The Wyckoff Point
Bainbridge Island, Washington
Generational Remedy Evaluation

Prepared for

Washington State Department of Ecology

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List of Abbreviations and Acronyms

Acronym/Abbreviation	Definition
ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
City	City of Bainbridge Island
db	Decibel
Ecology	Washington State Department of Ecology
DNAPL	Dense non-aqueous phase liquid
Engineering Evaluation	Wyckoff/Eagle Harbor Superfund Site Soil and Groundwater Operable Units Engineering Evaluation of Groundwater and Solid Remedial Scenarios
gpm	Gallons per minute
HDPE	High-density polyethylene
HPAH	High molecular weight polycyclic aromatic hydrocarbon
LNAPL	Light non-aqueous phase liquid
LPAH	Low molecular weight polycyclic aromatic hydrocarbon
MLLW	Mean lower low water
NAPL	Non-aqueous phase liquid
NPV	Net Present Value
PAH	Polycyclic aromatic hydrocarbon
Park District	Bainbridge Island Metro Park and Recreation District
PCP	Pentachlorophenol

Acronym/Abbreviation	Definition
ROD	Record of Decision
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
Point	Wyckoff Point
Wyckoff Site	Wyckoff/Eagle Harbor Superfund Site

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Executive Summary

INTRODUCTION

A portion of the Wyckoff/Eagle Harbor Superfund Site (Wyckoff Site), referred to as the Former Process Area or "the Wyckoff Point" (the Point) was once occupied by the former Wyckoff Company wood-treating facility. Historical operations for more than 85 years at this facility have resulted in an estimated 1.2 million gallons of wood-treating products (primarily creosote) contaminating soil and groundwater beneath the Point.

The Point is a very unique property. It is a promontory located in the heart of Puget Sound, forming the entry to Eagle Harbor. It lies adjacent to a sensitive shoreline in an area of significant wave action, exposed to a wide northeasterly fetch and vulnerable to constant ferry wake. It is located adjacent to tribal fishing grounds, with established eelgrass beds, precious to the Suquamish Tribe, who have fishing rights reserved under the 1855 Treaty of Point Elliott and are co-managers of the fishery resources within the State. The property is pivotal to the City of Bainbridge Island and Park District vision for Pritchard Park—as a showcase public waterfront park for the region.

The Wyckoff Site is a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) fund-lead site. The U.S. Environmental Protection Agency (USEPA) has worked to date to contain the mobile, oily wastes using barrier walls and a groundwater pumping system. As a permanent remedy, USEPA plans an enhanced containment system for the bulk of the mobile creosote, although creosote has already seeped onto beaches and into the Sound.

The USEPA plan would task the State with financial and management responsibility for operation and maintenance of the containment remedy in perpetuity. The Washington State Department of Ecology (Ecology) has declined that responsibility based on significant concerns about the long-term protectiveness of containment and the unlimited generational costs of operation, maintenance, and periodic rebuilding of the remedy.

Since September 2009, Ecology has evaluated remedial alternatives for the Point that would significantly reduce the volume and mobility of the contamination. This work was termed the Generational Remedy Evaluation because it evaluates remedies that would be protective of human health and the environment without burdening future generations with costly and disruptive operation, maintenance, and replacement of remedial components. Additionally, generational remedies would minimize the potential for gradual migration or a catastrophic environmental release of contamination from the Point into Eagle Harbor. Once implemented, a generational remedy would require little to no active management, significantly reducing long-term financial obligations to the State.

The Generational Remedy Evaluation process was managed by Ecology, with input from a steering committee composed of members from the local community including the City of Bainbridge Island (City), the Bainbridge Island Metro Park and Recreation District (Park District), Association of Bainbridge Communities, the Japanese-American Exclusion Memorial Committee, a citizen at large, the Suquamish Tribe, and Ecology. The evaluation included extensive engagement with local government, environmental and community groups, and the public. The evaluation involved bringing together national experts in remediation of similar sites for an interactive 3-day workshop on Bainbridge Island that included significant community participation. The workshop results were used to construct three alternative generational remedy scenarios, which were evaluated by Ecology's team in terms of risk reduction, cost and schedule, long-term maintenance needs, and other factors.

This Generational Remedy Evaluation Report has been prepared by Floyd|Snider and Aspect Consulting, under contract to Ecology, to assist Ecology with evaluating potential next steps for remediation of the Point. This Executive Summary provides a condensed overview of The Wyckoff Point Generational Remedy Evaluation. The Wyckoff Point Generational Remedy Evaluation was prepared for Ecology to present the outcome of the Generational Remedy Evaluation, which has resulted in the identification and description of three potential cleanup alternatives that meet the goals of a generational remedy alternative.

The following sections of the Executive Summary introduce the Point by providing a brief physical and environmental description of the area, discussing future site use, describing the remedial action USEPA has selected for this area, and explaining Ecology's concerns with the USEPA's remedy. This Executive Summary also includes sections that explain the Generational Remedy Evaluation process, describe the three potential generational remedy alternatives that have been developed during this process, and compare a generational remedy to the remedial action that has been selected by the USEPA. Greater detail regarding the topics introduced in the following sections can be found in the complete report. Additional information on the Generational Remedy Evaluation can be found on the project website: www.ecy.wa.gov/programs/tcp/sites/wyckoff/wyckoff_hp.htm.

LOCATION AND GEOLOGY OF THE FORMER PROCESS AREA

The Wyckoff Point is a 12-acre peninsula that juts into the entry of Eagle Harbor, which is located on the east side of Bainbridge Island, in central Puget Sound, Washington (refer to the Vicinity Map). The Point is a unique location in an area that receives significant wave action. The adjacent waters contain established eelgrass beds. It is located within the usual and accustomed fishing area of the Suquamish Tribe. It is owned by the City and the Park District, who plan to extend the surrounding regional public park, Pritchard Park, onto the Point to allow the public to take advantage of the beach access and sweeping view of Puget Sound and downtown Seattle.

The subsurface of the Point or Former Process Area includes three hydrogeologic units that are relevant to remediation of this area. These units are referred to as the Upper Aquifer, the Aquitard, and the Lower Aquifer.

- The Upper Aquifer consists of two primary geologic units, fill and marine sand and gravel. This unit is about 15 feet thick on the southern end of the Former Process Area and about 70 feet thick on the northern end. Groundwater is encountered at depths of approximately 5 to 10 feet below ground surface. The Upper Aquifer contains almost all of the contamination within the Former Process Area.
- The Aquitard is present beneath the Upper Aquifer and generally impedes the migration of the creosote contamination from the Former Process Area; however, localized sand layers within the Aquitard have allowed contamination to penetrate the Aquitard and leak into the Lower Aquifer below. The thickness of the Aquitard

generally ranges from about 10 to 40 feet, except in the southeastern corner of the Former Process Area where it is not present. The Aquitard is comprised of marine silt and glacial clay, silt, and sand units.

- The Lower Aquifer is a lower sand unit located below the Aquitard. The Lower Aquifer has groundwater levels ranging from approximately 5 to 10 feet below the surface (similar to the Upper Aquifer). Contamination, including layers of creosote, has been observed at the top of the Lower Aquifer.

ENVIRONMENTAL IMPACTS

Historical wood-treating operations resulted in contamination of the soil and groundwater beneath the Former Process Area with chemicals from the wood-treatment process, primarily creosote-derived polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol (PCP), aromatic carrier oils, and dioxins/furans. It is estimated that that there are approximately 1.2 million gallons of contamination in the form of non-aqueous phase liquid (NAPL) located over 9 acres in the Upper Aquifer of the Former Process Area.

Contamination also extends beyond the boundaries of the Former Process Area into the adjacent Eagle Harbor sediments. NAPL in sediments outside of the sheetpile wall is seeping onto the East Beach and North Shoal, which are the intertidal areas located to the east and north of the Former Process Area, respectively. These intertidal areas are being monitored, are signed to discourage access, and are being evaluated by USEPA. A sheetpile wall, extending from the surface down into the Aquitard, was installed by USEPA around the outer, shoreside perimeter of the Former Process Area to help contain contamination within the Former Process Area and prevent further releases to the surrounding sediment.

SITE OWNERSHIP AND FUTURE SITE USE

The Wyckoff Site is owned by the City and Park District. The City and Park District purchased the property between 2004 and 2006 for the creation of Pritchard Park. The City obtained a Prospective Purchases Agreement for the Wyckoff/Puget Sound Resources (PSR) property from USEPA in 2005. The park property is already open and accessible to the public with the exception of the Former Process Area, which is fenced to prevent access as USEPA continues design and development of its remedy. Park design concepts for the Former Process Area include a walking path along the perimeter of the Former Process Area for visitors to take in the view of Eagle Harbor and Puget Sound. Another design goal is to restore the shoreline surrounding the Former Process Area to a more natural beach profile.

REGULATORY HISTORY AND USEPA'S CONTAINMENT REMEDY

In 1987, the Wyckoff Site was placed on the National Priorities List. An extraction system to remove groundwater from the Former Process Area to help prevent the discharge of contamination to surface waters was first installed within the Former Process Area by the Wyckoff Company in 1990. In 1993, USEPA assumed control of the Wyckoff Site due to financial problems with the former Wyckoff Company. After issuing two proposed plans for this portion of the Wyckoff Site, the USEPA issued a final Record of Decision (ROD) for the Former Process Area in 2000. This ROD selected in-situ thermal remediation as the remedy. In the event that thermal remediation did not work at the Former Process Area, the ROD identified containment as a contingent, or fall back, remedy.

A thermal remediation pilot study, using steam-enhanced extraction, was conducted within the Former Process Area over a 6-month period in 2002 and 2003. According to the U.S. Army Corps of Engineers (USACE) evaluation of the pilot study, the pilot study had significant problems during both design and implementation due to funding limitations, scope change, design and technical difficulties, major equipment problems, and project management challenges. Due to the numerous equipment problems, the extraction system only operated continuously for 3 days, and the total operating time was only 1 month during the 6-month study period. Despite all of these problems, the pilot test was successful in demonstrating that steam injection dramatically increased the amount of contamination that could be removed from the subsurface and suggests that in-situ thermal remediation may still be a successful technology for the removal of contamination within the Former Process Area. However, USEPA determined that the pilot study was unsuccessful and decided to proceed with implementation of the contingent containment remedy.

