount of water requiring treatment, and the implementation of a new groundwater treatment system based, in part, on pilot testing of one or more new approaches. Enhanced monitoring of groundwater in the lower aquifer is also recommended in conjunction with these efforts, to improve the potential to detect current or future impacts to that aquifer. It is also recommended that the site team continue to monitor the seeps along the eastern beach, and take remedial actions if isolation efforts do not stop the seeps and a feasible remedial alternative is identified.

Once these high priority items are addressed and implemented, the site team could then reconsider aggressive mass removal and the technologies that might be availableat that time (potentially including but not limited to additional efforts related to steam injection). However, the RSE team believes the most cost-effective approach is to design and implement the new groundwater treatment system associated with hydraulic isolation (discussed above) independent of such efforts. This will reduce the potential of over-designing the groundwater treatment system required for hydraulic isolation. Cost/benefit evaluations for subsequent testing or implementation of more aggressive source removal would need to incorporate costs that might be required to further upgrade the groundwater treatment system above and beyond the treatment system associated with hydraulic isolation. The RSE team also believes that, if more aggressive source removal technologies are considered in the future, the costs and benefits of installing additional recovery wells and tying them into the P&T system should be included as a potential alternative.

During the RSE site visit there was discussion about armoring the existing sheet pile wall to prevent scour and extend the life of the wall, and there was also discussion about adding a second sheet pile wall inside the existing wall to create an "attenuation zone" that could be monitored. The RSE team felt that, if armoring was pursued, then the interior sheet pile wall would not be necessary because the armoring could likely be constructed in a manner to allow for an attenuation zone that could be monitored. Subsequent to the RSE site visit, the RSE team was informed that armoring may not be feasible due to potential impacts to the intertidal zone. It is likely that a variety of alternatives will need to be considered in the future regarding this issue, and this issue is not addressed in detail in this RSE report.

The RSE team's suggestions for simplifying the new groundwater treatment system could save EPA as much as $4 million relative to current estimates, while maintaining a protective remedy. This would represent a savings of approximately 20% relative to the preliminary three-year costs that have been estimated to date. If pilot test results of the recommended changes do not support the carbon usage assumptions of the RSE team (that are based on published isotherms plus a safety factor), savings might be lower. Additional savings would also result beyond the three year period by operating a simplified and automated treatment system. Table 7-1 summarizes the cost and protectiveness implications of the recommendations discussed in Section 6.0 of this report.

UPDATE

Substantial progress has occurred at the site since the submission of the revised draft RSE report in February 13, 2004, and this final version. The site team has prioritized remedial efforts and has been focusing on the high priority items, such as establishing hydraulic isolation of the contamination in the Former Process Area. The Region plans to finalize a ROD Amendment or ESD in summer 2005, following public comment. A public proposal for remedial action is scheduled for 2005 with final decision in FY06.

The following efforts have either taken place or are in progress as of the finalization of this report. RSE recommendations that correspond to these efforts are indicated in parentheses.

- The site team is proceeding with the high priority items first (as described below) with focus on hydraulic isolation. The site has not yet omitted thermal remediation as an option. A pilot summary report for the steam pilot study is being finalized and should be done in January 2005. In addition, an engineering evaluation for a full-scale thermal system is being prepared. Thus far, that evaluation suggests that hydraulic isolation will still be needed after thermal remediation to meet standards. Experts believe that heating would require both steam and electrical resistive heating. A 7.5 MW power plant for both electrical resistive heating and steam would likely be required. Other requirements would likely include a cooling tower and a treatment plant that could treat up to 350 gpm. (See discussion in 6.1)

- The site team conducted a pilot test to bypass the aeration basin (biological treatment) and use GAC only, yielding favorable results for eliminating the aeration basin from the treatment train. In addition, tests are underway to address recent problems with multimedia filters. The tests include using hypochlorite to reduce fouling and trying other filter types, such as walnut shells, spent carbon, bag filters, etc. Through contract renegotiation, the site team has been able to reduce the subcontractor O&M costs by approximately $30,000 per month. (See discussion in 6.2.1)

- A 50% design for a water treatment plant was submitted in November 2004. The design includes the DAF unit, mulitmedia filters, and GAC. The design includes contingencies for options to multimedia filters, and although the design does not include a biological treatment system, there is room in the treatment facility footprint if biological treatment is eventually required. A total cost of $5 million is estimated for the treatment plant design and construction. This cost does not include overhaul of the extraction system. Construction is scheduled for October 2005, and the site team is planning on using the existing boiler building to house the future treatment plant. (See discussion in 6.2.1 and 6.2.6)

- EPA and the State have agreed that installation of an upgradient sheet pile wall and a low permeability cap are high priorities that would limit the amount of water entering the contaminated Former Process Area and therefore limit the amount of water that would need to be treated. A preliminary water budget analysis suggests that with these features, the ground water extraction rate would be approximately 10 to 11 gpm. An alternatives evaluation has been drafted for the upgradient cutoff wall. Work has not yet begun on the cap design, which is complicated due to unknowns associated with the final remedy. (See discussion in 6.2.2, 6.2.3, and 6.2.4)

- The site team is conducting lower aquifer monitoring and has included transducers in various monitoring well pairs to get a better idea of hydraulic gradients for a water budget analysis. Further augmentation of monitoring in the lower aquifer will likely occur in the future. Recent data suggest that the hydraulic isolation is adequate and the extraction system does not need to be upgraded at this time. (See discussion in 6.2.7)

PREFACE

This report was prepared as part of a project conducted by the United States Environmental Protection Agency (U.S. EPA) Office of Superfund Remediation and Technology Innovation (OSRTI). The objective of this project is to conduct Remediation System Evaluations (RSEs) at selected pump and treat (P&T) systems that are jointly funded by EPA and the associated State agency. The project contacts are as follows:

Organization	Key Contact	Contact Information
USEPA Office of Superfund Remediation and Technology Innovation (OSRTI)	Jennifer Griesert	1235 S. Clark Street, 12th floor Arlington, VA 22202 Mail Code 5201G phone: 703-603-8888 griesert.jennifer@epa.gov
Dynamac Corporation (Contractor to U.S. EPA)	Daniel F. Pope	Dynamac Corporation 3601 Oakridge Boulevard Ada, OK 74820 phone: 580-436-5740 fax: 580-436-6496 dpope@dynamac.com
GeoTrans, Inc. (Contractor to Dynamac)	Doug Sutton	GeoTrans, Inc. 2 Paragon Way Freehold, NJ 07728 phone: 732-409-0344 fax: 732-409-3020 dsutton@geotransinc.com

TABLE OF CONTENTS

List of Tables

List of Figures

1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000, 2001, and 2002 Remediation System Evaluations (RSEs) were conducted at 24 Fund-lead pump and treat (P&T) sites (i.e., those sites with pump and treat systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, EPA OSRTI has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies. During fiscal years 2003 and 2004, RSEs at up to eight Fund-lead sites are planned in an effort to improve or optimize the sites. An independent EPA contractor is conducting these evaluations, and representatives from EPA OSRTI are attending the RSEs as observers.

The Remediation System Evaluation (RSE) process was developed by the US Army Corps of Engineers (USACE) and is documented on the following website:

http://www.environmental.usace.army.mil/library/guide/rsechk/rsechk.html

An RSE involves a team of expert hydrogeologists and engineers, independent of the site, conducting a third-party evaluation of site operations. It is a broad evaluation that considers the goals of the remedy, site conceptual model, above-ground and subsurface performance, and site exit strategy. The evaluation includes reviewing site documents, visiting the site for one to one and a half days, and compiling a report that includes recommendations to improve the system. Recommendations with cost and cost savings estimates are provided in the following four categories:

- improvements in remedy effectiveness
- reductions in operation and maintenance costs
- technical improvements
- gaining site closeout

The recommendations are intended to help the site team identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, might be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation by the RSE team, and represent the opinions of the RSE team.

The Wyckoff/Eagle Harbor Superfund Site was selected by EPA OSRTI based on a recommendation from EPA Region 10. In particular, the RSE team has been asked to provide input on the remedial approach at the site, particularly the use of thermal technologies to remediate the site or the use of engineered barriers and P&T to provide containment. This report provides a brief background for the site, a summary of observations made during a site visit, and recommendations regarding the remedial approach. Approximate costs and cost savings associated with the recommendations are also discussed.

1.2 TEAM COMPOSITION

The team conducting the RSE consisted of the following individuals:

Rob Greenwald, Hydrogeologist, GeoTrans, Inc.
Peter Rich, Civil and Environmental Engineer, GeoTrans, Inc.
Doug Sutton, Water Resources Engineer, GeoTrans, Inc.

The RSE team was also accompanied by the following observers:

Jennifer Griesert from EPA OSRTI

1.3 DOCUMENTS REVIEWED

Author	Date	Title
CH2M Hill	6/1996	Groundwater Extraction System Assessment Report No. 2
CH2M Hill	8/1996	Groundwater Extraction System Assessment Report No. 1
US EPA	12/1997	EPA Public Meeting: Proposed Plan for Cleanup of Contaminated Soil and Groundwater at the Former Wyckoff Wood Treatment Facility
USACE	4/1998	Offshore Field Investigation Report for the Barrier Wall Design Project
USACE	3-4/1999	In-situ Thermal Technology Advisory Panel Meeting Minutes
US EPA	2/2000	Wyckoff/Eagle Harbor Superfund Site Soil and Groundwater Operable Units Record of Decision
US EPA	7/2002	Wyckoff/Eagle Harbor Superfund Site Steam Injection Treatability Study
US EPA	9/2002	Five-Year Review, Wyckoff/Eagle Harbor Superfund Site
SCS Engineers	2002 - 2003	Wyckoff/Eagle Harbor Superfund Site Thermal Remediation Pilot O&M Project Monthly Reports (July 2002, October 2002, November 2002, December 2002, March 2003, and August 2003)
SCS Engineers	2002 - 2003	Wyckoff/Eagle Harbor Superfund Site Thermal Remediation Pilot O&M Project Monthly Chemical Data Reports (November 2002, December 2002, March 2003, and August 2003)
CH2M Hill	5/2003	Wyckoff Steam Pilot Deficiency List
USACE	8/2003	2002-2003 Year 8 Environmental Monitoring Report
CH2M Hill	9/2003	Process and Instrumentation Diagrams
USACE	10-12/2003	http://www.wyckoffsuperfund.com/

1.4 PERSONS CONTACTED

The following individuals associated with the site were present for the visit:

Mary Jane Nearman, Remedial Project Manager, EPA Region 10
Dan Gravning, EPA HQ
Don Heyer, Project Manager, CH2M Hill
Ken Scheffler, Process Engineer, CH2M Hill
Cliff Leeper, Lead Plant Operator, OMI
David Roberson, Plant Operations, SCS Engineers

1.5 SITE LOCATION, HISTORY, AND CHARACTERISTICS

1.5.1 LOCATION AND HISTORY

The Wyckoff/Eagle Harbor Superfund site is located on the eastern side of Bainbridge Island, in central Puget Sound, Washington along Eagle Harbor. The site includes the inactive 57-acre Wyckoff wood-treating facility, contaminated sediments in adjacent Eagle Harbor, and other upland sources of contamination to the harbor, including a former shipyard. The site is currently divided into the following four operable units, which are depicted in Figure 1-1.

- Operable Unit 1 (OU1) is called East Harbor and has subtidal and intertidal sediments that are contaminated by poly-aromatic hydrocarbons (PAHs).

- Operable Unit 2 (OU2) consists of 18 acres of unsaturated soil on the Wyckoff property that is contaminated with PAHs, pentachlorophenol (PCP), and dioxins/furans.

- Operable Unit 3 (OU3) is called West Harbor and consists of metals contaminated sediments and upland sources.

- Operable Unit 4 (OU4) consists of the contaminated ground water and saturated soil underlying the soil operable unit (OU2).

The wood-treating facility operated from the early 1900s through 1988, when the plant shut down and the Wyckoff Company was renamed Pacific Sound Resources. Investigations by EPA began in 1971, when there were reports of oil on the nearby beaches. The site was listed on the National Priorities List in July 1987. The East and West Harbor operable units have largely been addressed.

This RSE pertains only to the soil and ground water operable units (OU2 and OU4). Figure 1-2 is a schematic that depicts the area included in OU2 and OU4. The following chronology consists of excerpts from the September 2002 Five-Year Review and provides a brief summary of activities related to these two specific operable units.

Approximate Date	Activity
January 1990	A groundwater P&T system began operation.
June 1992 - April 1994	EPA 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 steel from on-site structures.
November 1993	EPA took control of the P&T system and then made improvements in 1994.
September 1994	EPA issued an Interim ROD for the Groundwater Operable Unit that included replacing the treatment system, upgrading the extraction system, installing a physical barrier, and sealing on-site production wells.
November 1994	EPA and the Washington Department of Ecology signed the State Superfund Contract (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.
November 1997	EPA issued a "final" Proposed Plan that preferred containment as the cleanup strategy for soil and ground water.
July 1998	EPA completed the design for a replacement treatment plant. The plant was not constructed pending a final decision regarding the ground water remedy.
1998-1999	Long-term O&M associated with the containment strategy concerned the State. EPA evaluated thermal technologies for possible application at Wyckoff.
April 1999	EPA completed the Focused Feasibility Study Comparative Analysis of Containment and Thermal Technologies.
September 1999	EPA completed conceptual design for thermal remediation and issued a second Proposed Plan to replace the previous one issued in 1997.
February 2000	EPA issued a Record of Decision for the soil and ground water remedies conditionally selecting steam injection as the cleanup remedy.
May 2000	EPA and Washington Department of Ecology signed the State Superfund Contract for the soil and ground water remedies.
February 2001	Over 1,800 lineal feet of sheet pile was installed around the Former Process Area (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 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, etc.
October 2002	Pilot steam injection began. Operation reached approximately 25% capacity with approximately 50% up-time. Ground water extraction in the Former Process Area continued during the steam pilot.
March 2003	Due to technical problems, steam injection was discontinued for further evaluation. Ground water extraction from the Former Process area continued.

As of the time of the RSE site visit, site team is faced with decision as to how to proceed with the remedy. The RSE team was specifically asked by EPA Region 10 and OSRTI to consider options for moving forward, ranging from containment only through full-scale steam injection, given both technical and fiscal considerations. This RSE report provides a summary of the findings from the site visit and the RSE team's recommendations for moving forward with the remedy.

1.5.2 POTENTIAL SOURCES

Facility operations included the storage and use of creosote, pentachlorophenol (PCP), and other hazardous materials, such as solvents and gasoline. Facility operations also included management and treatment of process wastes and storage of both treated and untreated wood. The release of contaminants into the environment resulted from daily operations through leaks and spills. OU2 (soil operable unit) is divided into three areas: the Log Storage/Peeler Area, the Former Process Area, and the Well CW01 Area, which are all depicted in Figure 1-2. The greatest magnitude of contamination is found in the Former Process Area. Remediation of the Log Storage/Peeler Area has been completed. The contaminated soils were excavated from this area and permanently placed in the Former Process Area for remediation during steam injection.

Non-aqeous phase liquid (NAPL) is present at the site in large quantities (estimates suggest that over one million gallons of NAPL are present in subsurface). The following text from the 2000 ROD describes the conceptual model for historical NAPL migration at the site and its role as a continuing source of ground water contamination. This conceptual model is also depicted in Figure 1-3.

- LNAPL accumulates at the water-table surface and continues to migrate laterally, eventually emerging as intertidal seeps in Eagle Harbor and Puget Sound.

- DNAPL continues migrating downward. Lateral movement may occur through high-permeability gravel and cobble zones, or during temporary accumulation on fine-grained layers in the aquifer.

- In shoreline areas, downward migration of some DNAPL may be slowed or halted as it encounters brackish ground water with approximately the same density.

- Along the northwest shoreline, DNAPL appears to be perched on clay and silt beds within the upper aquifer, and has been observed to move laterally through the bulkheads, discharging into the Log Rafting Area. This discharge appears to have been occurring for several decades, contemporaneously with sedimentation; the result is several feet of NAPL saturated harbor-bottom sediments in the Log Rafting Area.

- DNAPL entered the lagoon which extended from the Log Rafting Area into the Tram Loading Area [not shown in RSE report figures], either from the upper aquifer, from surface discharges, or from treated logs placed in the lagoon. This discharge was apparently contemporaneous with sedimentation and filling, resulting in as much as 10 feet of NAPL-saturated soil at the bottom of the old lagoon, now covered with clay fill.

- Most of the DNAPL migrates downward through the upper aquifer until it encounters the relatively low-permeability aquitard layer. The aquitard layer dips toward the north and east. The DNAPL builds up above the aquitard, forming large accumulations in depressions in the aquitard, and generally migrating down-dip toward Eagle Harbor.

- Small amounts of the DNAPL continue to migrate downward into fractures or sandy zones in the aquitard. Data from the current explorations indicate that continued downward migration of

DNAPL occurs primarily in the central portion of the site, where the aquitard contains numerous sand beds and lenses.

- Based on the data collected to date, it appears that NAPL has not reached the lower aquifer.

NAPL undergoes dissolution as it encounters ground water in the upper aquifer, resulting in dissolved contamination. The aqueous-phase contaminants are then transported with the ground water flow, laterally toward Eagle Harbor. Downward advective transport of dissolved contamination through the aquitard is unlikely under natural conditions, since the hydraulic head is higher in the lower aquifer than it is in the upper aquifer.

Although NAPL is now primarily confined to the Former Process Area behind 1,800 linear feet of sheet pile, source material exists as seeps up to 100 feet beyond the sheet pile wall along the beach east of the Former Process Area. It is hoped that the current remedy (sheet pile and pumping) will contain the NAPL and reduce the magnitude of the seeps or eliminate them altogether because natural habitats in the area would likely be destroyed by active remediation in that area.

1.5.3 HYDROGEOLOGIC SETTING

Figure 1-4 conceptually depicts the hydrogeology at the site. Ground water at the site is approximately 5 to 15 feet below ground surface (bgs). This water table forms the upper limits of the upper aquifer. The upper 5 to 10 feet of this upper aquifer consists of both fill and native materials that overlay marine sand containing small amounts of interbedded gravel, silt, and clay. These marine sands range in thickness of 5 to 70 feet. In general, the upper aquifer thickness is approximately 20 feet at the southern (upland) edge of the site and 75 feet at the northern edge of the site along the harbor. Separating the upper aquifer from the semi-confined lower aquifer is a relatively impermeable layer that slopes from north to south. This layer is composed of silt and glacial till and ranges in thickness from 4 to 40 feet. Although it is considered an aquitard, site documents indicate that this layer has interbedded lenses of sand or other material that might provide the potential for downward migration of DNAPL. The lower aquifer, which consists primarily of sand, with small amounts of silt, clay, and gravel, extends to a depth of approximately 200 feet bgs. Clay layers underlay the lower aquifer and separate it from deeper, potable water aquifers that range from 200 to 1,500 feet bgs. A 1,800-foot long sheet pile wall along the shoreline in the Former Process Area extends from a few feet above the tidal high into the glacial till aquitard, nearly 95 feet bgs.

In general, ground water flows from the upland area at the southern boundary of the site toward the harbor and is affected by the tidal cycle. Flow may be downward from upper to the lower aquifer at the upland boundary, but measurements of hydraulic head beneath the Former Process Area generally suggests upward flow in the area of ground water contamination. The flux of water into and out of the upper and lower aquifers is not known, but significantly higher flux is expected during the rainy season, which includes fall, winter, and spring. With the sheet pile in place, preliminary estimates by the site team suggest that the flux of water into the upper aquifer underlying the Former Process Area is approximately 35 gpm during the summer (dry season) and over 80 gpm during the remainder of the year (rainy season). This increase comes from both upland flow that is recharge by precipitation and infiltration of precipitation through the approximate 8-acre extent of the Former Process Area.

Prior to the installation of the sheet pile wall, the upper aquifer underlying the process area was brackish with total dissolved solids exceeding 10,000 mg/L, resulting in a Class III designation. The upper aquifer upgradient of the Former Process Area and the entire lower aquifer in the vicinity of the site has lower total dissolved solids and has a Class II designation. The sheet pile between the harbor and the Former Process Area combined with pumping from within the Former Process Area has resulted in a decrease of the salinity and total dissolved solids in the upper aquifer. The site team expects the upper aquifer underlying Former Process Area to be predominately non-saline water within a few years.

1.5.4 RECEPTORS

The site is currently secured with a fence. Therefore, current receptors of soil contamination include underlying ground water, site workers, and visitors. The site workers and visitors adhere to a site-specific health and safety plan that limits their exposure to soil contamination. Given that future land use will likely include a park that is open to the public, future receptors to soil contamination would likely include both ground water and the public. This potential exposure would presumably be eliminated by the selected remedy.

The primary receptor of ground water contamination is the surface water and sediments of Eagle Harbor and Puget Sound. Ground water use is present in the area, but is limited to upgradient or side-gradient locations within the lower or deep aquifers. Historical quarterly ground water sampling at the nearby supply wells have consistently shown no detectable concentration. The sampling has been discontinued given that site-related contamination is apparently beyond the influence of these wells.

1.5.5 DESCRIPTION OF GROUND WATER PLUME

The ground water plume is primarily confined to the upper aquifer beneath the Former Process Area. However, limited ground water contamination has been reported in at least one well in the lower aquifer. Although no measurable NAPL was detected in the wells, NAPL has been observed on a probe used to gauge one of the lower aquifer wells. As ground water in the upper aquifer flows toward the harbor, it discharges to surface water. Therefore, the interface between the subsurface and the harbor marks the end of the ground water plume. The sheet pile wall has been installed along the shoreline. Some contamination has historically migrated beyond the location of the wall and some remains in the Former Process Area. To the east, some of this contamination outside of the wall continues to discharge to the surface in the form of seeps.

2.0 CURRENT STATUS OF REMEDY

2.1 REMEDY OVERVIEW

The long-term remedy for the ground water and soil operable units targets the Former Process Area. The current components of the remedy include the following:

- a sheet pile wall installed along the outer boundary of the Former Process Area to help contain NAPL and contaminated ground water

- a ground water extraction and NAPL recovery system consisting of nine extraction wells throughout the Former Process Area (only six are active)

- a treatment system to separate the extracted NAPL from ground water and treat the ground water

- pilot injection and extraction systems targeted in a one-acre parcel of the Former Process Area for steam enhanced recovery

- a boiler system used to produce steam for injection and to destroy non-condensable vapors recovered during steam enhanced extraction pilot study

Figure 2-1 depicts the OU2 area and indicates portions of the remedy including the treatment system, the extraction wells, and steam pilot test area.

2.2 CONTAINMENT SHEET PILE WALL

The containment sheet pile wall extends continuously along the western, northern, and eastern boundaries of the Former Process Area. The southern boundary is open to flow from upgradient. The sheet pile extends vertically from a few feet above sea level to approximately 95 feet bgs where it is keyed into the aquitard. Every other seam is welded to reduce the flow of ground water between the joints, and joint observation points have been installed to monitor flow through eight of the unwelded remaining seams. No sealant was used during construction of the wall because the use of steam would likely melt the sealant.

2.3 P&T EXTRACTION SYSTEM

The current extraction system consists of six active extraction wells that extract a total of approximately 35 gpm from the upper aquifer. The wells are eight inches in diameter, are constructed of stainless steel, and include a 4-foot DNAPL sump. Each of the wells is outfitted with separate above-ground progressive cavity ground water and NAPL pumps. The ground water pumps operate continuously and pump water through above-ground HPDE pipe to the head of the treatment system. The NAPL pumps are operated manually on a periodic basis. Information regarding the active wells from October 2002 is summarized in the following table.