USEPA is now in the process of implementing a containment remedy in the Former Process Area. Based on reports and communications with USEPA, it is understood that the containment remedy consists of the following components:

- The current sheetpile wall to contain contaminated soil, groundwater, and NAPL within the Upper Aquifer of the Former Process Area, along with a shoreline protection system (still to be constructed) to help protect the portion of the existing sheetpile wall above the mudline from corrosion.
- A groundwater extraction system (pumping wells) to maintain an average inward and upward gradient of groundwater into the Upper Aquifer of the Former Process Area to prevent contaminated groundwater and NAPL from leaving the site.
- The replacement groundwater treatment plant (recently completed), to treat extracted groundwater before discharging to Eagle Harbor.
- A proposed low-permeability surface site cap to limit the infiltration of precipitation into the Former Process Area, decreasing the volume of groundwater that requires extraction and treatment to maintain a hydraulic gradient into the Upper Aquifer, and to prevent direct contact of the contaminated soil by humans.
- Possibly an upgradient groundwater cutoff wall, to reduce the volume of groundwater entering the Former Process Area, further decreasing the volume of groundwater that requires extraction and treatment to maintain a hydraulic gradient into the Upper Aquifer. USEPA is still determining if this component will be part of the containment remedy.
- A long-term containment monitoring system to monitor the effectiveness of the remedy.

It will likely take approximately 4 to 5 years to finish construction of the USEPA containment remedy. This includes construction of new extraction wells, a shoreline protection system, a site cap, and potentially an upgradient groundwater cutoff wall. The estimated cost to complete the construction is $30.0 million, adjusted to 2010 dollars and assuming an upgradient groundwater barrier wall is constructed.

Following construction, the containment remedy will require operations and maintenance of the groundwater extraction and treatment system in perpetuity, as there is no defined endpoint with the creosote existing in the subsurface for hundreds, and possibly thousands, of years. The estimated annual cost for operations and maintenance of the remedy is $857,000 (this annual cost includes periodic replacement costs for the groundwater extraction system and the monitoring system). In addition to the long-term operations and maintenance costs, there are also periodic replacement costs for some of the other remedy components, including an estimated $8.5 million every 20 years for a groundwater treatment plant and $6.9 million every 50 years for the sheetpile wall, in 2010 dollars. There will likely also be additional periodic replacement costs for the shoreline stabilization system and the surface cap that have not been estimated at this time.

The Wyckoff Site is a fund-lead site, which means that USEPA funds the remedy, but that the State pays 10 percent of the construction costs and is responsible for all operations and maintenance costs, including component replacement costs, once construction is complete. Following completion of construction of the remedial action, USEPA will turn the Former Process Area over to Ecology for long-term operations and maintenance.

ECOLOGY'S CONCERNS WITH THE CONTAINMENT REMEDY

Ecology's primary concerns with the USEPA containment remedy that prompted this Generational Remedy Evaluation are:

1. The long-term environmental consequence of leaving large amounts (over 1 million gallons) of mobile contamination beneath the Former Process Area, especially given the important and sensitive location of the Former Process Area on the shores of Puget Sound. Leaving the contamination in place poses a continual threat to the Puget Sound environment either through a gradual release or a catastrophic release of contamination.
2. The financial and logistical burden that this action places on the State and the Bainbridge Island community—a perpetual and inordinately disproportionate obligation for active operations and maintenance, including periodic rebuilding of the remedy containment components. The life cycle costs for the containment remedy are estimated to be hundreds of millions of dollars.

There are concerns with the efficacy and effectiveness of containment at this location, given the possibility of hydraulic continuity between the Upper and Lower Aquifers. Existing data indicate that contaminant leakage is occurring downward toward and into the Lower Aquifer. Groundwater elevations indicate that there is a hydraulic connection between the Upper and Lower Aquifers. Recent data also indicate that the Aquitard is not as continuous as previously thought, includes discontinuities, and shows evidence of structural displacement, thereby limiting its effectiveness even if there was constant upward hydraulic control.

A large earthquake may result in a failure of the containment remedy resulting in a significant and potentially catastrophic release of contamination into Puget Sound. Additionally, beach erosion or increased wave action coupled with water level rise may require that significant modifications be made to the containment remedy in hundreds of years.

Monitoring the effectiveness of the containment remedy will also prove to be very difficult due to the substantial and widespread sediment contamination already present in sediments outside of the Former Process Area and because contamination has already been measured in the Lower Aquifer beneath the Former Process Area. This contamination makes it difficult to determine if a contaminant occurrence is due to a recent release or a past release and creates the potential that remedial failure of a containment system would not be recognized or corrected.

GENERATIONAL REMEDY EVALUATION PROCESS

Due to the multiple concerns listed above, Ecology conducted the Generational Remedy Evaluation to develop new information defining and evaluating protective, durable, cost-effective remedial alternatives for the Former Process Area that reduce the source and/or mobility of the contamination and that would be protective for future generations with little active management.

The Generational Remedy Evaluation process began with the formation of a steering committee composed of members from the local government, community, and Suquamish Tribe. At the beginning of the evaluation process, Ecology and the steering committee developed the Generational Remedy Evaluation Project Objectives (included as Appendix A). The steering committee also worked with Ecology throughout the evaluation process, providing input and advice on the process and participating in community meetings and the expert panel workshop (described below).

This process also included forming a panel of eight nationwide technical experts to assist with the identification and evaluation of innovative alternatives focusing on source removal or mobility reduction of the contamination at this complex site. The experts that were selected for this panel have experience remediating sites with similar types of contamination and on large construction projects in challenging or constrained environments. The expert panelists, along with Ecology, the steering committee, and Ecology's consultants participated in a 3-day workshop on Bainbridge Island to explore, evaluate, and advise Ecology on potential generational remedy alternatives for the Former Process Area.

As part of the Generational Remedy Evaluation process, the Bainbridge Island Community has also been provided with opportunities to learn about and be involved in the evaluation process. Two community meetings were held by Ecology during the evaluation process to provide the community with information on the evaluation process, the remedial options being considered, and the long-term advantages of implementing a generational remedy over the planned containment remedy. The community was invited to provide input on the options being considered at these community meetings. Steering committee meetings and the expert panel workshop were also open to public attendance and the community was invited to attend these events and provide their comments. Additionally, USEPA was invited to and attended steering committee meetings, community meetings, and the expert panel workshop.

GENERATIONAL REMEDY ALTERNATIVES

The Generational Remedy Evaluation process resulted in the identification of three viable generational remedy alternatives, which could be applied to remove, treat, and/or immobilize the NAPL currently contained within the Former Process Area. Each of the generational remedy alternatives will remove most of the contamination present in the Point, significantly reduce costs over the long-term, and remove the short- and long-term environmental risks posed by this site. If any residual contamination is left after mass removal, it is felt that no active waste management will be needed, given its anticipated state and site conditions.

These remedial alternatives are described at a conceptual level of design in the report. The report details how each alternative meets the generational remedy objectives and the likely construction techniques, schedule, community impacts, uncertainties, and estimated costs for each alternative. A brief description of the three generational remedy alternatives is provided below.

In-situ Thermal Treatment (Alternative 1)

Alternative 1 would heat in place all contaminated soil and groundwater within the Upper Aquifer of the Former Process Area to the boiling point of water to aid in the removal of the subsurface contamination. The primary components of this alternative include:

- a heating system to mobilize the contamination,
- a fluid extraction and treatment system to remove the creosote and contaminated vapor and groundwater during the treatment,
- a hydraulic and thermal control system to help minimize the entry of cool water into the treatment area and to prevent the migration of contamination out of the treatment area (including a temporary surface cap, an improved perimeter barrier wall, and an upgradient barrier wall).

This alternative would remove most of the mass of the contamination within the Former Process Area. There would be some residual contamination left behind, but this contamination would primarily be adsorbed to soil and would be very poorly soluble in water. This alternative would eliminate the need for long-term operations and maintenance of an active pumping system and the risk of future releases of contaminants from the Former Process Area.

Following treatment and cool down of the Former Process Area, the entire area would be converted to a park, as planned by the City and Park District. The area would be graded to create a natural beach profile and the top portions of the existing sheetpile wall and perimeter barrier wall would be cut off to below ground surface. The entire area would be covered with imported clean soil to prevent human contact with any residual contamination in the soil.

Implementation of this alternative is estimated to take between 7 and 20 years from initial design through site restoration. The wide range in the time frame is dependent on power availability, which determines the rate of in-situ thermal heating, and the length of time required for the treated area to cool down following treatment. The conceptual level cost for this alternative is estimated to range from $96 to $123 million.

Excavation and Ex-situ Thermal Treatment (Alternative 2)

In Alternative 2, contaminated soil within the Former Process Area would be excavated and treated aboveground on-site by heating the soil up to 1,100°F. The treated soils would be used as backfill in the excavated area. The primary components of this alternative include:

- a perimeter barrier wall surrounding the excavation area for shoring and hydraulic control,

- a dewatering system to allow excavation to occur in relatively dry conditions to the extent practicable,
- excavation of contaminated soil, thermally treating the contaminated soil in aboveground facilities to destroy contaminants, and replacing the clean soil as backfill in the excavation.

This alternative would destroy the contaminants in the soil, likely to concentrations less than cleanup levels. Excavation that occurs in the deepest portion of the Former Process Area may have to be conducted in saturated conditions, possibly resulting in some residual contamination being left in place in this area; however almost all of the contamination would be removed with this alternative. This alternative would eliminate the need for long-term operations and maintenance of an active pumping system and the risk of future releases of contaminants from the Former Process Area.

After backfilling of the clean soils, the entire Former Process Area would be converted to a park as planned by the City and Park District. The area would be graded to create a natural beach profile and the top portions of the existing sheetpile wall and perimeter barrier wall would be cut off to below ground surface. The entire area would be covered with imported clean soil.

Implementation of this alternative is estimated to take between 4 and 7 years from initial design through site restoration. The conceptual level cost for this alternative is estimated to range from $89 to $107 million.