Extraction Well	Average Ground Water Extraction Rate (gpm)	Recovered DNAPL 11/2002 (gallons)	Recovered LNAPL 11/2002 (gallons)	Total Recoverd NAPL (gallons)
1	4.2	12	42	7,668
2	Inactive			5,663
3	Inactive			771
4	5.9	0	0	145
5	7.5	0	0	9,678
6	6.4	17	0	6,440
7	Inactive			102
8	5.3	17	0	3,588
9	4.0	36	0	3,206
Totals	**33.4**	**82**	**42**	**37,261**

2.4 P&T TREATMENT SYSTEM

The treatment system was originally installed in 1990 by the responsible party but EPA took over responsibility for O&M in 1993 and made upgrades in 1995. A replacement treatment system was designed in 1998, but that system was never installed due to uncertainty at the time in the future use of steam to enhance recovery. The treatment system includes a dissolved air flotation (DAF) unit (which replaced a nonfunctioning depurator in 2002), a pumping tank, activated sludge system, clarifier, multimedia filters, and three 8,000-pound GAC vessels. Water is discharged to the harbor in accordance with an NPDES permit.

The system treats an average flow rate of approximately 35 gpm. In the absence of steam injection, influent PAH and PCP concentrations are approximately 15 mg/L and 500 ug/L, respectively. This flow rate and influent concentrations yield a mass removal rate from the dissolved phase of approximately 6.5 pounds per day as calculated below.

$$\frac{35\text{ gal.}}{\text{min.}} \times \frac{3.785\text{ L}}{\text{gal.}} \times \frac{15.5\text{ mg.}}{\text{L}} \times \frac{1440\text{ min.}}{\text{day}} \times \frac{2.2\text{ lbs.}}{1\times 10^{6}\text{ mg}} = \frac{6.5\text{ lbs.}}{\text{day}}$$

The DAF unit removes approximately 90% of the PAHs (primarily naphthalene). The aeration basin and GAC remove the remainder of the contamination (less than one pound per day). The DAF also removes product. The October 2002 Monthly Operations Report, written prior to the steam pilot study, reported that approximately 22,000 gallons of NAPL had been recovered from treatment plant operations (i.e., use of the DAF and its predecessors). In sum, nearly 60,000 gallons of NAPL have been recovered from the NAPL recovery wells and treatment plant operations.

2.5 PILOT INJECTION AND EXTRACTION SYSTEM

The pilot injection and extraction system includes 16 steam injection wells and seven extraction wells in a one-acre parcel of the Former Process Area. The extraction wells are completed to the aquitard (approximately 25 to 30 feet bgs in this part of the Former Process Area) and have 20-foot screened intervals. The injection wells are also completed to the aquitard have 5-foot screened intervals. All piping between the wells, steam system, and treatment plant is above ground.

To semi-isolate this system from the rest of the Former Process Area, approximately 530 feet of sheet pile was installed on the western, northern, and eastern boundaries of the one-acre parcel. As with the containment sheet pile wall, the southern boundary is open to flow from upgradient. The wall extends from a few feet above ground surface to approximately 35 feet deep where it is keyed into the aquitard, which is shallower in this location than it is along the outer boundaries of the Former Process Area. An HDPE vapor cap is installed at the surface to help contain contaminant vapors that are released from the subsurface during steam injection. When operating at 25% of capacity at near steady-state conditions in March 2003, approximately 2,000 pounds of steam per hour were injected through the injection network and approximately 20 gpm was extracted through the extraction network. No extraction was occurring at wells EW-1 and EW-7. The pilot steam project extracted approximately 2,200 gallons of NAPL in under six months, but the pilot project never achieved levels of steam delivery and temperature distribution originally planned for the test due to a variety of site-specific complications that were encountered.

2.6 STEAM SYSTEM

The steam system includes the following items:

- an extraction well upgradient of the former process area and approximately 300 feet deep that provides clean water for generating steam
- a water softening system to condition the water for the boiler
- a heat exchanger that condenses recovered vapors and preheats water prior to the boiler
- a boiler to generate steam and combust the recovered vapors that were not condensed
- vapor recovery pumps to recover contaminant vapors from the subsurface
- a thermal oxidizer to combust non-condensable recovered vapors (never used)
- a total organic carbon (TOC) analyzer to quantify recovered contamination

Uncondensed vapors are destroyed by the boiler flame, and the condensed vapors are sent to the treatment plant.

2.7 MONITORING PROGRAM

The monitoring program for OU2/OU4 includes sampling of water quality from approximately 10 to 12 wells within the Former Process Area and weekly process monitoring. The weekly monitoring consists of approximately eight samples throughout the treatment plant that are analyzed for PAHs and PCP plus a few other samples that are analyzed for oil and grease or solids. The weekly samples include the effluent samples that are needed to meet the NPDES permit requirements. Quarterly biomonitoring is also conducted on the effluent as directed by the NPDES permit. Laboratory analysis is provided by the EPA Regional Laboratory at no cost to the site.

3.0 REMEDY OBJECTIVES, PERFORMANCE, AND CLOSURE CRITERIA

3.1 REMEDY OBJECTIVES AND CLOSURE CRITERIA

The remedial action objectives (RAOs) for the soil operable unit, as identified in the February 2000 ROD are as follows:

- prevent human exposure through direct contact (ingestion, inhalation, or dermal contact) with contaminated soil
- prevent storm water runoff containing contaminated soil from reaching Eagle Harbor

The soil Log Storage/Peeler Area has already been addressed. The Former Process Area is the only remaining area of the site where contaminated soils still need to be addressed.

The RAOs for the ground water operable unit, as identified in the February 2000 ROD are as follows:

- reduce the NAPL source and the quantity of NAPL leaving the upper aquifer beneath the Former Process Area sufficiently to protect marine water quality, surface water, and sediments (e.g., ensure the quantity of NAPL leaving the site will not adversely affect aquatic life and sediments)
- ensure contaminant concentrations in the upper aquifer ground water leaving the Former Process Area will not adversely affect marine water quality, and aquatic life in surface water and sediment
- protect humans from exposure to ground water containing contaminant concentrations above MCLs
- protect the ground water outside the Former Process Area and in the lower aquifers, which are potential drinking water sources

The ROD states that site-specific ground water contaminant concentrations are to be met at the mudline. However, the addition of the sheet pile wall introduces another potential point of compliance. For the upper portion of the sheet pile wall, where the surface water is present on the exterior of the wall, the interior side of the sheet pile wall is considered the point of compliance. This is because the sheet pile is relatively thin (less than one inch) and there is no expected attenuation of the contaminants over this short distance. For the lower portion of the sheet pile wall, where sediments are present on the exterior of the wall, the mudline (i.e., the interface between the sediments and the surface water) is the point of compliance.

The marine water quality, surface water, and marine sediments in Eagle Harbor are the media of primary concern. The following table summarizes the ground water cleanup standards for the Wyckoff site. These standards are the most stringent of the State and Federal marine water quality standards, risk-based surface water standards for human consumption of organisms, and calculated pore-water maximums based on Sediment Management Standards for marine sediments.

Contaminant of Concern	Ground Water Cleanup Level* (ug/L)
Naphthalene	83
Acenaphthylene	
Acenaphthene	3
Fluorene	3
Phenanthrene	
Anthracene	9
Fluoranthene	3
Pyrene	15
Benzo(a)anthrancene	0.0296
Chrysene	0.0296
Benzo(b)fluoranthene	0.0296
Benzo(k)fluoranthene	0.0296
Benzo(a)pyrene	0.0296
Dibenzo(a,h)anthracene	0.007
Benzo(g,h,i)perylene	
Indeno(1,2,3-cd)pyrene	0.0296
HPAH	0.254
Pentachlorophenol	4.9

** Where there is no cleanup level specified for a certain chemical, benzo(a)pyrene will be used as an indicator chemical during remediation. Ground water cleanup levels will be measured at the point of compliance.*

3.2 TREATMENT PLANT DISCHARGE CRITERIA

An NPDES permit provides the criteria for the discharge from the treatment plant. The criteria for PAHs and PCP are provided below. The table below does not provide the criteria for metals, inorganics, or biomonitoring. Sampling for all parameters (except biomonitoring) is required on a weekly basis.

Contaminant of Concern	Discharge Criteria (ug/L)
Total of 16 PAHs	20
Individual PAHs	
Naphthalene	4
Acenaphthylene	4
Acenaphthene	4

Contaminant of Concern	Discharge Criteria (ug/L)
Fluorene	2
Phenanthrene	2
Anthracene	2
Fluoranthene	2
Pyrene	2
Benzo(a)anthrancene	2
Chrysene	2
Benzo(b)fluoranthene	2
Benzo(k)fluoranthene	2
Benzo(a)pyrene	2
Dibenzo(a,h)anthracene	2
Benzo(g,h,i)perylene	2
Indeno(1,2,3-cd)pyrene	2
Pentachlorophenol	6

For some of the PAHs, the cleanup standards are orders of magnitude lower than the discharge standards. The RSE team notes this disconnect between these cleanup and discharge standards, particularly since the cleanup standards are based on marine water quality and the discharge standards apply to marine water.

4.0 FINDINGS AND OBSERVATIONS FROM THE RSE SITE VISIT

4.1 FINDINGS

The RSE team observed a knowledgeable and competent site team led by an effective, motivated, and organized EPA RPM. The observations provided below are not intended to imply a deficiency in the work of the system designers, system operators, or site managers but are offered as constructive suggestions in the best interest of the EPA and the public. These observations obviously have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of ground water remediation have changed over time.

4.2 SUBSURFACE PERFORMANCE AND RESPONSE

4.2.1 NAPL AND PLUME CAPTURE

The OU2 and OU4 contamination is located primarily within the Former Process Area and is surrounded on three sides by 1,800 feet of sheet pile. The sheet pile separates the Former Process Area from Eagle Harbor and Puget Sound but leaves it open to ground water flow from the upgradient highlands. Because the sheet pile is not completely impermeable (leaks at the seals), containment of dissolved contamination can only be provided if inward hydraulic gradients are established on all sides of and beneath the Former Process Area. For this to occur, more water should be extracted from the Former Process Area than enters it. Because flow from Eagle Harbor and Puget Sound are limited by the barrier wall, extraction is primarily needed to offset ground water flow from upgradient, infiltration from the surface, and infiltration from the underlying formation. The P&T system currently pumps approximately 35 gpm, and a hydrogeologic investigation is underway to determine how much water should be extracted to offset incoming flow. Preliminary estimates suggest that 35 gpm might be sufficient during the dry season (i.e., summer) but that more than 80 gpm might be required during the wet season (i.e., fall, winter, and spring). Therefore, it is likely that the current system does not provide containment of dissolved contamination during three of the four seasons of the year. Containment may also not be sufficient during low tide, because at low tide, the water elevation in Eagle Harbor and Puget Sound is likely much less than the water table in the Former Process Area.

Even if hydraulic gradients can establish containment of dissolved contamination, mobile DNAPL can potentially migrate through sand beds or other permeable material dispersed throughout the glacial till aquitard that separates the upper and lower aquifers beneath the Former Process Area. To date, a limited amount of contamination has been found in the lower aquifer; however, a more extensive sampling program could identify additional contamination. If contamination in the lower aquifer is in fact limited after nearly a century of wood treating operations at the former facility (and remediation that has only taken place over the last decade), it suggests that migration through the aquitard is possible but likely limited. Of the 10 monitoring wells sampled during November 2002, five of them (CW-05, CW-09, CW-15, 99CD-MW02, and 99CD-MW04) are screened in the upper portion of the lower aquifer (i.e., below the aquitard). The other five wells are screened in the upper aquifer. The lower-aquifer wells show detections of dissolved contamination. Few of the detections are above the cleanup criteria, and these are primarily associated with CW-015. These detections indicate contamination has migrated to the lower aquifer, but it is unknown to what degree the migration occurred in the past and to what degree it continues to occur. Although no measurable NAPL has been found in the lower aquifer, one of the probes used to gauge a lower-aquifer well had NAPL on it when it was retrieved from the well.

Despite efforts to contain contamination within the Former Process Area, there is NAPL contamination in the form of seeps that is present outside of the sheet pile along the Puget Sound shoreline. This area is marked on Figure 2-1. The site team reports that when the tide is low, a sheen is often visible. This contamination was discovered during the offshore field investigation for the design of the barrier wall and is documented in the associated report dated April 1998. No specific remedial actions are underway to address these seeps, and it is not clear that a feasible remedy exists for this contamination given the natural habitat that would be destroyed by remedial activities. It is hoped that containment of the upper aquifer beneath the Former Process Area will cut off the NAPL migration pathway and reduce the magnitude of the seeps or eliminate them completely.