Shallow Excavation and Ex-situ Thermal Treatment with In-situ Thermal Treatment or Stabilization at Depth (Alternative 3)

In Alternative 3, contaminated soil within the Former Process Area would be treated by a combination of in-situ and ex-situ treatment. Shallow contaminated soil would be excavated, treated aboveground on-site by heating the soil up to 1,100°F, and then put back into the excavated area (similar to Alternative 2). Deep contaminated soil would be treated in place using either in-situ thermal treatment (Treatment Option A, similar to Alternative 1) or stabilized by immobilizing contaminants by mixing in cement and contaminant binding agents (Treatment Option B). The primary components for treating the shallow soils in this alternative are generally the same as those described above in Alternative 2. The primary components for treating the deeper soils with Treatment Option A are generally the same as described above in Alternative 1. The primary components of Treatment Option B include using large diameter augers to complete the soil stabilization.

This alternative would destroy the contaminants in the shallow soil, likely to concentrations less than cleanup levels. In the deeper soils, the contamination would either be removed or immobilized. With Treatment Option A, there would be some residual contamination left behind, but this contamination would primarily be adsorbed to soil and would be very poorly soluble in water. With Treatment Option B, the contamination would be bound in a cement matrix; however, there is the potential for some leaching of residual contamination not fully incorporated into the matrix. Alternative 3, with either Treatment Option, would eliminate the need for long-term operations and maintenance of an active pumping system and the risk of future releases of contaminants from the Former Process Area.

After backfilling of the clean soils, the entire Former Process Area would be converted to a park as planned by the City and Park District. The area would be graded to create a natural beach profile and the top portions of the existing sheetpile wall and perimeter barrier wall would be cut off to below ground surface. The entire area would be covered with imported clean soil.

Implementation of this alternative with Treatment Option A is estimated to take between 8 and 19 years from initial design through site restoration (the wide range is again dependent on power available to conduct the in-situ thermal treatment). For implementation with Treatment Option B, the timeframe is estimated to range from 4 to 6 years. The conceptual level cost for this alternative with in-situ thermal treatment is estimated to range from $126 to $158 million. If soil stabilization is used for this alternative, then the conceptual level cost for this alternative is estimated to range from $101 to $125 million.

COMPARISON OF A GENERATIONAL REMEDY TO THE USEPA CONTAINMENT REMEDY

The containment remedy leaves existing contamination in place within the Former Process Area and the risk of a contaminant release remains in perpetuity. There are concerns with the containment remedy regarding leakage of contamination through the Aquitard, risks associated with long-term changes to site conditions (e.g., earthquakes, shoreline erosion, or water level rise), the ability to accurately monitor containment effectiveness, and the availability of funding and resources to maintain active treatment for hundreds of years. While a generational remedy will cost more money in the short-term, it would greatly reduce or eliminate the risk for a release of contamination from the Former Process Area following implementation.

Given the factors that affect government financing, the USEPA containment remedy is the most expensive long-term approach to solve this environmental problem. The cost for any of the generational remedies is significant; however, these costs pale to the actual cost of the USEPA containment remedy. The short-term capital costs of the generational remedies are estimated to range from $107 to $158 million spent over 4 to 20 years, with minimal operational and maintenance costs. Based on current information provided by USEPA, the short-term capital costs for the USEPA containment remedy are estimated to be $30 million spent over 4 to 5 years; perpetual long-term operational and maintenance, and capital costs associated with infrastructure replacement are estimated to be $280 million after 200 years, and $539 million after 400 years of operation (all costs presented in 2010 dollars).

There will be greater impacts on the community in the short term with construction of a generational remedy compared to the impacts for finishing implementation of the containment remedy. These impacts include increased construction activity and noise, increased traffic to the area, increased power usage, and a longer period of construction relative to the containment remedy before the park can be constructed and opened to the public on the Point. However, the continual presence of the containment remedy components on the Point and the periodic construction to replace and maintain elements of the containment remedy will limit park design and future use of the Point. The generational remedy alternatives allow for more options in future design and use of the entire area as a park. These alternatives also allow for restoration of a natural beach profile.

CONCLUSIONS

The Generational Remedy Evaluation has identified several viable options to meet generational remedy objectives, with expert panel, steering committee, and community involvement. Evaluation of new information has determined that there are significant concerns as to whether the USEPA containment remedy would be protective in the long-term, as required by federal law. Given the factors that affect government financing, the containment remedy is the most expensive long-term approach to solve this problem.

Environmental decisions today on this unique site have significant consequences for future generations. A remedy should be implemented that meets multi-generational environmental goals, community and tribal values, and sustainability objectives in terms of climate change, protection of Puget Sound, and reduction of risk and obligation for future generations. Implementation of a protective, permanent remedy for the Point should be undertaken in concert with active remediation of uncontrolled contamination in adjacent beach areas (the East Beach and North Shoal areas).

Based on input received from the community and steering committee during the Generational Remedy Evaluation, broad public support exists for further significant cleanup, even with the understanding of the cost and time involved. This level of engagement with the public must continue, as the decisions made today have significant consequences for future generations.

1.0 Introduction

Since September 2009, the Washington State Department of Ecology (Ecology) has undertaken a Generational Remedy Evaluation for the portion of the Wyckoff/Eagle Harbor Superfund Site (Wyckoff Site) once occupied by the former Wyckoff Company wood-treatment facility and referred to as the Former Process Area or the Wyckoff Point (the Point). The Generational Remedy Evaluation has included an evaluation of remedial alternatives for soil and groundwater beneath the Former Process Area that would reduce the mass or mobility of the approximately 1.2 million gallons of mobile contamination that remains in this area, and that would remain protective for multiple generations with minimal reliance on operation, maintenance, and replacement of remedial components. This large volume of contamination, if left within the Former Process Area, poses a significant environmental threat to Puget Sound in perpetuity and the challenge of containing this contamination within the Former Process Area requires long-term financial and resource obligations by the State of Washington (State) and the local community.

The Wyckoff Point is a unique area. It is a promontory located in the heart of Puget Sound, forming the entry to Eagle Harbor. It is in an area of significant wave action, exposed to a wide northeasterly fetch and vulnerable to constant ferry wake. It is located adjacent to an ancestral and important current tribal fishing ground, with established eelgrass beds. The Suquamish Tribe has fishing rights reserved under the 1855 Treaty of Point Elliott, and is a co-manager of the fishery resources within the State. The City of Bainbridge Island (City) and the Bainbridge Island Metro Park and Recreation District (Park District) have purchased the Wyckoff property, including the Point, with plans to establish a showcase regional public park, with beach access and sweeping views of Puget Sound and the Seattle skyline.

The Wyckoff Site is a Federal-lead site. Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) program, the U.S. Environmental Protection Agency (USEPA) has decided to implement a containment remedy to contain on-site contaminants within the Former Process Area using a perimeter wall, surface cap, and groundwater extraction and treatment system. Following construction of the containment remedy, the USEPA intends to turn responsibility of this portion of the Wyckoff Site over to the State.

USEPA's proposed containment remedy does not remove the threat of an environmental release of contamination from the Former Process Area, and would place a significant financial and logistical burden on the State and community in perpetuity to operate and maintain the containment system. There are also concerns with the effectiveness of the containment remedy to keep contamination in place and the possible long-term risk of failure of this remedy. For these primary reasons, Ecology has undertaken this "Generational Remedy Evaluation" to develop new information identifying protective, durable, and cost-effective remedy options for the Former Process Area that would remove or treat the bulk of contamination. By removing or treating the bulk of the contamination, a generational remedy would:

- minimize gradual migration of contamination out of the Former Process Area,
- minimize the risk of a catastrophic release of contamination out of the Former Process Area leading to an environmental disaster,
- significantly reduce long-term financial obligations to the state government and burdens on the local community for future generations.

The objectives for the Generational Remedy Evaluation process and the guiding principles for a Generational Remedy are presented in the Generational Remedy Evaluation Project Objectives document (Ecology 2009). This document is included in Appendix A. The objectives outlined in this document have been completed, as described in the paragraphs below, and have resulted in the development of three remedial alternatives that meet the guiding principles of a generational remedy.

Additional information on the Generational Remedy Evaluation, and many of the references listed in this document, can be found on the Generational Remedy Evaluation website (www.ecy.wa.gov/programs/tcp/sites/wyckoff/wyckoff_hp.htm).

The Generational Remedy Evaluation process began with the formation of a steering committee composed of members from the local government, community, and Suquamish Tribe. The steering committee included the following individuals:

- Perry Barrett, Bainbridge Island Metro Park and Recreational District
- Rich Brooks, Suquamish Tribe
- Libby Hudson, City of Bainbridge Island
- Janet Knox, Association of Bainbridge Communities
- Clarence Moriwaki, Japanese American Exclusion Memorial Committee[1]
- Tim Nord, Ecology
- Frank Stowell, Citizen at Large

This local steering committee worked with and provided input and advice to Ecology throughout the process. They provided input on structuring the effort, in defining the Generational Remedy Evaluation Project Objectives, selecting an expert panel, and reviewing outcomes. The steering committee met a number of times throughout this process and was active in the Expert Panel Workshop and community meetings (described below). Further detail on the role of the steering committee in the process is included in Appendix A.

Ecology also formed a panel of 8 technical experts, selected from a field of 43 nationwide, as part of the process to explore and evaluate potential generational remedy alternatives for this complex site. The experts selected for this panel (listed in Section 4.1.1) have experience in the remediation of sites with similar contamination and on large construction projects in challenging or constrained environments, which was critical in the development and critique of potential remedial alternatives at the Former Process Area. The expert panelists identified, evaluated, and collectively brainstormed potential generational remedial alternatives during a 3-day workshop held on Bainbridge Island in January 2010. The Bainbridge Island community has also been provided with opportunities to learn about and to be involved in the evaluation process, including participation in two community meetings held during the evaluation process and an invitation to attend the Expert Panel Workshop. EnviroIssues, a consultant to Ecology, planned and implemented community outreach and involvement related to the Generational Remedy Evaluation process.

[1] Clarence Moriwaki stepped away from the steering committee part way through the Generational Remedy Evaluation process to start a new job.

Following the Expert Panel Workshop, Ecology and their consultants for the Generational Remedy Evaluation process, Floyd|Snider and Aspect Consulting, identified three generational remedy alternatives for further evaluation that could be implemented at the Former Process Area. This Generational Remedy Evaluation Report, prepared by Floyd|Snider and Aspect Consulting, documents the three selected generational remedy alternatives, including conceptual level descriptions of each alternative, how each alternative would meet the generational remedy objectives, and the likely construction techniques, schedule, community impacts, uncertainties, and estimated costs for each alternative. An evaluation comparing implementation and maintenance of a generational remedy to the implementation and maintenance of the USEPA containment remedy is also included as part of this report.

The Generational Remedy Evaluation Report is organized as follows:

- **Section 1.0** provides a summary of Ecology's Generational Remedy Evaluation process.
- **Section 2.0** provides an overview of the Former Process Area with background information on the regulatory process, the USEPA containment proposal, Ecology's concerns about the containment remedy, and future site use. This section also provides a brief summary of site conditions in the Former Process Area and the key uncertainties regarding the site conditions.
- **Section 3.0** provides a brief description of the USEPA containment remedy.
- **Section 4.0** presents descriptions of three generational remedy alternatives, along with a comparison of these alternatives and a discussion of the ability of these alternatives to meet the generational remedy objectives.
- **Section 5.0** is an evaluation comparing the USEPA containment remedy against a generational remedy approach.
- **Section 6.0** concludes with a recommended approach forward, including further evaluation of responsibilities and funding for the Generational Remedy and what key information gaps need to be filled to hone in on a preferential Generational Remedy.
- **Section 7.0** provides references for the documents cited in this report.

2.0 Site Overview

2.1 BACKGROUND

2.1.1 Description and History of the Site

The Wyckoff Site is located on the east side of Bainbridge Island, in central Puget Sound, Washington (Figure 2.1). The Wyckoff Site comprises the former Wyckoff Company wood-treatment facility and intertidal and subtidal sediments in Eagle Harbor.

The Generational Remedy Evaluation focuses on a portion of the Wyckoff Site that is referred to as the Former Process Area. The Former Process Area occupies the Point, which is a small peninsula jutting into Eagle Harbor that was largely created by filling up and around a pre-existing sand spit to create the land area used for the wood-treatment facility (Figure 2.2). The Former Process Area covers approximately 12 acres. Approximately 9 acres of the Former Process Area contains soil and groundwater contamination and this area is contained by a sheetpile wall. The sheetpile wall encloses the peninsula around the harbor side of the landmass, to the west, north, and east. The ground surface within the sheetpile wall is generally flat with grades approximately 15 to 19 feet above mean lower low water (MLLW) for central Puget Sound. South of the Former Process Area is a hillside where the land surface gradually rises to elevations of about 200 feet.

The former Wyckoff Company wood-treatment facility operated on the Point for 85 years, and these operations resulted in the soil and groundwater beneath the Former Process Area being contaminated with chemicals from the wood-treatment process, primarily creosote-derived polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol (PCP), aromatic carrier oils, and dioxins/furans. It is estimated that there are approximately 1.2 million gallons of contamination in the form of non-aqueous phase liquid (NAPL) in the subsurface of the Former Process Area (USACE 2000).

Approximately 2,000 people live within 1 mile of the Wyckoff Site with the nearest residence approximately ⅛ mile away. Land use in the area is largely residential and commercial. Eagle Harbor is heavily used by recreational boaters and is the location of one of the State's most active ferry routes, with ferries making trips between Bainbridge Island and Seattle at least 23 times per day. Eagle Harbor is within the traditional territory and the usual and accustomed fishing area of the Suquamish Tribe. Creosote contamination is also present in sediment and groundwater located outside of the sheetpile wall surrounding the Former Process Area. Much of the intertidal and subtidal surface sediment within the Wyckoff Site has been addressed by USEPA with remedial capping projects. However, in two areas of the Wyckoff Site outside the sheetpile wall, creosote contamination in the intertidal areas has not been addressed. These areas include the East Beach, the intertidal area located to the east of the Former Process Area, and the North Shoal, the intertidal area located to the north of the Former Process Area. On the East Beach, NAPL is seeping onto the beach and into Puget Sound in numerous locations. USEPA has yet to decide how contamination in these areas of the Wyckoff Site should be addressed. These areas are currently signed to restrict public access.

For additional information on the Wyckoff Site, historical operations within the Former Process Area, and a chronology of major events, refer to the *Wyckoff Site Summary Report for the Generational Remedy Evaluation* (Floyd Snider and Aspect Consulting 2009).

2.1.1.1 Exposure to Creosote and Other Site Contaminants

Soil and groundwater beneath the Former Process Area is contaminated with creosote, as well as PCP, aromatic carrier oils, and mixtures of these products from former wood-treatment operations. Chemicals associated with these products include the following:

- PAHs
- Polychlorinated phenols (primarily PCP) and polychlorinated dioxins/ furans
- Light aromatic hydrocarbons including ethylbenzene, toluene, and xylenes
- Heterocyclic hydrocarbons such as carbazole and dibenzofuran

There are human and ecological threats posed by these contaminants if this contamination were to leave the Former Process Area and reach Puget Sound or the nearby beaches.

Health effects from site contaminants are dependent on the exposure concentration, exposure duration, the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of contaminants). Human exposure to creosote and creosote-derived compounds in low doses for an extended period of time by either direct contact or exposure to vapors can result in damage to the eye or skin (blistering or peeling), and possibly even cancer. Eating food or drinking water with high levels of creosote may cause burning in the mouth and throat, and stomach pain (ATSDR 2002, ATSDR 2009). A seafood consumption advisory has been in place at Eagle Harbor since the early 1980s due to site-related contamination. This advisory is based on contamination that had already left the Former Process Area and reached Puget Sound. Additionally, recreational shell fishing in Eagle Harbor is not advised (ATSDR 2009). The Suquamish Tribe fishing regulations prohibit the harvesting of resident fish within Eagle Harbor due to the potential for human health risks, and the area is not open to the harvesting of intertidal bivalves because of contamination concerns.

Low levels of creosote-related chemicals can also be harmful or toxic to aquatic species and the Puget Sound ecology. Various field monitoring studies have shown that aquatic invertebrates and fish can bioaccumulate creosote components, primarily PAHs. Creosote-contaminated groundwater, surface water, or sediments have been shown to cause adverse reproductive and developmental effects in fish (World Health Organization 2004).

A recent Health Consultation was completed by the federal Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate current exposure risks on the Wyckoff Site. The exposure to contamination within the Former Process Area is currently restricted through access restrictions (fencing), the perimeter sheetpile wall, and the groundwater pump and treatment system, which has been installed to keep contaminants in the Former Process Area from moving further off-site. Because of these exposure controls, the recent Health Consultation states that, “Current conditions do not present a risk of exposure to contaminants on the Former Process Area” (ATSDR 2009).

Creosote is present in seeps on the East Beach and a seep has also been observed on the North Shoal. The ATSDR report recommends that adults avoid obvious signs of contamination and that dogs or children not be allowed to play or dig on this beach (ATSDR 2009). USEPA has posted signs on the East Beach and North Shoal to inform the public of the hazards.

Further details about creosote and the effects of creosote exposure on humans are included as an appendix in the ATSDR Health Consultation Report for the Wyckoff Site.

2.1.2 Site Ownership and Future Site Use

The Wyckoff Site (approximately 50 acres plus tidelands) is owned by the City and the Park District. The property was purchased in three phases between 2004 and 2006. The first two phases were co-purchased by the City and the Park District. The last phase, which includes the Former Process Area, was purchased by the City. The City obtained a Prospective Purchases Agreement for the Wyckoff/Puget Sound Resources (PSR) property from USEPA in 2005. The City and the Park District are developing Pritchard Park on the property. During the purchase of the property, a theme evolved for Pritchard Park to become a healing park, for healing two past wrongs, "one to the social fabric of the community and constitutional rights of citizens, and the second to the contamination of the land itself" (Pritchard Park Design Advisory Committee 2008). An approximate 8.5-acre portion of the park, located on the west end, is recognized by the National Park Service as the Japanese American Exclusion Memorial. The property is currently used as a park with the exception of the Former Process Area, which is fenced to prevent access as the USEPA continues design and development of its containment remedy.

Results of park planning efforts, led by the Park District, for the Former Process Area for the future include a walking path along the perimeter of the Former Process Area for visitors to take in the views of Eagle Harbor and Puget Sound. Another design goal is to restore the shoreline surrounding the Former Process Area to make the sheetpile wall currently in place less visible from the water. Whatever the final remedy for the Former Process Area is, it will influence the design for this portion of the park. Additional information about the Park District's and City's Recommended Design for Pritchard Park, along with schematic drawings of future parks plans, can be found at the following link:

http://www.biparks.org/parksandfacilities/UniversityofWashingtonsUrbanDesignandPlanning.htm.

A drawing of one of the two recommended design plans for Pritchard Park, created by the Pritchard Park Design Advisory Committee, is included as Figure 2.3.

2.1.3 Regulatory Status and USEPA's Containment Remedy

The Wyckoff Site was placed on the National Priorities List in 1987. USEPA issued an Interim Record of Decision for the groundwater operable unit of the Wyckoff Site (which encompasses the Former Process Area) in September 1994. This Interim Record of Decision resulted in an upgrade of the groundwater extraction system that was originally constructed in 1990. In November 1997, USEPA issued a Proposed Plan for the cleanup of the Soil and Groundwater Operable Units, which focused on containment of the contamination. A second Proposed Plan was issued by USEPA in September 1999, as thermal remediation was determined to be a promising cleanup strategy to address the contaminated soil and groundwater within the Former Process Area.

A final ROD was issued for both the Groundwater and Soil Operable Units in February 2000. This ROD selected thermal remediation as the appropriately protective remedy for the Former Process Area because:

- a containment strategy has no completion end point and the pump-and-treat system would have to be operated and maintained in perpetuity to maintain the integrity of the containment option,

- prominent researchers and industry experts in thermal remediation fully supported thermal technologies for the remediation of the site contamination,
- the National Contingency Plan (NCP) establishes an expectation that USEPA will use treatment to address the principal threat wastes whenever practicable.

In the event that thermal remediation did not work at the Former Process Area, the ROD identified containment as a contingent, or fallback, remedy (USEPA 2000a).