4.2.2 CONTAMINANT LEVELS

Contaminant levels in the Former Process Area are significantly above marine water quality standards as would be expected given the presence of NAPL.

4.2.3 STEAM INJECTION PILOT RESULTS

A full report of the steam pilot test is forthcoming from site contractors. The summary provided herein is intended to provide information summarized to the RSE team that is pertinent to the recommendations contained in this RSE report.

The steam pilot test operated primarily between late October 2002 and April 2003, a total of approximately 160 days. On approximately 50 of those 160 days, no steam was injected due to technical issues or problems resulting from use of this experimental technology. The steam system only operated at full capacity for about 30 days. The system appeared to operate at a relatively steady rate between mid-January and late March of 2003 (approximately 2.5 months), but this was a level of steaming substantially below the intended levels for the pilot test. This steady rate consisted of approximately 2,000 pounds per hour of steam injected and approximately 22 gpm of total fluids extracted. Over this portion of the pilot, approximately 1,500 gallons of NAPL were removed according to total organic carbon analysis of the effluent presented in the August 2003 Monthly Report. An additional 700 gallons were removed during periods before and after this approximate 2.5-month period of steady operation. Approximately 60,000 gallons are estimated to be present in the pilot test area. Additional mass removal would have been expected from the NAPL and vapor phase recovery if the aquifer was sufficiently heated. However, the current treatment processes were overwhelmed even with the limited steaming, and if full heating of the pilot area did occur, treatment capacity would not have been available to address the extracted contaminant mass.

Temperatures in some areas of the pilot test reached above 100 degrees Celsius, but temperatures immediately below the cap (where LNAPL would be expected) or along the aquitard (where DNAPL would be expected) were generally between 40 and 80 degrees Celsius. This limited the amount of NAPL recovery, and was due to a series of site-specific complications associated with the stratigraphy of the site, the capacity of the existing liquid and vapor treatment systems, and fouling of equipment and pipes from crystallization of naphthalene.

4.3 COMPONENT PERFORMANCE

4.3.1 CONTAINMENT SHEET PILE WALL

The containment sheet pile wall has performed as expected. It has reduced the exchange between the upper aquifer and Eagle Harbor. The site team has already observed a decrease in the salinity of the upper aquifer because ground water has been extracted, flow of salt water from the Harbor has been reduced, and fresh water is entering from both upgradient and from the upward flux from the lower aquifer. The primary concern regarding this sheet pile wall is scouring and corrosion of the portion in the intertidal zone. Although the wall is supposed to last for 50 years, the site team believes that this corrosion and scouring will likely reduce the lifetime of this portion of the wall if it is not protected. The site team is currently considering strategies to protect the wall, such as placement of sand and rip rap armor along its exterior side. Subsequent to the RSE visit, the RSE team was informed that placing armor along the exterior side may not be feasible due to impacts that would result to the intertidal zone.

4.3.2 P&T EXTRACTION SYSTEM

The P&T extraction system has functioned as expected. Sacrifical zinc anodes are placed on each pump to avoid corrosion in the brackish water. The piping from the extraction system to the treatment plant are cleaned approximately once every 18 months due to biofouling. The piping and pumps are above ground, which could provide a complication for future land use if pumping is to continue indefinitely.

4.3.3 TREATMENT SYSTEM

Although the activated sludge tank has been very effective for PAH and PCP removal, it is in poor condition and the existing system as a whole is overly complex and difficult to operate for treating a relatively low flow rate and manageable PAH and PCP concentrations. Additionally, the system has had excessive corrective maintenance requirements due to degradation or corrosion because of chemical incompatibility. For example, during October 2002, two portions of the above-ground piping cracked (likely due to corrosion) causing contaminated liquid to discharge to the treatment pad surface. The site contractor also indicates a number of improvements that are required for current treatment system. Some of those are listed below.

- The existing wet well tank on the discharge of the aeration basin may fail causing the treatment system to be shut down. A new parallel tank should be added to provide a contingency.
- New diffusers should be provided for the aeration basin.
- The existing aeration basin blowers are worn out and need to be replaced.
- A new polymer feed system is required, a temperature controlled polymer storage tank is required (current storage location is unacceptable).
- Pumps require rebuilding and seals require replacement.
- Heat tracing is marginal and offers protection to the plant for temperatures down to approximately 25 degrees Fahrenheit, and improvements are necessary.
- Electrical system upgrades are needed

A number of other issues would need to be addressed if steam injection is to be used again in the future. These issues include (but are not limited to) replacing the undersized aeration basin and clarifier, providing knockout chambers for removal of naphthalene crystals, and improving solids handling capabilities. The existing groundwater treatment plant was a rate limiting step with regard to ground water and NAPL extraction during the steam pilot test.

In general, the existing groundwater treatment system needs to be replaced whether or not the remedy calls for P&T only or enhanced recovery with steam injection. However, the treatment system components and expense could differ greatly on whether or not the system is designed to accommodate influent associated with steam injection. A design for a modified system was proposed in 1998, but a replacement treatment plant was not constructed due to the pending change in the preferred ground water remedy. Approximately $250,000 of upgrades were made to help the system provide treatment during the steam injection pilot, but the system was generally inadequate in terms of capacity during the steam pilot test and suffered from a number of technical problems.

4.3.4 PILOT STEAM INJECTION AND EXTRACTION SYSTEM

The pilot steam injection and extraction system never reached the expected capacity and performance as a result of several site-specific technical problems. First, the high concentrations of naphthalene in the vapor phase led to crystalization and fouling of the extraction lines and a naphthalene wax buildup on the extraction pump screens. Second, the bottom of the aquifer, where DNAPL is located, did not reach the high temperatures that were expected and therefore did not increase DNAPL recovery along the aquitard as high as expected. Finally, the rate of extraction was limited by the capacity of the existing treatment system. In particular, the aeration basin and clarifier were undersized for treating the extracted contaminant mass.

4.3.5 STEAM GENERATION SYSTEM

The steam generation system also encountered site-specific technical problems that prevented the pilot program from reaching the expected capacity. Some of those problems were as follows:

- Naphthalene crystalization caused fouling at a number of locations.
- The liquid ring vacuum pumps had seals that were incompatible with naphthalene, and the moisture knock out tank was too small causing the seal to become displaced.
- The heat exchanger seals for the vapor condenser melted.
- Using the boiler for destroying off-gas may result in dioxin production and emission.
- The thermal oxidizer was never used because the blower would extinguish the flame.

According to the site contractor, a number of other site-specific issues directly associated with the steam system would need to be addressed prior to using it further.

4.4 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF OU2 AND OU4 COSTS

Site activities are currently funded through a trust established by Pacific Sound Resources. Approximately $100 million has been spent to date on all four operable units. Of the remaining funds in the trust, approximately $4 million are allocated to this site, and after that $4 million is spent, the site activities will be funded by EPA and the State. It is difficult to project accurate cost estimates for future activities because the steam pilot test has ended, the existing groundwater treatment system requires replacement, the further use of steam is uncertain, and a number of other site improvements are required.

If no further steam injection is conducted, the site contractors preliminarily estimate that approximately $20 million might be spent over the next three years for OU2 and OU4. A breakdown of those estimated costs, as provided by the site contractor, is provided in the following table. Although these expenditures are expected to be somewhat representative of costs for fiscal years 2004 through 2006, they should not be used to extrapolate costs beyond fiscal year 2006.

With regard to steam injection, approximately $10 million was spent on attempting the steam pilot test. If full-scale steam injection is used in the future, the cost of the remedy might be $60 to $80 million in addition to the above-mentioned $20 million. Such cost estimates would obviously be a function of the time estimate assumed to reach site closeout as a result of the steam technology. If full-scale steam did not achieve site closeout, additional costs would then be required for continued P&T operation that would likely be needed to provide containment of the remaining contamination.

Estimated Costs for Fiscal Years 2004 through 2006 (without Steam Injection)

Item Description	Estimated Cost
Site Improvements	
Upgrades to treatment plant	$630,000
Mothball steam equipment	$60,000
Upgradient sheet pile wall	$1,180,000
Bentonite seal for upper portion of outer sheet pile wall	$850,000
Low permeability site cap	$3,580,000
Shoreline improvements	$2,090,000
New water treatment plant	$3,500,000
New/rebuilt extraction wells and discharge piping	$900,000
Removal of steam equipment and pilot wells	$140,000
Site Improvements Subtotal	**$12,930,000**
O&M and Engineering	
Carbon usage	$30,000
Disposal of materials	$400,000
Operator and sampling labor, utilities, materials, etc.	$3,960,000
Engineering and construction management	$2,350,000
O&M and Engineering Subtotal	**$6,740,000**
Total Estimated Cost	**$19,670,000**

Note: These costs do not include costs for USACE oversight and contract management.

The items in the above table are briefly discussed below:

Site Improvements

Upgrades to the current treatment plant - These expenditures are deemed necessary by the site contractor to keep the current treatment plant operating effectively while a new treatment plant is designed and constructed.

Mothball the steam pilot equipment - This includes a $40,000 estimate to properly store the equipment and $20,000 to fix the thermal oxidizer.

Upgradient sheet pile wall - Installing this wall would prevent ground water flow from the highlands from entering the Former Process Area. With installation of this wall, the Former Process Area would be completely enclosed by sheet pile, thereby reducing the amount of water that would require extraction and treatment. The cost is based on the costs of installing the original 1,800 feet of sheet pile adjusted for the shallower sheet pile depth required at the upgradient location.

Bentonite seal for upper portion of outer wall - A 30-inch wide slurry wall is proposed along the upper portion of the sheet pile along the shoreline to provide an attenuation zone between the Former Process Area and surface water. Because no attenuation zone currently exists where sediments are not present on the outside of the sheet pile, the inside of the sheet pile is considered the compliance point. With the addition of this slurry, an attenuation zone would exist and the compliance point would theoretically be the outside of the slurry wall. Because sediments offer an attenuation zone, this slurry would only be placed along portions of the wall where surface water (and not sediments) is present on the outside of the sheet pile.

Low permeability site cap - This item includes both grading and contouring along with the installation of a low permeability cap to prevent precipitation from infiltrating into the contaminated area enclosed by the sheet pile and to prevent exposure to the public during future land use. The cost of the site grading and contouring is estimated at approximately $500,000, and the cost of the low permeability cap is estimated at over $3 million.

Shoreline improvements - Approximately $1.7 million is estimated for using sand and rip rap to protect the outer sheet pile from corrosion. An additional $300,000 is estimated for beach mitigation and meeting requirements associated with the Shoreline Management Act.

New water treatment plant - A cost of $3.5 million is expected for the cost of a new water treatment plant. This cost estimate assumes a treatment capacity of approximately 25 gpm, which is lower than the treatment capacity of the existing system.

New/rebuilt extraction wells and outfall - Approximately $900,000 is estimated for upgrading the extraction system, the extraction system piping, and the discharge outfall to be inaccessible to the public in the future.

Removal of steam equipment and pilot wells - Approximately $140,000 is estimated to remove the steam equipment and abandon the wells in the pilot area. This estimated cost includes estimated refunds associated with selling the boiler and unused fuel.

O&M and Engineering

Carbon usage - The cost assumes replacement of one 8,000-pound unit per year at approximately $1.10 per pound, which is consistent with current costs and usage.

Disposal of materials - Approximately $400,000 is estimated for disposing of material already on site as well as drummed materials, recovered product, and biosolids through fiscal year 2006 (a three-year period).

Treatment plant O&M - Based on an estimated cost of $110,000 per month, the contractor estimates that the cost for P&T operation for three years (i.e., through fiscal year 2006) is just under $4 million. The treatment plant is operated by at least two people, eight hours per day, seven days per week. Other contributors to this $110,000 per month costs might include monthly operations reports and sample collection.

Engineering and construction management - The contractor estimates approximately $2.35 million for engineering and construction management over the next three years. The contractor assumes that $1 million will be required in fiscal year 2004, $800,000 will be required in fiscal year 2005, and $550,000 will be required in fiscal year 2006.