2.1.3.1 Thermal Remediation Pilot Study

A thermal remediation pilot study, using steam-enhanced extraction, was identified as the test for a thermal alternative. The pilot study was conducted over a 6-month period in 2002 and 2003. Due to funding limitations, the thermal pilot study was not constructed as designed. The U.S. Army Corps of Engineers (USACE) completed an evaluation of the pilot study in 2006 that documented the problems that occurred during the pilot study. The pilot study encountered numerous operational problems during implementation, including the following:

- The incompatibility of seals, gaskets, heat exchangers and other components with contaminants.
- The inability of the water treatment system, which relied on bioremediation of contaminants, to handle the increased contaminant load (high contaminant concentrations were toxic to the microbial population, requiring periodic shutdown of the system to re-inoculate the treatment basin).
- PAH precipitation/condensation (particularly naphthalene), which led to clogging of valves and pipes.
- Liquid in vapor lines that reached the vacuum pumps (USACE 2006).

Due to numerous equipment problems, the longest interval of continuous operation was 3 days, and the total operating time of the extraction system was approximately 1 month. Additional information on the problems with the thermal remediation pilot study is provided in Section 6.0 of the *Wyckoff Site Summary for the Generational Remedy Evaluation* (Floyd Snider and Aspect Consulting 2009) and the *Thermal Remediation Pilot Study Summary Report* (USACE 2006). Rather than address the technical problems, the thermal pilot study was deemed unsuccessful by USEPA, and USEPA decided to implement the contingent containment remedy as the final Superfund remedial action at the Former Process Area.

The failure of the pilot test, due to funding limitations, scope change, design and technical difficulties, and project management challenges, does not mean that thermal remediation technology cannot be successfully applied at the Former Process Area. Because of its limited implementation, the USACE concluded that “the pilot study should not be viewed as a definitive application of thermal remediation technology” (USACE 2006). Rather, the pilot study was successful in demonstrating that steam injection dramatically increases the amount of contaminants that could be removed. This, and the successful application of thermal remediation at many other sites in the 8 years since the Wyckoff Site pilot test was conducted, indicate that a properly constructed thermal remediation system could be effectively implemented at the Wyckoff Site.

2.1.3.2 USEPA Contingent Containment Remedy

USEPA is currently in the process of implementing a containment remedy for the contaminated soil, groundwater, and NAPL within the Former Process Area. No Explanation of Significant Differences (ESD) or ROD amendment has been issued by USEPA following the 2000 ROD regarding selection of the containment remedy as the contingent remedy. However, based on more recent reports and communications with USEPA, it is understood that the USEPA's containment remedy will consist of:

- the current sheetpile wall to contain contaminated soil, groundwater, and NAPL within the Former Process Area,
- a groundwater extraction system (pumping wells) to maintain an average inward and upward gradient to prevent contaminated groundwater and NAPL from leaving the Former Process Area,
- the replacement groundwater treatment plant (recently completed), to treat extracted groundwater before discharging to Eagle Harbor,
- proposed future shoreline protection of the sheetpile wall,
- a proposed future surface site cap to limit exposure to site soils and to reduce precipitation infiltration,
- long-term monitoring of the effectiveness of the containment system (USACE 2007, CH2M HILL 2007).

USEPA is still determining whether an upgradient groundwater cutoff wall (to reduce the volume of groundwater reaching the Former Process Area) will also be part of the containment remedy. Further details on the components of the USEPA's containment remedy are provided in Section 3.0 of this report.

The groundwater extraction system has been in operation at the Former Process Area since the early 1990s and the sheetpile wall was installed in 2001. A new treatment plant, replacing the 1990 treatment plant, became operational in March 2009. Through calendar year 2010, USEPA plans to upgrade the existing groundwater extraction well system and to continue to monitor for groundwater hydraulic containment, water quality of the groundwater beneath the Former Process Area, and water quality of the treated groundwater discharging to Eagle Harbor. The sheetpile wall shoreline protection and the surface site cap have not yet been designed. USEPA has concluded the containment remedy is protective of human health and the environment (USACE 2007).

2.1.4 Ecology's Concerns with the Containment Remedy

The Wyckoff Site is a fund-lead site, which means that USEPA leads in funding the remedy, but that the State has to pay 10 percent of the construction costs and is responsible for all operations and maintenance costs, including component replacement costs, once construction is complete. Following completion of construction of the remedial action, USEPA will turn the Former Process Area over to Ecology for long-term operations and maintenance.

The Former Process Area contains a massive amount of mobile contamination that poses a threat to the Puget Sound environment, either through a gradual release or a catastrophic release of contamination out of the Former Process Area. The containment remedy would not remove this risk, and would place a significant financial and logistical burden on the State and the local community to maintain the containment systems over hundreds of years—in perpetuity. The primary concerns that prompted this Generational Remedy Evaluation are:

1. The long-term environmental consequence of leaving large amounts (over 1 million gallons) of mobile contamination beneath the Former Process Area, especially given the important and sensitive location of the Former Process Area on the shores of Puget Sound.
2. The financial and logistical burden that this action places on the State and the Bainbridge Island community—a perpetual and inordinately disproportionate obligation for active operations and maintenance, including periodic rebuilding of the remedy containment components such as the groundwater extraction system, groundwater treatment system, and perimeter wall. Life cycle costs are estimated to be hundreds of millions of dollars (refer to Section 3.0 for estimates on long-term costs for the USEPA containment remedy).

Further discussion of these concerns with the USEPA containment remedy, as well as concerns with the effectiveness of the containment remedy, is provided in Section 3.5 of this report.

As a result of these concerns, Ecology has deferred entering into a long-term Superfund State Contract with USEPA for the long-term operations and maintenance of the Soil and Groundwater Operable Units. Instead, Ecology has undertaken this Generational Remedy Evaluation, partnering with local stakeholders to develop new information defining and evaluating protective, durable, cost-effective remedial alternatives for the Former Process Area that reduce the source and/or mobility of the contamination and that would be protective for future generations with little active management.

2.2 SITE CONDITIONS

A brief summary of the Former Process Area site conditions is included below. For further detail on subsurface conditions, the nature and extent of contamination, and the fate and transport of contaminants in the Former Process Area refer to the *Wyckoff Site Summary Report for the Generational Remedy Evaluation* (Floyd|Snider and Aspect Consulting 2009). The Wyckoff Site Summary Report is based on material compiled and summarized from existing documents provided to Floyd|Snider and Aspect Consulting by the USEPA, the USACE, and the City, and the report acts as a road map for locating additional and more in-depth information regarding the Former Process Area.

2.2.1 Subsurface Units

There are three hydrogeologic units described at the Former Process Area and relevant to remediation: an Upper Aquifer, an Aquitard, and a Lower Aquifer. Cross sections of the subsurface distribution of material types, based on boring log data, are shown in Figures 4 through 9 in the Wyckoff Site Summary Report. Included as Figure 2.4 in this report is Geologic Profile C-C’, which has been edited to include additional boring data not provided in the summary report.

The Upper Aquifer contains the vast majority of the NAPL contamination, although some pathways for deeper migration through the Aquitard exist (refer to NAPL in Geologic Profile C-C’, Figure 2.4). The Upper Aquifer is continuous across the Former Process Area with thickness ranges from about 15 feet on the southern side of the area to about 70 feet on the northern side (total depth of 20 to 80 feet below ground surface). Groundwater in the Upper Aquifer is encountered under unconfined conditions at depths ranging from approximately 5 to 10 feet below ground surface. The Upper Aquifer is composed of two primary geologic units: fill and marine sand and gravel. The fill unit occurs throughout the surface of the Former Process Area and is generally composed of silts and fine sands dredged from nearby locations. The marine sand and gravel unit is generally composed of loose to dense poorly-graded sand and fine gravel with little silt; however, interbedded layers of silty sand or coarse gravel with cobbles are also present. Shell fragments are abundant in this unit.

A low-permeability Aquitard underlies the Upper Aquifer and acts as an impediment to NAPL migration from the Upper Aquifer into the Lower Aquifer; however, localized sand layers within the Aquitard have allowed NAPL to penetrate the Aquitard (USACE 2000) and leakage has been inferred from hydraulic testing (CH2M HILL 2007) and groundwater sampling (CH2M HILL 2008). The Aquitard extends from near ground surface in the south-central portion of the Former Process Area to depths of 80 feet in the northern portion of the Former Process Area. It ranges in thickness from about 10 to 40 feet, with the thinnest area localized near the northeast and central areas of the Former Process Area. It is not found in the southeastern area, near the location of the former groundwater-treatment plant. The Aquitard is interpreted to be composed of marine silt (where present) and glacial clay, silt, and sand units. The composition of the marine silt unit ranges from silty sand to soft, low-plasticity silt or clay. Thin layers of sand and occasional gravel are present. This layer also contains abundant shells and wood fragments. The marine silt unit is generally not present beneath the southern half of the Former Process Area. The thickness of the marine silt unit varies from less than 1 foot to up to 16 feet on the northern portion. The glacial clay, silt, and sand unit is composed of very dense, glacially-overridden silty sand with gravel (possibly glacial till) and layers of very stiff to hard non-marine silt or clay (possibly a glacially-overridden interglacial lacustrine deposit). This unit is present under much of the Former Process Area but may be absent in the southeast corner. The thickness of the glacial clay, silt, and sand unit varies from 0 to 37 feet.

The Lower Aquifer is defined as the lower sand unit encountered in the borings drilled below the Aquitard. The Lower Aquifer is encountered at a depth ranging from approximately 40 feet on the southern edge of the Former Process Area to 90 feet on the northern edge of the Former Process Area. It is interpreted to be composed of fluvial sand, described as glacially-overridden dense to very dense, gray-brown to brown, well-graded to poorly-graded with varying amounts of gravel and cobbles. Interbeds of silty sand and silt up to 1-foot thick have been observed in this unit. The fluvial sand is differentiated from the marine sand by its color (brown instead of gray), its density, and its lack of organic material. The Lower Aquifer is confined with groundwater levels ranging from approximately 5 to 10 feet below ground surface (similar to the Upper Aquifer). The Lower Aquifer is also tidally-influenced with fluctuations in the range of 6 to 9 feet. The thickness and hydraulic parameters of the Lower Aquifer are not well known.