4.5 REGULATORY COMPLIANCE

The site regularly meets its treated water discharge criteria. If steaming were to continue, further studies would be necessary to evaluate the compliance of air discharges from the combustion of the off-gas with the boiler and/or thermal oxidizer.

4.6 TREATMENT PROCESS EXCURSIONS AND UPSETS, ACCIDENTAL CONTAMINANT/REAGENT RELEASES

Although leaks have occurred from pipes and seals, no significant contaminant mass is known to have discharged to the environment as a result of the OU2 and OU4 activities.

4.7 SAFETY RECORD

The site team has an excellent safety record. The contractors stated that no reportable incidents occurred during the steam pilot test. A site-specific health and safety program is in place to minimize exposure of workers to site-related contamination.

5.0 EFFECTIVENESS OF THE SYSTEM TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT

5.1 GROUND WATER

Ground water use is present in the area, but is limited to upgradient or side-gradient locations within the lower or deep aquifers. Historical quarterly ground water sampling at the nearby supply wells have consistently shown no detectable contaminant concentrations. Therefore, site conditions appear protective of human health with respect to ground water use.

The primary receptor of ground water contamination is the surface water and sediments of Eagle Harbor and Puget Sound. There are two likely mechanisms for contamination to enter these surface water bodies under current conditions. The first is the contamination that already exists outside of the sheet pile in the form of seeps along the eastern side of the Former Process Area in Puget Sound. These seeps may become inactive in the future due to the presence of the sheet pile, which will mitigate a potential route for continued NAPL migration. The second is the potential for contamination (dissolved or NAPL) to seep from the Former Process Area through the sheet pile seams into either Eagle Harbor or Puget Sound. Because of the pumping, inward gradients are likely established between the surface water and the inside of the sheet pile (during the majority of the tidal cycle) and the amount of contamination seeping through the sheet pile is likely minimal relative to the contamination already outside of the sheet pile.

The lower aquifer is also a potential receptor of contamination. To date, a limited amount of contamination has been found in the lower aquifer. Because upward gradients are established from the lower to the upper aquifer, any contamination in the lower aquifer is likely due to DNAPL that may have migrated downward under the influence of gravity. Based on current monitoring, impacts to the lower aquifer appear to be minimal. However, as discussed in Section 4.2.1, the current monitoring network may need to be expanded to improve confidence in that conclusion.

5.2 SURFACE WATER

As discussed above, surface water is the primary receptor of site-related contamination. The RSE team has not evaluated surface water concentrations. The remedy is not currently protective of surface water, but the site team knows this and is working toward a remedy that will hopefully be protective of surface water.

5.3 AIR

With the exception of naphthalene, site contaminants are not particularly volatile, and air is not one of the primary routes of exposure to ground water or saturated soil contamination. If steam is used in the future, the system should be designed to incorporate adequate vapor off-gas treatment.

5.4 SOILS

Soil contamination is present in saturated zone and potentially in the unsaturated zone. A health and safety plan is currently in place to minimize conduct with contaminated soils, and the final remedy should provide adequate protectiveness.

5.5 WETLANDS AND SEDIMENTS

Wetlands are not associated with this site, and sediments are potentially threatened as contaminated ground water migrates toward surface water (see above).

6.0 RECOMMENDATIONS

Cost estimates provided herein have levels of certainty comparable to those done for CERCLA Feasibility Studies (-30/+50%), and these cost estimates have been prepared in a manner consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July 2000.

RSEs generally classify recommendations for operating remedies into four categories:

- improvements in remedy effectiveness
- reductions in operation and maintenance costs
- technical improvements
- gaining site closeout

This site, however, has an interim remedy that will shortly be replaced by a final remedy. Therefore, rather than provide recommendations associated with the operating interim remedy, the RSE team is providing ideas to consider as the final remedy is chosen, designed, and implemented. EPA specifically asked the RSE team for its position on the merits of remediation via full-scale steam injection versus long-term containment with P&T and physical barriers. The following sections describe the ideas and opinions regarding the final remedy for OU2 and OU4 that the RSE team developed based on the site visit and a review of background documents. Consideration is given to both protectiveness and cost-effectiveness.

A table summarizing the cost and protectiveness implications of the recommendations is provided in Table 7-1, which is located at the end of Section 7.0.

6.1 ROAD MAP FOR A FINAL REMEDY

Based on the reviewed information, the RSE site visit, and subsequent discussion with the site team, the RSE team believes that the best approach for this site is to initially focus efforts on hydraulic isolation of the contamination underlying the Former Process Area, including the installation of an upgradient barrier wall and low permeability cap to minimize the amount of water requiring treatment, and the implementation of a new groundwater treatment system based, in part, on pilot testing of one or more new approaches. Enhanced monitoring of groundwater in the lower aquifer is also recommended in conjunction with these efforts, to improve the potential to detect current or future impacts to that aquifer. It is also recommended that the site team monitor the active seeps along the eastern beach, and take remedial actions if the seeps persist and a feasible remedial alternative is identified.

Once these high priority items are addressed and implemented, the site team could then reconsider aggressive mass removal and the technologies that might be available at that time (potentially including but not limited to additional efforts related to steam injection). However, the RSE team believes the most cost-effective approach is to design and implement the new groundwater treatment system associated with hydraulic isolation (discussed above) independent of such efforts. This will reduce the potential of over-designing the groundwater treatment system required for hydraulic isolation. Cost/benefit evaluations for subsequent testing or implementation of more aggressive source removal would need to incorporate costs that might be required to further upgrade the groundwater treatment system above and beyond the treatment system associated with hydraulic isolation. The RSE team also believes that, if more aggressive source removal technologies are considered in the future, that the costs and benefits of installing additional recovery wells and tying them into the P&T system should be included as a potential alternative.

During the RSE site visit there was discussion about armoring the existing sheet pile wall to prevent scour and extend the life of the wall, and there was also discussion about adding a second sheet pile wall inside the existing wall to create an "attenuation zone" that could be monitored and provide a backup barrier in case of premature failure of the outer sheet pile wall. The RSE team felt that, if armoring was pursued, then the interior sheet pile wall would not be necessary because the armoring could likely be constructed in a manner to allow for an attenuation zone that could be monitored. Subsequent to the RSE site visit, the RSE team was informed that armoring may not be feasible due to potential impacts to the intertidal zone. It is likely that a variety of alternatives will need to be considered in the future regarding this issue, and this issue is not addressed in detail in this RSE report.

As is evident from the pilot test, steam injection requires a substantial level of effort and money that can potentially detract from hydraulic isolation and other important issues. The existing treatment system is currently in a state of disrepair and failure of some components could disrupt the extraction and treatment required for continued hydraulic isolation. Furthermore, the cost of non-routine maintenance of the existing system is rising. The site contractor indicates that over $600,000 is required in the short-term to keep the existing system operational. The long-term cost estimate for full-scale steam application is $60 to $80 million. The RSE team believes that, if the focus were to return to steam injection as the initial priority at this point, then the funding and level of effort that is required to address the other priority items suggested above may be diverted to address steam-specific considerations. Therefore, the other high priority items should be addressed first.

The RSE team, however, does not necessarily suggest that steam enhanced recovery or other aggressive remediation should never be used at the site. While the site moves forward with providing a protective remedy based on the high-priority items suggested above, technological progress will likely be made in the application of steam enhanced recovery and other aggressive source remediation approaches. The site team can reconsider more aggressive source removal options in the future. The following is a partial list of items that should be considered when evaluating whether or not to purse more aggressive source removal in the future:

- Will more aggressive source removal action shorten the estimate of cleanup duration, and if so, what is the uncertainty in that estimate?

- What is the estimated life-cycle cost impact of more aggressive source removal, and how does that calculation depend on the cleanup time estimate and related uncertainty of that estimate?

- Will more aggressive source removal require modifications to the new groundwater treatment system, and have those modifications been accounted for in the cost estimates?

- If further steam injection is considered, will the problems encountered in the pilot test (such as heating the lower part of the aquifer and the naphthalene crystallization) be overcome with alternative engineering, and have additional site-specific complications been anticipated?

- Is there an increased potential to mobilize DNAPL flow downward to the lower aquifer as a result of the more aggressive source removal?

- Are increased health and safety protocols included to account for any increased potential hazards associated with more aggressive source removal?

- Are there potential negative impacts from more aggressive source removal (such as noise, odor, etc.)? Can such impacts (if any) be mitigated through reasonable engineering efforts, and if not, do the potential benefits of the action outweigh these impacts?

The site team can decide whether or not to pursue more aggressive source removal in the future by evaluating these (and potentially other) considerations as part of a detailed cost/benefit analysis and an evaluation of potential costs versus available resources.

6.2 HIGH PRIORITY, SHORT-TERM ITEMS

To improve hydraulic isolation of site contamination expeditiously and cost-effectively, the RSE team recommends addressing the following high priority, short-term items below.

6.2.1 SIMPLIFY THE EXISTING TREATMENT SYSTEM (PILOT TEST ALTERNATIVES)

The contractor indicates that the treatment system requires approximately $630,000 in upgrades/repairs for it to operate reliably over the next year or two while decisions are made regarding other remedial components. This assumes continued operation of the biosystem with a three-year cost of approximately $4 million. A greatly simplified system, however, might provide adequate treatment at reduced capital and annual costs. This simplified system would bypass the biological treatment components and use the GAC units to treat the effluent from the DAF unit. The reduction in costs would be dependent on GAC usage rates and other factors.

The RSE team was provided with a number of chemical analysis reports that provide the analytical results from process water sampling. Two of those reports (October 2002 and August 2003) were from periods where the steam injection was not occurring and therefore are seen as representative of the concentrations that would be expected at the site with the current extraction system. The data from these two reports suggest that the effluent from the dissolved air flotation (DAF) unit (i.e., the influent to the rest of the treatment plant) has less than 1,500 ug/L of PAHs and PCP combined and approximately 10 mg/L of total suspended solids. As shown in the calculation below, this influent concentration and the current flow rate of under 40 gpm translates to a mass loading of less than one pound of PAHs and PCP per day after the DAF.

$$\frac{40\text{ gal.}}{\text{min.}} \times \frac{3.785\text{ L}}{\text{gal.}} \times \frac{1{,}500\text{ ug.}}{\text{L}} \times \frac{1440\text{ min.}}{\text{day}} \times \frac{2.2\text{ lbs.}}{1 \times 10^{9}\text{ mg}} = \frac{0.72\text{ lbs.}}{\text{day}}$$

For treating the DAF effluent, the theoretical GAC usage rate calculated with published isotherms is approximately 10 pounds of GAC per pound of contaminants in the DAF effluent. A more conservative estimate of the GAC usage rate might be 20 pounds of GAC to one pound of contaminants in the DAF effluent. Using this usage rate of 20 to 1, approximately 8,000 pounds of GAC might be required per year. The Wyckoff GAC units are approximately 8,000-pound units; therefore, according to these calculations, one replacement would be required per year. Actual GAC usage, however, does not always follow the published isotherms due to solids loading to the GAC or other factors. Site-specific data would provide a more accurate representation of GAC usage. Site-specific GAC usage data in the absence of the biosystem is not available. Therefore, the RSE team recommends proceeding with a pilot test in which the GAC usage rates are evaluated based on treating the effluent from the DAF unit without the biosystem operating.

If the pilot suggests that the GAC usage rate is sufficiently low, the cost of operation and maintenance could be significantly reduced by permanently bypassing the biosystem. For example, one full time operator should be sufficient for operating a treatment plant with a DAF, filters, and GAC, but given the age of this system, the potential need for repairs, manual NAPL recovery, and other responsibilities at the site, a full time technician might also be appropriate. The labor requirements for system operation should therefore decrease from five full time employees to two full time employees. Other costs savings should be realized as well. The utility costs should decrease because the aeration blowers for the biological system would not be needed, and the disposal costs should decrease because the biosolids would not be generated. Until the treatment system is replaced, operator labor costs might be $250,000 per year and electrical might be $20,000 per year. Other costs for ground water sampling, project management, O&M reporting, and analytical costs (for OU2/OU4) should be well under $200,000 per year for this simpler system. The GAC cost would depend on the usage rate and would cost approximately $9,000 per changeout. The above calculations suggested that a single changeout per year might be possible, but a more conservative estimate would be appropriate. If GAC changeouts were required quarterly ($36,000 per year), monthly ($108,000 per year), or biweekly ($234,000 per year), the total annual O&M cost would range from $506,000 (quarterly changeouts) to $704,000 (biweekly changeouts).

For a three year period, this translates to approximately $1.5 million to $2.1 million and represents a substantial decrease from the approximately $4 million estimated by the contractors using the current system. Furthermore, eliminating the biological treatment component and simplifying the system should eliminate most of the $630,000 in capital expenditures that would have been necessary to keep the current treatment system operating over the next few years. Process monitoring might also be reduced for this simpler system. This reduction in process sampling would reduce the workload on the plant operators and would prevent the Regional EPA laboratory from analyzing unnecessary samples. Therefore, a pilot test of the alternate treatment approach discussed above is strongly recommended by the RSE team to reduce O&M costs over the next three years and to serve as a basis for designing and implementing a cost-effective long-term groundwater treatment system that will replace the current groundwater treatment system.

6.2.2 INSTALL UPGRADIENT SHEET PILE

Installing the upgradient sheet pile wall will help isolate the contamination in all horizontal directions. This should significantly reduce the amount of ground water entering the system and should therefore decrease the amount of water that requires extraction and treatment. Without the upgradient wall, the site team’s preliminary estimate is that approximately 80 gpm or more would require extraction. With the upgradient sheet pile wall, the influx of ground water should be reduced to limited flow through the sheet pile seams, upflow from the underlying aquifer, and recharge from infiltration. With this limited influx, pumping at current levels may be sufficient to maintain an inward gradient through all or most of the tidal cycle. The cost of installing the wall would be offset by savings from designing a lower capacity treatment system and reduced O&M costs over an indefinite number of years.

6.2.3 REMOVE STEAM INJECTION/EXTRACTION SYSTEM AND APPLY CAP

Steam activities should not take place for a number of years for the reasons stated in Section 6.1. Therefore, it is reasonable to remove the steam injection and extraction system and associated steam equipment from the site. This would allow a suitable cap to be placed on the Former Process Area. The RSE team defers to the site team's estimate of approximately $140,000 for these activities.

Once the steam injection and extraction system have been removed, the surface will be ready for surface grading, contouring, and applying a cap. By applying the cap, the site team will be able to work on clean surface material and will be able to make extraction system upgrades (new wells and piping) through clean surface material. If the cap is delayed until after the extraction system upgrades, then the site team will be working in potentially contaminated soil and future repairs or replacement of the piping or wells would require work in potentially contaminated soil. Special surface requirements for the cap (i.e., asphalt or vegetation) that are dependent on future land use and development plans could be delayed until the extraction system upgrades are made.

Another role of the cap is to reduce pumping requirements by reducing infiltration of precipitation. The approximate precipitation rate for the area is approximately 36 inches per year, and the area encircled by the sheet pile would be approximately eight acres (350,000 square feet). This translates to approximately 15 gpm of precipitation per year into the encircled area. Only a portion of this would infiltrate, and constructing a low permeability cap with adequate management for surface runoff should further reduce the infiltration rate.

The cost for the cap will vary depending on the type of cap, and the type of cap will depend on the anticipated future land use. Of the three caps proposed by the site contractor, the asphalt cap should be the least expensive and will be preferable with operating and maintaining an active extraction system within the cap limits. The RSE team estimates the cost of an asphalt cap at approximately $1,500,000 including surface grading and assuming a 3-inch wearing layer, a 6-inch base course, and eight acres of coverage. The site team also provided two options that would allow for a vegetated cap. One includes a clay layer and the other includes a geomembrane. Relative to an asphalt cap, a geomembrane cap and (depending level of quality assurance) a clay cap would require more effort to repair/maintain during extraction system repairs. Both cap options would have similar maintenance requirements and the geomembrane cap would offer slightly better infiltration reductions than the clay cap. After $500,000 in surface grading, each of these two caps might cost $2,000,000 for eight acres of coverage. However, the RSE team does not know the availability of clay in the area, and the lack of availability would increase cost of the clay cap and make the geomembrane cap preferable to clay cap. The difference between these preliminary cost estimates and those provided by the site contractor (see Section 4.4 of this report) is likely due to additional contingency in site contractor's estimate and additional oversight and engineering costs beyond the $2.35 million of engineering that the contractor estimates for 2004 through 2006 (see Section 4.4 of this report). Because of the difference between the RSE cost estimates ($1.5 million to $2.5 million, excluding oversight) and the site contractor's preliminary cost estimates ($3.6 million), the RSE team recommends that EPA carefully review the revised cost estimate that will be provided by the site contractor in the near future.

6.2.4 MONITOR DRAWDOWN IN FORMER PROCESS AREA AND CONDUCT A WATER BUDGET ANALYSIS

With the upgradient wall and cap installed, the site team should be able to conduct a fairly accurate water budget analysis. Water levels in the area encircled by the wall can be monitored and correlated with the extraction rate, rain events, and changes in water elevations of the lower aquifer. If water levels within the encircled area increase, it is an indication that inflow exceeds extraction, and if water levels decrease within the encircled area, it is an indication that extraction exceeds inflow. This water budget analysis should give the site team a relatively accurate idea as to the extraction rate necessary to maintain an inward hydraulic gradient across the sheet pile and therefore an approximate treatment capacity for the new treatment system. The water budget analysis should be conducted during both the dry and rainy seasons so that the water budget accounts for the upper and lower limits of pumping that would be required. This water budget analysis should not require additional wells, but would require monitoring water levels, pumping rates, and precipitation over perhaps six months as well as data analysis.

6.2.5 UPGRADE EXTRACTION SYSTEM

With the upgradient wall and cap in place and the water budget analysis conducted, the site team should then have the appropriate information to upgrade the extraction system. Existing wells may be abandoned or replaced, and/or additional wells may be added to provide the extraction rate necessary for cleanup. The wells could also be placed and constructed to maximize NAPL recovery. Because of future development opportunities, the site team should consider placing extraction piping under ground. Manually controlling NAPL collection may also be impractical depending on the future land use. The site team may want to consider the use of pneumatic submersible pumps for total fluids recovery.

Pump tests should be conducted from these new wells for the following reasons:

- confirm that the wells are capable of providing the intended extraction rate

- confirm that the intended and/or actual extraction rate yields the intended hydraulic results (i.e., inward gradients across the sheet pile

- provide information regarding the characteristics of the influent so that the treatment plant can be designed accordingly

The RSE team defers to the site contractor's preliminary estimate of approximately $900,000 for upgrade to the extraction system and the discharge outfall.

6.2.6 REPLACE THE EXISTING TREATMENT PLANT

The site team should begin consideration of alternate approaches technologies for the treatment plant, and the pilot test suggested in 6.2.1 should provide valuable information. In addition, once information from the water budget analysis is available, the site team should have a better understanding of the future extraction rates and required treatment capacity. The pump tests described in Section 6.2.3 would also provide valuable information. Ideally, the treatment plant should have sufficient capacity to maintain an inward gradient through the sheet pile and an upward gradient from the lower to upper aquifer. With the upgradient wall in place, a treatment plant with 50 gpm capacity might be sufficient and is assumed in the preparation of this recommendation. Even with this increased flow rate the effluent from the DAF would likely have less than one pound per day of contamination. The system should be designed with automation and low annual costs in mind. If pilot testing supports it, the ideal system would have the DAF unit (or a standard oil/water separator), sediment filters, organoclay (only if needed), and GAC followed by discharge. If pilot testing does not support the use of that type of system, a fixed-film bioreactor (such as the BioTrol model 12K4 used at the MacGillis and Gibbs Fund-lead site in Minnesota) could be considered in place of the current biosystem. The MacGillis and Gibbs system treats similar constituents and is designed for 50 gpm and influent PCP concentrations of 10 mg/L.

Once the system reaches steady-state operation, the total annual O&M costs (including labor, utilities, materials, sampling, laboratory analysis, reporting, and project management) should be well under $500,000 per year. A system similar to the "ideal system" discussed above operates at the Bayou Bonfouca Superfund Site (a Fund-lead site that has recently been turned over to the State) in Slidell, Louisiana. The Bayou Bonfouca system has an oil/water separator instead of a DAF unit, but is designed to treat up to 50 gpm and handles influent concentrations over 6,000 ug/L of PAHs. Under EPA-lead and USACE oversight, annual O&M costs for the system (including sampling, project management, USACE oversight, reporting, etc.) were approximately $400,000 per year. Over the past two years, the State of Louisiana has operated the site for approximately $260,000 per year, with the majority of savings reportedly due to eliminating USACE oversight.

The new long-term treatment system would likely be smaller than the current system and, as the site team suggested, could be moved back toward the tree line to allow for more flexibility in determining future land use. The design, construction, and start-up for either of the above-mentioned types of treatment plants should be well under the site contractor’s estimate of $3.5 million, which is for a more complex system. For the simpler systems described in this section, the RSE team suggests that a cost of under $2 million might be appropriate for design, construction, and 3-month startup.

6.2.7 POTENTIALLY ENHANCE MONITORING FOR THE LOWER AQUIFER

To monitor the effectiveness of hydraulic isolation, it is appropriate to continue monitoring the lower aquifer to determine if contamination in either separate or dissolved phase is migrating from the upper to the lower aquifer. The current monitoring program includes sampling at five wells (CW-05, CW-09, CW-15, 99CD-MW02, and 99CD-MW04) in the lower aquifer. In addition to these five wells, it appears that there are four other wells (CW-02, CW-12, EW-C1, and 99CD-MW01) that are also screened in the lower aquifer. These wells appear to provide relatively good coverage of the lower aquifer, and it may be appropriate to sample some or all nine of these wells, perhaps once or twice per year, especially for those wells where there is known to be overlying contamination in the upper aquifer. It may also be appropriate to install up to three additional wells in the lower aquifer; however, the benefits of adding these wells should be weighed against the potential for breaching the aquitard. Appropriate locations for these new wells might be between CW-09 and CW-02 (i.e. along the eastern boundary of the Former Process Area), below CW-13 (i.e., along the western boundary of the Former Process Area), and below CW-08 (i.e., along the northwestern boundary of the Former Process Area).

If contamination in these wells remains relatively stable or decreases and an upward gradient is maintained between the lower and upper aquifers, then the site team can have reasonable confidence that vertical hydraulic isolation is effective. If substantial increases in contamination become evident, the eventual fate of that contamination should be determined so that the necessary remedial actions can be implemented.

If the site team opts to install the additional wells, the installation might require up to $75,000, including preparation of a work plan and providing oversight. Sampling of these additional wells should not significantly increase annual costs because a full time operator and technician would be on-site to conduct the sampling and the analysis is provided by the Regional laboratory at no cost to the site.

6.3 OTHER RELATED ITEMS

Once the above items are addressed, the site team can continue with other site-related activities. Some of these activities are described below.

Alter LTM approach to emphasize monitoring for hydraulic isolation

This item is necessary to evaluate the effectiveness of hydraulic isolation of the contamination and will be an ongoing activity. The gradients can be monitored by measuring water levels in wells inside the area encircled by sheet pile and comparing them to water levels measured from either sampling points within armoring if it is installed (see Section 6.2.5) or the elevation of the surface water.

Water quality sampling in the upper aquifer beneath the Former Process Area should be kept to a minimum. The site is not expected to clean up for decades, and water quality sampling in this area of known contamination will not provide useful information. Rather, monitoring efforts in this area should likely consist of measuring water levels and NAPL thickness. However, water quality sampling should continue in the lower aquifer (see Section 6.2.7), and if an attenuation zone is included along the sheet pile, then water quality sampling should be conducted at those locations as well.

The current monitoring costs for OU2/OU4 were not broken out of the total annual O&M costs; however, it is very likely that a monitoring program as described above would be similar in cost to the current monitoring program, which includes water quality sampling and analysis.