2.2.2 Groundwater Flow Conditions

The containment remedy's extraction pumping system and sheetpile are intended to create an average inward and upward hydraulic gradient of groundwater into the Former Process Area. That means that groundwater, on average, in the Lower Aquifer is drawn into the Upper Aquifer. This flow pattern reduces the potential for dissolved-phase contamination within the Upper Aquifer to be transported via groundwater flow to the deeper units and Puget Sound. However, mobile NAPL migration through sand layers within the Aquitard could still continue even with groundwater extraction occurring.

Currently, there are between six and nine groundwater extraction wells operating most of the time. It is uncertain whether these extraction wells create an inward and upward gradient across the entire Former Process Area or if the gradient is more localized around the wells. USEPA is evaluating the integrity and coverage of the existing groundwater extraction system as part of their containment plan. Pumping rates in the individual extraction wells in 2008 ranged from about 2 to 8 gallons per minute (gpm) for a total extraction rate of about 35 gpm from the Upper Aquifer. During the winter months, the extraction rates increased to about 55 to 60 gpm due to increased precipitation and groundwater recharge.

The majority of groundwater flow into the Former Process Area appears to come from precipitation onto the Former Process Area and inflow from upgradient sources in the south hillside area. Some minor amounts of inflow may come from the Lower Aquifer in areas where the Aquitard is leaky or not continuous (e.g., the southeastern corner of the Former Process Area) or through unwelded seams or openings in the sheetpile wall, but likely not in any significant volumes. Average groundwater inflow rates of about 38 gpm, with transient peaks of up to 167 gpm, have been estimated from modeling work (URS Greiner and CH2M HILL 2004).

During high-precipitation periods and equipment maintenance periods, a downward gradient occurs in some areas of the Former Process Area, particularly during low tides and in the southeast area of the Former Process Area where the Aquitard is absent. In these cases, some advective transport of dissolved phase contamination from the Former Process Area toward Puget Sound could occur through discontinuities in the Aquitard, leaky joints of the sheetpile wall, at discontinuities in the sheetpile wall, or at locations where the sheetpile wall is not inserted into the Aquitard. Water quality results from Lower Aquifer monitoring indicate some leakage through the Aquitard.

2.2.3 Nature and Extent of Contamination

Much of the contamination in the subsurface is associated with NAPLs, which generally consist of mixtures of creosote, PCP, and aromatic carrier oils that were used in the former wood-treatment operations. Depending on the mixture, NAPL may behave as either a light NAPL (LNAPL; less dense than water) or dense NAPL (DNAPL; more dense than water). The chemical and physical characteristics of LNAPL and DNAPL at the Wyckoff Site are generally quite similar. Both LNAPL and DNAPL at this site are primarily composed of PAHs, with naphthalene as the dominant constituent.

The estimated volume of NAPL in the Upper Aquifer of the Former Process Area is approximately 1.2 million gallons. The estimated volume of LNAPL is 230,000 gallons and the estimated volume of DNAPL is 960,000 gallons (USACE 2000). The LNAPL is primarily located in the central and eastern portions of the Former Process Area, with LNAPL thicknesses ranging up to 10 feet. Estimated contours of LNAPL thickness are shown on Figure 2.5. DNAPL is distributed across most of the Former Process Area in multiple discrete layers throughout the Upper Aquifer as well as in accumulations at the base of this aquifer. DNAPL has also been observed in thin sand layers within the Aquitard in the central portion of the Former Process Area and in the Lower Aquifer in the most recent borings (refer to Borings VG-2L and VG-3L in Figure 2.4, revised Geologic Profile C-C'). Total DNAPL thickness (calculated as a sum of multiple layers within the aquifer) ranges up to 14 feet (USACE 2000). Estimated contours of

DNAPL thickness are shown on Figure 2.6. Both LNAPL and DNAPL also extend beyond the boundaries of the sheetpile wall to adjacent sediments.

Six cross sections of the Former Process Area showing the general occurrence of NAPL in the subsurface are provided on Figures 4 through 9 in the Wyckoff Site Summary Report (from USACE 2000 with additional data from CH2M HILL 2009a). Refer to Figure 2.4, revised Geologic Profile C-C', in this report for a representative cross section view of NAPL in the subsurface.

2.2.4 Uncertainties and Data Gaps in Site Conditions

Over the past two decades an extensive amount of data has been collected on the Former Process Area, but significant uncertainties still exist. Additional analyses that provide a more comprehensive understanding of site conditions in three dimensions would be valuable to evaluate the benefits and costs of any potential remedy for the Former Process Area. Key data needs for the site conceptual model are discussed below. Refer to Section 3.5 for additional discussion on uncertainties regarding the containment remedy.

One area of uncertainty critical to the containment alternative is the integrity and thickness of the Aquitard. Previous data indicated sandy layers in the central site area where DNAPL may be migrating through the Aquitard. The most recent series of borings/well installations (CH2M HILL 2009a) identified a new area where DNAPL occurs in the Lower Aquifer (Well VG-2L in C-C'). In this location the upper and lower aquifers respond identically to tidal fluctuations, suggesting hydraulic continuity between these aquifers. There is also limited data to define the lower boundary of the Aquitard and its thickness. The lower aquifer contamination occurrences indicate there may be some areas where permeable strata are continuous enough to form preferential pathways for DNAPL migration. With a comprehensive database of the boring and well information, cross sections and maps can be made to determine if additional deep data are needed to better understand the integrity of the Aquitard beneath the Former Process Area.

Additional uncertainties exist in groundwater inflow and outflow sources and volumes. Groundwater modeling work was conducted in 2004 to determine how much pumping is needed for hydraulic containment (URS Greiner and CH2M HILL 2004). The modeling concluded that a water balance independent of the modeling work was needed to more accurately simulate site conditions and constrain the model to a unique solution. A water balance has not been completed to date. Additional data on the aquifer and aquitard parameters and extraction well pumping rates would be needed to define the major water budget terms. With an adequate site water budget, a better groundwater flow model could be developed and calibrated to the site conditions, which would be better able to predict inflows and outflows and their sources (URS Greiner and CH2M HILL 2004). These data are important for detailed design of any generational remedial alternative and to assess the protectiveness of the containment remedy.

3.0 USEPA Containment Remedy

This section of the report describes the USEPA containment remedy in as much detail as possible based on USEPA reports and current information received from USEPA. Although elements of the containment remedy have been installed, the final remedy components have not been fully defined by the USEPA. Components of the containment remedy, along with future site conditions, schedule, costs, and concerns or uncertainties, are described below as understood. Details on the containment remedy are provided in this report in order to support a comparative evaluation between a generational remedy and the containment remedy, which is included as Section 5.0 of this report.

It should be noted that the USEPA containment remedy does not address the significant volume of NAPL that is located outside of the sheetpile wall to the east and to a lesser degree to the north and west of the Former Process Area (refer to Figures 2.5 and 2.6). NAPL outside of the sheetpile wall is seeping onto the East Beach in numerous locations and into Puget Sound. A seep has also been observed on the North Shoal. Currently, no specific remedial actions are underway to address these seeps. The East Beach and North Shoal areas are being monitored, are signed to discourage access, and are being evaluated by USEPA. Some remedial capping projects have been completed by USEPA on intertidal and subtidal surface sediment on the west side of the Former Process Area.

3.1 CONTAINMENT REMEDY COMPONENTS

In 1990, the Wyckoff Company, under an order from USEPA, installed a groundwater extraction system to control discharge of wood treating chemicals to surface water. USEPA assumed control of the site in 1993 and found that the extraction system was not effective in containing contamination. USEPA installed eight new extraction wells, upgraded the treatment equipment, and in their 1994 Interim Record of Decision for groundwater called for the following additional interim containment measures:

- Replace the groundwater treatment plant
- Upgrade the extraction system
- Evaluate the need for, and install if necessary, a physical barrier

These activities have been completed. The physical barrier installed consists of a sheetpile wall along the shoreline (east, west, and north sides of the Former Process Area), which was installed in 2001. A new groundwater treatment plant was put into operation in 2009.

The proposed USEPA containment remedy adopts the interim containment measures identified above in conjunction with a surface cap to prevent contact with contaminated soil and to reduce precipitation infiltration into the Former Process Area. The proposed remedy consists of the following components (CH2M HILL 2007, USACE 2007):

- Shoreline Protection/Sheetpile Wall
- Groundwater Extraction and Treatment System
- Site Cap

- Upgradient Groundwater Cutoff Wall (dependent on further characterization of the Aquitard)
- Long-term Containment Monitoring

These components are described below. Plan and profile views of the components of the proposed containment remedy are illustrated on Figures 3.1 and 3.2, respectively.

3.1.1 Shoreline Protection/Sheetpile Wall

In 2000 and 2001, a steel sheetpile containment wall was constructed around the outer, shoreside perimeter of the Former Process Area. The wall is 1,800 feet in length and extends approximately 20 to 90 feet below grade. It was constructed to be inserted into the Aquitard. Based on a recent 2008 exploration in the southeast corner of the Former Process Area, it has been determined that the last 100 to 150 feet of the sheetpile wall in this area is not inserted into the Aquitard, but is inserted into the Lower Aquifer, as the Aquitard is not present in this area (CH2M HILL 2009a).

When installed, alternating seams on the sheetpile wall were welded to reduce groundwater flow between the joints. Therefore water may flow through the remaining unwelded seams. Because the wall was installed at the time that steam injection was proposed for implementation at the site, no sealant was placed on the wall during construction as it was thought that use of steam would affect the sealant (USEPA 2005).

A 50-year life was initially predicted for the sheetpile wall. However, an assessment completed on the wall in 2004 adjusted this prediction, concluding that the current rate of corrosion would lead to the penetration of the wall in the intertidal zone in less than 20 years (CH2M HILL 2004). As a result, USEPA plans to install a shoreline protection system sometime in the future, which would protect the existing sheetpile wall that is exposed above the mudline and subject to corrosion (CH2M HILL 2007).