Monitor seeps along the eastern beach

The seeps along the eastern beach appear to provide the greatest threat to protectiveness because they are the only source of unaddressed contamination that appears to remain outside of the sheet pile area. It is presumed that the installation of the sheet pile and isolation efforts will reduce the magnitude of the seeps or eliminate them altogether over time. Monitoring of the seeps should continue to determine if isolation activities are effective at addressing the seeps.

If contaminant isolation efforts are effective at reducing or eliminating the seeps within the next few years, then the site team may wish to address the contaminated surface sediments by dredging and/or capping, if such actions are determined to be feasible. If isolation efforts are not effective at reducing or eliminating the seeps within the next few years, then the site team may wish to investigate alternative solutions. It may be that NAPL is migrating out of the Former Process Area from areas that have not been sampled. It may also be that substantial sources of NAPL are already present outside of the Former Process Area that are yet to be discovered. Properly addressing the seeps (if they are not addressed by isolation efforts) would require further investigation and is beyond the scope of this RSE. Once again, if the seeps continue, they are likely the greatest threat to protectiveness at the site and efforts should likely be focused on them.

Consider adding extraction points for enhanced recovery

The site team, State, and community have expressed interest in enhanced NAPL recovery with the hope that the site can be remediated in a shorter time frame. It is not certain that NAPL recovery, with or without steam, will allow the site to be remediated in a reasonable time frame (i.e., less than 30 years). However, if enhanced recovery is desired once hydraulic isolation of the contamination is achieved (i.e., the system is protective), the RSE team would recommend that additional recovery wells be considered to augment product recovery to the extent the additional pumping does not compromise the treatment system or significantly add to the life-cycle cost. In other words, the benefits of some additional product recovery in this manner may not be considered to be great enough to merit substantial additional cost.

7.0 SUMMARY

The RSE team observed a knowledgeable and competent site team led by an effective, motivated, and organized EPA RPM. The observations provided in this report are not intended to imply a deficiency in the work of the system designers, system operators, or site managers but are offered as constructive suggestions in the best interest of the EPA and the public. These observations obviously have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of ground water remediation have changed over time.

The RSE team believes that the best approach for this site is to initially focus efforts on hydraulic isolation of the contamination underlying the Former Process Area, including the installation of an upgradient barrier wall and low permeability cap to minimize the amount of water requiring treatment, and the implementation of a new groundwater treatment system based, in part, on pilot testing of one or more new approaches. Enhanced monitoring of groundwater in the lower aquifer is also recommended in conjunction with these efforts, to improve the potential to detect current or future impacts to that aquifer. It is also recommended that the site team monitor the active seeps along the eastern beach, and take remedial actions if the seeps persist and a feasible remedial alternative is identified.

Once these high priority items are addressed and implemented, the site team could then reconsider aggressive mass removal and the technologies that might be available at that time (potentially including but not limited to additional efforts related to steam injection). However, the RSE team believes the most cost-effective approach is to design and implement the new groundwater treatment system associated with hydraulic isolation (discussed above) independent of such efforts. This will reduce the potential of over-designing the groundwater treatment system that is associated with the hydraulic isolation efforts. Cost/benefit evaluations for subsequent testing or implementation of more aggressive source removal would need to incorporate costs that might be required to further upgrade the groundwater treatment system above and beyond the treatment system associated with hydraulic isolation. The RSE team also believes that if more aggressive source removal technologies are considered in the future, the costs and benefits of installing additional recovery wells and tying them into the P&T system should be included as a potential alternative.

During the RSE site visit there was discussion about armoring the existing sheet pile wall to prevent scour and extend the life of the wall, and there was also discussion about adding a second sheet pile wall inside the existing wall to create an “attenuation zone” that could be monitored. The RSE team felt that, if armoring was pursued, then the interior sheet pile wall would not be necessary because the armoring could likely be constructed in a manner to allow for an attenuation zone that could be monitored. Subsequent to the RSE site visit, the RSE team was informed that armoring may not be feasible due to potential impacts to the intertidal zone. It is likely that a variety of alternatives will need to be considered in the future regarding this issue, and this issue is not addressed in detail in this RSE report.

The RSE team’s suggestions for simplifying the new groundwater treatment system could save EPA as much as $4 million relative to current estimates, while maintaining a protective remedy. This would represent a savings of approximately 20% relative to the preliminary three-year costs that have been estimated to date. If pilot test results of the recommended changes do not support the carbon usage assumptions of the RSE team (that are based on published isotherms plus a safety factor), savings might be lower. Additional savings would also result beyond the three year period by operating a simplified and automated treatment system. Table 7-1 summarizes the cost and protectiveness implications of the recommendations discussed in Section 6.0 of this report.

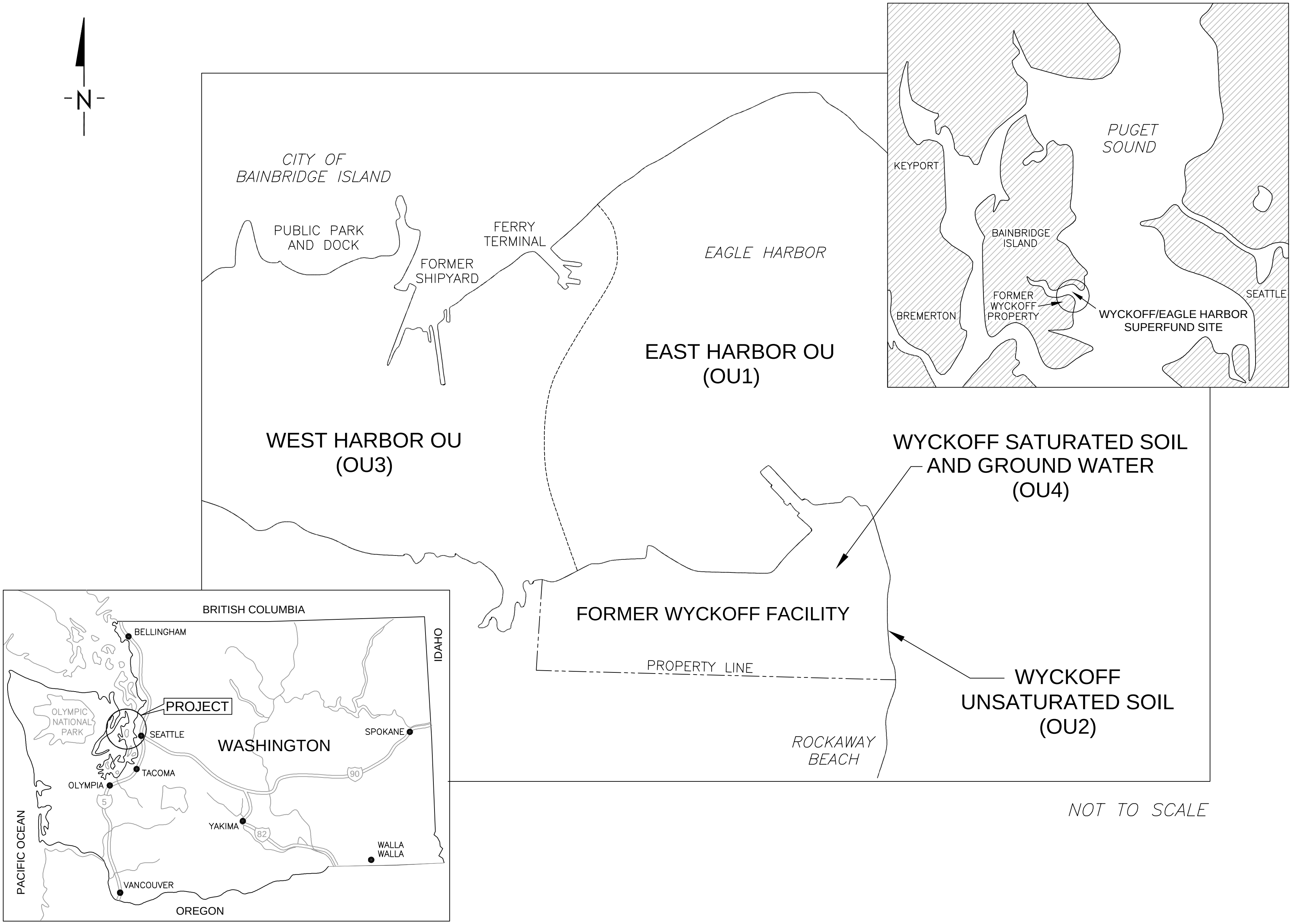
Table 7-1. Cost summary Table

RSE Recommendation	Estimated Potential Change in Cost*	Notes
6.1.1 A Road Map to a Final Remedy	($45 million) to ($65 million)	The cost comparison ($15 million vs. $60 million to $80 million) includes an optimized P&T system providing hydraulic isolation versus the projected steam injection costs over a 5-year period until site closure. The P&T cost of $15 million assumes 30 years of operation at $750,000 per year, a discount rate of 5%, and some contingency. Although the P&T system would likely operate longer than 30 years, the costs beyond 30 years are neglected because they are small contributions to the life-cycle cost when discounted. The steam injection cost of $60 million to $80 million was provided by the site team. This cost projection and the ability to reach closure in five years is optimistic.
6.2.1 Simplify existing treatment plant	($2.5 million)	The indicated savings results from operating a simplified system over a three year period. Additional potential savings is likely possible from simplifying the system rather than making some anticipated repairs.
6.2.2 Install upgradient sheet pile	no change	This recommendation is consistent with that provided by the site team.
6.2.3 Remove steam injection/extraction system and apply cap	potential savings	This recommendation is consistent with that provided by the site team; however, a comparison of the preliminary cost estimates provided by the RSE team and the site contractor suggest that potential savings may be possible.
6.2.4 Upgrade extraction system	no change	This recommendation is consistent with that provided by the site team.
6.2.5 Conduct water budget analysis	no change	This recommendation can likely be conducted as part of the $2.35 million in engineering costs that are expected over the next three years.
6.2.6 Replace the existing treatment plant	~ ($1.5 million)	The indicated potential cost savings reflects the design, construction, and startup of a simpler system than the one anticipated by the site team. Substantial savings in annual O&M costs would also likely be realized if the new treatment system follows the RSE recommendation rather than the more complex system that has been anticipated by the site team.
6.2.7 Augment monitoring in lower aquifer	$75,000	Additional wells in the lower aquifer might be appropriate to monitor hydraulic isolation. The site team would need to weigh the benefits of adding new lower-aquifer wells against the potential for breaching the aquitard. The RSE team provides three potential well locations.
6.3 Other related items	Not quantified	The RSE team suggests the following be considered after those in Section 6.2 are addressed: • Alter LTM to focus on hydraulic isolation • Monitor active seeps along the eastern beach • Consider adding extraction points for enhanced recovery