Two alternatives for a future shoreline protection system were proposed in the *Wyckoff/Eagle Harbor Superfund Site Soil and Groundwater Operable Units Engineering Evaluation of Groundwater and Soil Remediation Scenarios* (Engineering Evaluation), prepared for the USEPA (CH2M HILL 2005). The first alternative proposed includes a new fiberglass sheetpile wall adjacent to the existing sheetpile wall. The fiberglass sheetpile wall would not corrode in seawater. A concrete step revetment would be placed over the fiberglass sheetpile wall to protect it and to help create a more natural looking shoreline. The second proposed alternative would also include a new fiberglass sheetpile wall, but in this case a concrete seawall would be placed inshore of the fiberglass sheetpile wall.

3.1.2 Groundwater Extraction and Treatment System

The groundwater extraction system is intended for hydraulic containment of contaminated groundwater and NAPL within the Former Process Area. The system currently consists of nine extraction wells. Between six and nine of the extraction wells are operating most of the time to pump a combination of groundwater and NAPL for the purpose of maintaining a lower water level in the Upper Aquifer relative to the water level in the Lower Aquifer. As stated previously, it is uncertain whether these extraction wells create an inward and upward gradient across the entire Former Process Area or if the gradient is more localized around the extraction wells. This pumping system is intended to create a net upward vertical gradient between the Lower Aquifer and Upper Aquifer; thus the potential for groundwater flow is inward and upward into the site instead of outward into the marine sediments and downward to the Lower Aquifer where it would then discharge to Eagle Harbor. There may be a point in a tidal cycle where water may flow out of the Upper Aquifer, but over the entire tidal cycle more water is pulled back into the site with the extraction system operating, therefore the general movement of contamination is into the Upper Aquifer. Based on existing monitoring data, it is uncertain whether the extraction system is effectively influencing contaminant transport throughout the entire contaminated portion of the Former Process Area. Design and construction of additional extraction wells is being considered by USEPA to improve containment performance.

Groundwater and NAPL extracted by the wells are treated by an on-site groundwater treatment plant. Treated groundwater is discharged through an outfall into Puget Sound. The discharged water is monitored to verify that it is in compliance with discharge requirements.

In 2009, USEPA completed construction of the replacement groundwater treatment plant. In 2010, USEPA plans to upgrade the existing groundwater extraction well system and demolish the former groundwater treatment plant.

The majority of flow from Eagle Harbor to the Former Process Area is limited by the sheetpile wall; hence, extraction within the Upper Aquifer is needed to keep groundwater inflows from the hillside south of the Former Process Area, precipitation infiltration, and upflow from the Lower Aquifer from accumulating in the Upper Aquifer and causing a downward and outward gradient.

Two components of the containment remedy not yet installed—the site cap and upgradient cutoff wall—would further reduce the volume of uncontaminated water that is currently reaching the Upper Aquifer. Cutting off this clean water before it reaches the Upper Aquifer and becomes contaminated is critical. Reducing the volume of extracted groundwater requiring treatment would help reduce operations and maintenance costs. The site cap and upgradient cutoff wall are described below.

3.1.3 Site Cap

A low-permeability site cap would be installed to limit the infiltration of precipitation entering the Former Process Area, thereby reducing the hydraulic loading to the groundwater treatment plant. Preliminary groundwater modeling completed in 2004 estimated that with a site cap installed, there would be a long-term average reduction of approximately 19 gpm of groundwater requiring extraction and treatment (URS Greiner and CH2M HILL 2004). The precipitation would be diverted into Eagle Harbor. The cap would also prevent direct contact with contaminated soil by humans (CH2M HILL 2007).

This cap has not yet been designed or constructed at the Former Process Area. Three kinds of caps have been considered for this site (CH2M HILL 2005), including the following:

- An impermeable asphaltic cap over a layer of crushed rock and clean fill.
- A vegetative/soil cap with an underlying geomembrane, drainage layer, impermeable high-density polyethylene (HDPE) liner, and a crushed rock layer.
- A vegetative/soil cap with an underlying clay liner.

3.1.4 Upgradient Groundwater Cutoff Wall

The purpose of an upgradient groundwater cutoff wall is to reduce the amount of clean groundwater from the south hillside entering the Former Process Area, and thus reduce the volume of water that needs to be extracted and treated to maintain an inward and upward gradient within the Former Process Area. This component of the containment remedy is identified as optional by USEPA (CH2M HILL 2007). The Aquitard is present at the surface or near the surface along the central portion of the southern boundary of the Former Process Area, possibly making an upgradient cutoff wall unnecessary in this area. However, this wall may be most useful at reducing operating costs where the Aquitard appears to be discontinuous (the southwest and southeast portions of the Former Process Area). Near these areas, the upgradient groundwater cutoff wall would need to be designed to cut off groundwater flow from the hillside and groundwater that is being exchanged between the Upper and Lower Aquifers where the Aquitard is absent. It would need to be placed where it could be inserted into the Aquitard unit (CH2M HILL 2005). Further analysis to determine the need for a cutoff wall in the southern portion of the Former Process Area is being conducted by USEPA (Yee 2010).

If implemented, this wall would tie into both ends of the existing perimeter sheetpile wall. Potential designs for this wall include a sheetpile wall, a bentonite-slurry trench, and an injected grout curtain (CH2M HILL 2007).

Preliminary groundwater modeling completed in 2004 estimated that with an upgradient cutoff wall in place, there would be an average reduction of approximately 14 gpm of groundwater requiring extraction and treatment. With both the upgradient cutoff wall and site cap installed, the groundwater modeling estimated that there would be a long-term average reduction of approximately 30 gpm, or a total of 8 gpm of groundwater requiring extraction and treatment (URS Greiner and CH2M HILL 2004).

3.1.5 Long-term Containment Monitoring

Currently monitoring wells installed in the Upper and Lower Aquifers are used to monitor conditions in the Former Process Area. Groundwater level monitoring is completed on a regular basis to ensure that a net inward and upward gradient is maintained within the Former Process Area. Contaminant concentration monitoring is also completed twice a year; with groundwater samples collected from the Lower Aquifer used to assess contaminant migration through the Aquitard. Additional monitoring wells were installed in 2008 to create additional hydraulic containment well pairs for monitoring and to complete the Lower Aquifer monitoring well network at the Former Process Area (CH2M HILL 2009a).

Long-term monitoring for the containment remedy is also anticipated to include surface water monitoring to evaluate potential impacts to the marine environment (CH2M HILL 2007). Monitoring wells will also be installed in the Lower Aquifer outside the sheetpile wall to act as compliance monitoring points (CH2M HILL 2005). The long-term monitoring program, including well network, monitoring frequency, points of compliance, and levels of concern has not yet been determined, and would need to be coordinated with the design of future shoreline protection. However, because substantial contamination is present in sediments outside as well as inside the sheetpile wall, it will be difficult to design a monitoring network that accurately evaluates the effectiveness of the containment remedy. Challenges associated with monitoring the effectiveness of containment are discussed below in Section 3.5.1.

3.2 FUTURE SITE CONDITIONS

Once the containment remedy construction has been completed within the Former Process Area, a large portion of this area is planned to be converted for use as a park. This could occur within 4 to 5 years (refer to schedule in Section 3.3). The groundwater extraction system and treatment plant would remain as permanent features in the Former Process Area and would be off limits to the public. The low-permeability site cap would also be a permanent feature within this area and may affect park use or design. It is uncertain what the shoreline protection system for the sheetpile wall will ultimately look like; however, this system could be designed to meet design goals for the park as discussed in Section 2.1.2. Design of the park will be constrained since it will need to take into account future access requirements for maintenance and replacement of containment elements.

As containment would have to continue in perpetuity within the Former Process Area, it would be necessary to periodically close portions of this area for maintenance activities or replacement of the remedy components in order to maintain the effectiveness of the containment remedy. Without maintenance or replacement of remedy components, system performance would decline over time due to clogging of well screens and pipes and wearing out of pumps and treatment equipment. The extraction wells, which will need to be located uniformly across the area, would have to be redeveloped often to maintain adequate pumping rates and replaced periodically, which will require providing access to the well locations by large drilling equipment. Replacement of the entire extraction system would likely not occur all at once, but over time each component would need to be replaced. In the 2005 Engineering Evaluation, it was assumed that the extraction system (wells, pumps, and piping) would have to be replaced every 20 years and the groundwater treatment plant would be replaced every 30 years (CH2M HILL 2005). Monitoring wells would also need to be periodically redeveloped or replaced to remove accumulated sediment.

When constructed, the sheetpile wall was intended to provide hydraulic containment for 50 years (CH2M HILL 2004). As discussed above, the portion of the sheetpile wall in the intertidal zone could be penetrated in less than 20 years due to seawater corrosion and wave action; therefore a shoreline protection system will be constructed to protect the sheetpile wall above the mudline. However, the entire sheetpile wall will likely still need to be replaced approximately every 50 years, unless some other type of wall with a longer lifetime expectancy is eventually installed to replace the sheetpile wall. Replacement of the sheetpile wall would also require reconstruction of the shoreline protection system.

The low permeability site cap would also require periodic maintenance or replacement. Specific maintenance activities, the frequency of these activities, and the associated costs would depend on the type of cap constructed (e.g., asphalt, clay, or HDPE). Because the site cap would extend over the entire area, replacement or significant repairs would be a major disruption to use of this area as a park.

It is likely that periods of construction would occur within the Former Process Area at least once every 20 years in perpetuity following the initial construction of the containment remedy. However, because replacement of the major components is likely to occur in stages rather than all at once, portions of the park within this area would be closed more frequently. In addition, maintenance activities on extraction wells, extraction pumps, and monitoring wells are likely to be required at least every few years, making maintenance or replacement work occurring within the park almost constant.

If long-term groundwater monitoring of the containment remedy were to reveal additional contamination was moving into the Lower Aquifer, then further actions would need to be taken to ensure containment of the contamination within the Former Process Area.

3.3 SCHEDULE

USEPA currently plans to upgrade the existing groundwater extraction well system and demolish the former groundwater treatment plant in 2010. If a Superfund State Contract is not in place between USEPA and Ecology by the end of 2010, USEPA has stated they plan to stop all work in the Former Process Area, including finishing the installation of the containment remedy.