* *Cost changes in parentheses indicate a decrease (i.e., cost savings)*

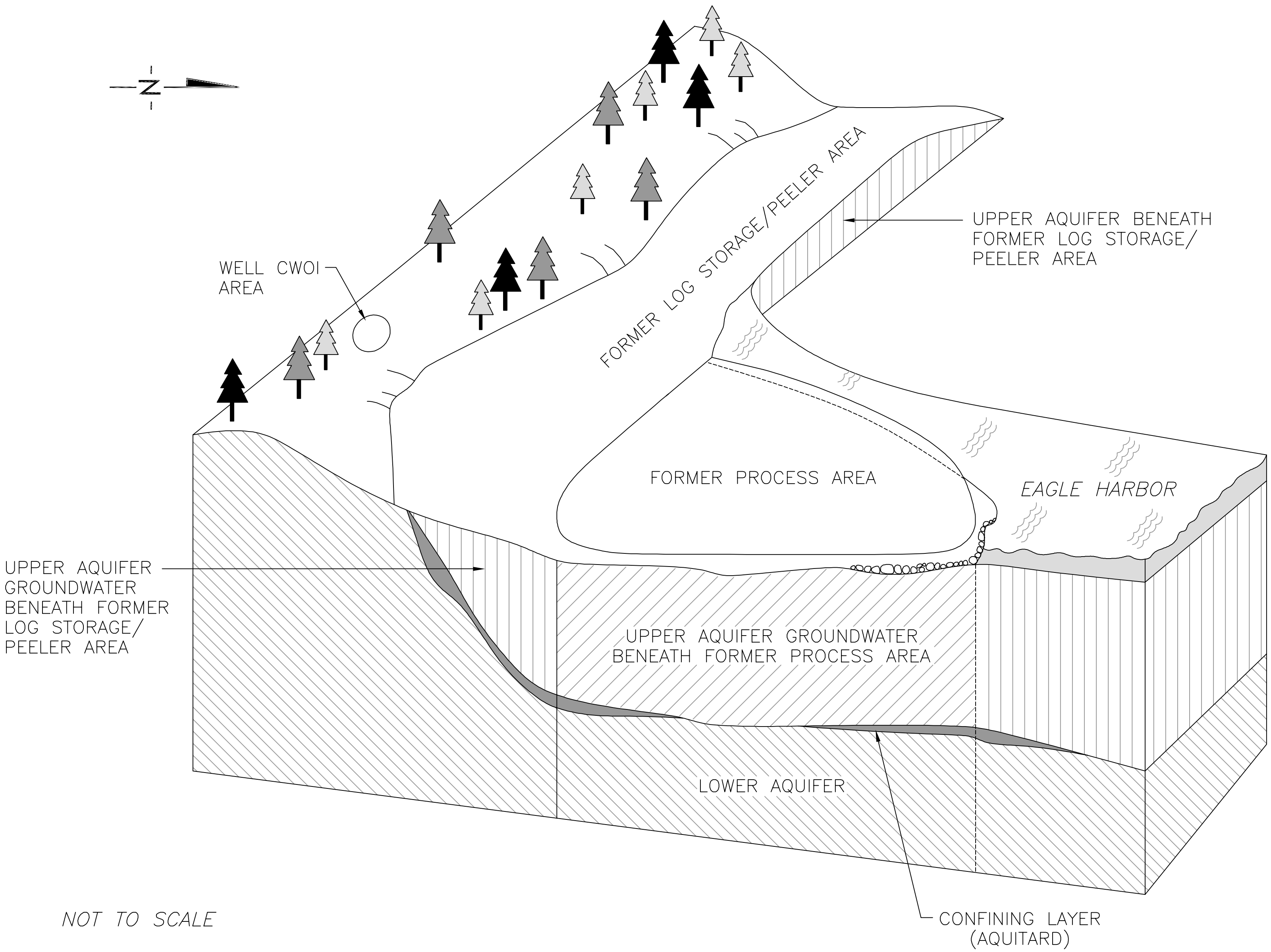
FIGURES

FIGURE 1-1. WYCKOFF/EAGLE HARBOR OPERABLE UNITS.



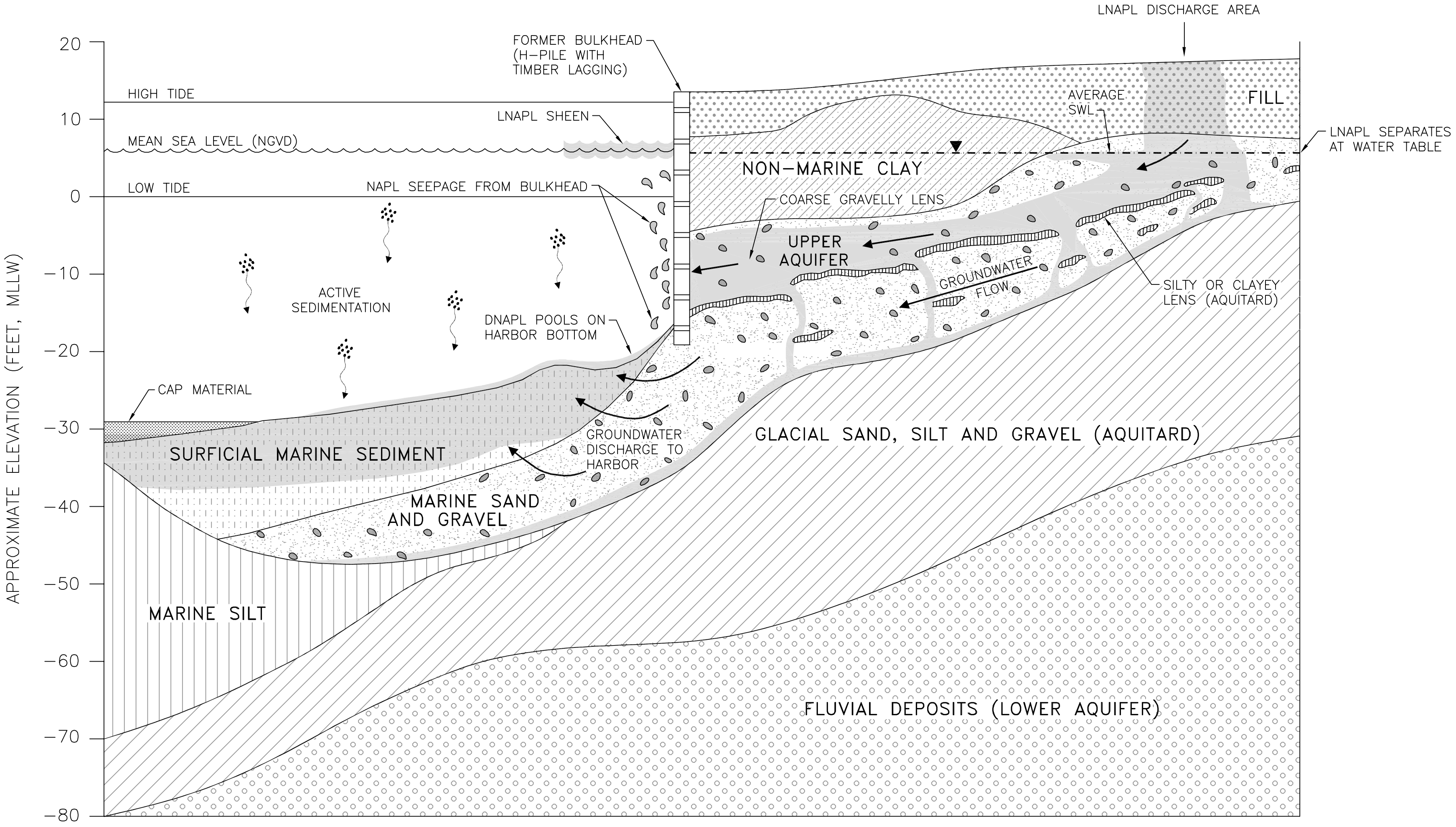
(Note: This figure is taken from the September 2002 Five-Year Review.)

FIGURE 1-2. SCHEMATIC OF OU2 (GROUND WATER) AND OU4 (SATURATED SOILS).



(Note: This figure is taken from the September 2002 Five-Year Review.)

FIGURE 1-3. CONCEPTUAL MODEL OF NAPL MIGRATION PRIOR TO REMEDY IMPLEMENTATION.

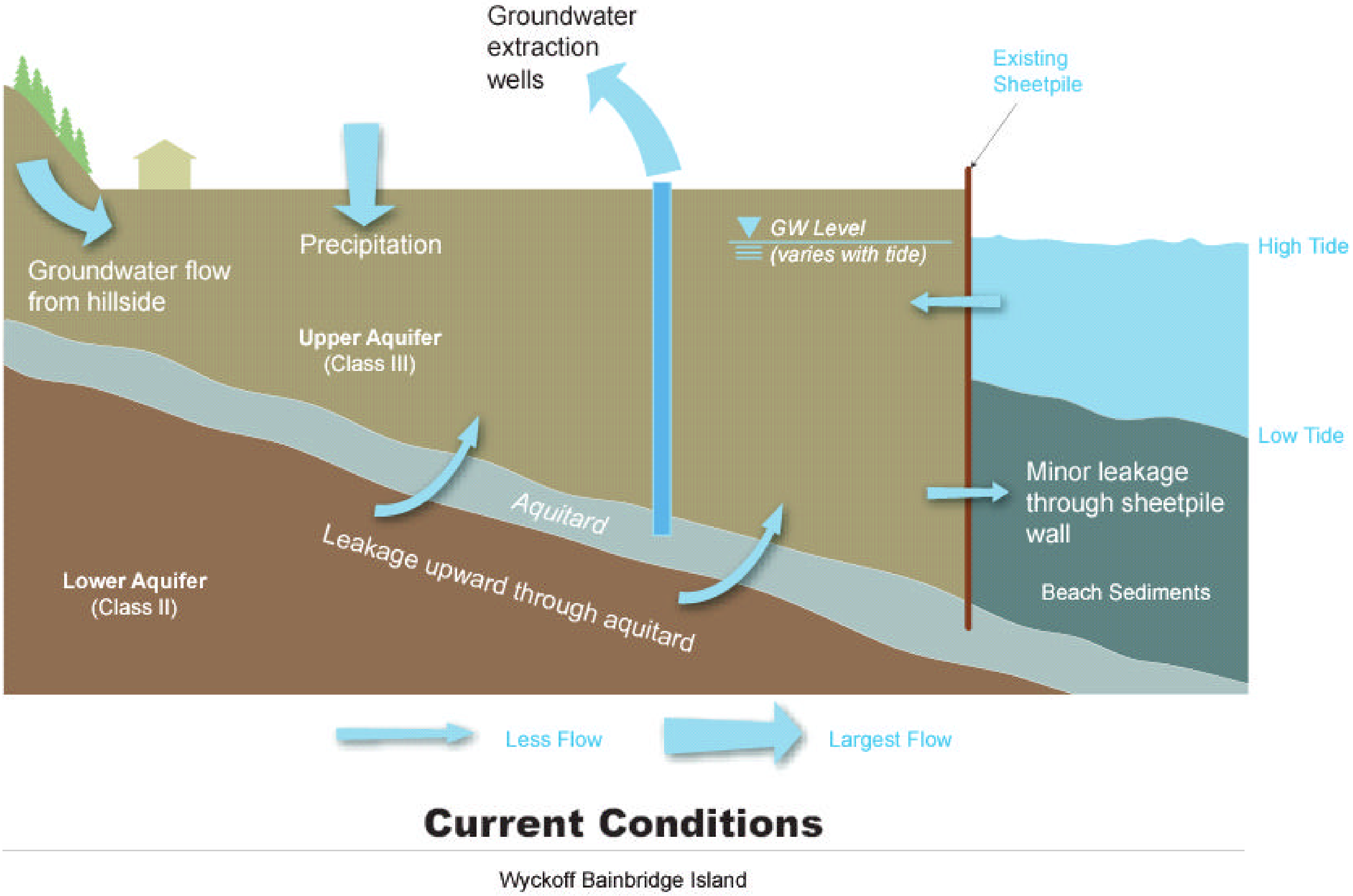


NOTES:

1. MODEL IS NOT TO SCALE. APPROXIMATE VERTICAL EXAGGERATION = 5X.
2. THE CONCEPTUAL MODEL SHOWN ON THIS DRAWING IS REPRESENTATIVE OF THE NORTHWEST SHORELINE AND LOG RAFTING AREA ONLY. GEOLOGY, HYDROLOGY, AND NAPL MIGRATION MECHANISMS MAY BE DIFFERENT FOR OTHER SHORELINE AND OFFSHORE AREAS.
3. NAPL LEAKAGE IS SHOWN DIRECTLY THROUGH THE BULKHEAD, BASED ON DIVERS' OBSERVATIONS. THERE IS A POSSIBILITY, HOWEVER, OF ADDITIONAL LEAKAGE UNDER THE BULKHEAD ONTO THE SURFICIAL MARINE SEDIMENTS.

(Note: This figure is taken from the Offshore Field Investigation Report for the Barrier Wall Design Project, USACE, April, 1998.)

FIGURE 1-4. CONCEPTUALIZATION OF HYDROGEOLOGY BENEATH THE FORMER PROCESS AREA



(Note: This figure was taken from a presentation prepared by the site contractor, CH2M Hill, presented at the RSE site visit.)

FIGURE 2-1. OU2 LAYOUT WITH SHEET PILE AND WELL LOCATIONS.