Assuming that USEPA continues the installation of the containment remedy in 2011, it would likely take approximately 4 to 5 years to finish design and construction of the shoreline protection system, the site cap, and the upgradient barrier wall (if installed). Estimates on the time frames to complete the design, bid, and construction of each component are provided below (CH2M HILL 2005):

- 2 years for the shoreline stabilization system
- 2 years for the surface cap
- 15 months for the upgradient groundwater cutoff wall

Operation and maintenance of the groundwater extraction and treatment system has no defined endpoint and would be required in perpetuity (USEPA 2000a, CH2M HILL 2005). As discussed above in Section 3.2, components of the containment remedy would also require periodic replacement in perpetuity.

3.4 COSTS

Estimated costs for the USEPA containment remedy are described here, and are used in Section 5.0 as the basis for a cost comparison with a generational remedy. The estimated costs of the containment remedy adjusted to 2010 dollars are $30.0 million for construction of the remaining containment components and $857,000 per year for operations and maintenance of the remedy in perpetuity. Replacement costs for the groundwater extraction system and monitoring wells are included in the annual operations and maintenance costs. Additionally, there are estimated periodic replacement costs for other remedy components in perpetuity, including $8.5 million every 30 years for a groundwater treatment plant and $6.9 million every 50 years for the sheetpile wall, in 2010 dollars. There will likely be additional costs for the periodic replacement of the shoreline stabilization system and the surface cap that have not been accounted for in the costs summarized above. The estimated costs for the containment remedy are based on information and documentation provided by USEPA adjusted for inflation. Details are provided below.

3.4.1 Construction Costs

Components of the containment remedy still to be constructed include the new extraction wells, the shoreline protection system, the site cap, and potentially the upgradient groundwater cutoff wall. USEPA recently made available estimated design, contractor procurement, construction, and technical support costs for completion of the containment remedy (Orlean 2010). The costs recently provided did not include costs for an upgradient groundwater cutoff wall. The estimated costs provided by USEPA were based in 2008 dollars. These 2008 estimated construction costs are reportedly based on costs provided in the 2005 Engineering Evaluation Report increased upward by 30 percent adjusting for construction cost inflation (Orlean 2010).

The construction costs are based on a concrete step revetment shoreline protection system and a vegetative/soil cap with an underlying clay liner. For the extraction system, the 2005 Engineering Evaluation Report capital cost was based on the installation of five additional extraction well heads in below grade vaults, the movement of the nine existing extraction well heads to below grade vaults, and moving all discharge piping below grade (CH2M HILL 2005). Design and construction oversight costs were assumed to be 35 percent of the construction cost (Orlean 2010).

The recent 2008 costs provided by USEPA, adjusted to 2010 dollars using an annual inflation rate of 3 percent, are summarized in the table below:

USEPA Estimated Costs for Completing Containment Remedy Construction

Item	Estimated Cost (in 2010 Dollars)
Extraction Wells:	
Design and Construction Oversight	$990,000
Contractor Procurement	$212,000
Construction	$2,827,000
Shoreline Protection System/Improvement:	
Design and Construction Oversight	$3,519,000
Contractor Procurement	$212,000
Construction	$10,054,000
Site Cap:	
Design and Construction Oversight	$1,955,000
Contractor Procurement	$212,000
Construction	$5,586,000
Subtotal	*$25,567,000*
Technical Support and Oversight (Annual)	$743,000

Assuming 5 years of technical support and oversight for project completion (5 years at $743,000 per year), the total construction cost for the remaining components of the containment system is $29.3 million in 2010 dollars. If an upgradient groundwater cutoff wall is included as a component of the containment remedy, this cost would be increased. The cost provided in the 2005 Engineering Evaluation Report for an upgradient bentonite slurry wall (approximately 20 feet deep, 3 feet wide, and 1,100 feet long) was $330,000. In order to adjust the 2005 cost for the upgradient cutoff wall to 2008 costs, the same USEPA cost assumptions used above for the other remedy components were applied to the 2005 cost. These assumptions include a 30 percent increase for construction cost inflation, a cost for design and construction oversight equal to 35 percent of the construction cost and a contractor procurement cost of $100,000[2]. The cost for the upgradient bentonite slurry wall in 2008 dollars is $679,000. In order to adjust the cost from 2008 to 2010 dollars an assumed annual rate of inflation of 3 percent was applied bringing the total cost for the upgradient cutoff wall to $720,000 in 2010 dollars. The capital cost total with the upgradient cutoff wall included would be approximately $30.0 million in 2010 dollars.

3.4.2 Operations and Maintenance Costs

An estimate of operation and maintenance costs for the containment system is provided in the 2005 Engineering Evaluation Report in Table 7-2 (CH2M HILL 2005). The costs cover operation and maintenance of the extraction system, the wastewater treatment plant, the site cap, the shoreline stabilization system, and the groundwater monitoring system. Additionally, costs for replacement of groundwater extraction wells, pumps, and monitoring wells are included in these costs. The costs as reported in the 2005 Engineering Evaluation Report and then adjusted to 2010 dollars using an annual inflation rate of 3 percent are provided in the table below.

USEPA Estimated Costs for Containment Remedy Operations and Maintenance

Item	Estimated Annual Cost (in 2010 dollars)
Containment Operations Includes labor, disposal, re-activated carbon, supplies, power, City water, and polymer	$505,000
Containment Maintenance Includes maintenance for the groundwater treatment plant, extraction wells, site cap, and shoreline protection system, plus replacement and power for the extraction wells and pumps	$180,000
Groundwater Monitoring Includes groundwater sampling and analysis, reporting, monitoring well maintenance and replacement	$172,000
Total Annual Operation and Maintenance Cost	**$857,000**

The annual operation and maintenance cost the State would be required to pay in perpetuity is estimated at $857,000 in 2010 dollars.

3.4.3 Remedy Component Replacement Costs

In addition to the annual operation and maintenance costs in perpetuity, there are also costs associated with periodic replacement of the containment remedy components, such as the groundwater extraction and monitoring well systems, the groundwater treatment plant, and the

2 The USEPA assumption for contractor procurement costs was $200,000 per component for the new extraction wells, the shoreline protection system, and the site cap. As the total cost of the upgradient barrier wall was significantly lower than these other components, a contractor procurement cost of $100,000 was applied to the upgradient barrier wall.

sheetpile wall/shoreline protection system in perpetuity. The site cap may also require periodic replacement depending on the type of cap installed. Maintenance costs for the site cap have been included in the operation and maintenance costs listed above in Section 3.4.2. The State would be responsible for the containment remedy replacement costs.

Replacement costs for the extraction and monitoring well systems have been included in the operations and maintenance costs (refer to Section 3.4.2 above). For the other remedy components, the estimated replacement schedule, discussed above in Section 3.2 would be approximately every 30 years for the groundwater treatment plant and every 50 years for the sheetpile wall. It is uncertain if and how often the site cap would need to be replaced and what the cost would be for this replacement.

The cost for the replacement groundwater treatment plant that was recently constructed in the Former Process Area was $8.2 million based on the bid price from 2007[3]. Assuming an annual increase of 1.3 percent for construction cost inflation[4], the cost for a groundwater treatment plant in 2010 dollars would then be approximately $8.5 million. The cost to install the sheetpile wall in 2000/2001 was $3.7 million[5]. Assuming an annual increase of 7.1 percent for construction cost inflation[6], the cost for this sheetpile wall in 2010 dollars would then be approximately $6.9 million. This cost does not factor in the cost for the shoreline protection system. Potential replacement costs for these two components of the containment remedy are summarized in the table below:

Estimated Costs for Select Containment Remedy Replacement Components

Item	Estimated Cost (in 2010 dollars)
Groundwater Treatment Plant	$8.5 million every 30 years
Sheetpile Wall	$6.9 million every 50 years

3.5 UNCERTAINTIES AND CONCERNS

The greatest concern about the containment remedy at the Former Process Area is that it could be considered an interim remedy, not a permanent solution. The ability for society to operate and maintain the containment remedy effectively for hundreds of years into the future is uncertain. This area contains over a million gallons of highly mobile oily wastes with high concentrations of toxic compounds, which if not removed, will present an environmental risk to Puget Sound in perpetuity. In addition to the higher risk of failure in the long-term for containment, there are concerns on the efficacy and effectiveness of containment at the Former Process Area, given the possibility of hydraulic continuity between the Upper and Lower Aquifers. The uncertainties and concerns with the containment remedy are elaborated on below.

3 Cost information from 2007 Replacement Groundwater Treatment Plant bid from Environmental Chemical Corporation, Contract No. W912DQ-04-D-0017, issued by USA Engineer District, Seattle, March 2, 2007.
4 Annual construction cost inflation rate of 1.3 percent based on the Washington State Department of Transportation construction material cost index data between 2007 and 2010: (http://www.wsdot.wa.gov/biz/construction/constructioncosts.cfm).
5 Cost information from Bay West, Inc. (http://www.baywest.com/cutsheets/seattle%20marc.pdf).
6 Annual construction cost inflation rate of 7.1 percent based on the Washington State Department of Transportation construction material cost index data between 2001 and 2010: (http://www.wsdot.wa.gov/biz/construction/constructioncosts.cfm).

3.5.1 Uncertainties of Long-term Stewardship

With the USEPA containment remedy, creosote must be contained within the Former Process Area for hundreds, if not thousands, of years. The actual length of time containment must be implemented with this remedy depends on how long it would take for most of the over 1 million gallons of creosote to be removed or break down naturally in the subsurface. The rate of creosote degradation is extremely slow (hence its use as a wood preservative) within the NAPL phase, and USEPA's proposed containment remedy would leave almost all of the contaminant mass in place. A calculation to approximate the amount of time required to degrade the bulk of the NAPL mass inside the Former Process Area is included as Appendix B[7]. It is assumed that operation of the containment remedy will occur in perpetuity due to the longevity of the contamination (USEPA 2000a, CH2M HILL 2005). There will be significant costs and resources associated with keeping this containment remedy operating for hundreds of years into the future.

Not only is there a cost to keep the containment remedy operating in perpetuity, but as discussed above under future site conditions (Section 3.2), in order to maintain the effectiveness of the containment remedy, components of the remedy will need to be maintained and periodically replaced in perpetuity as well. This includes the sheetpile wall, the shoreline protection system, the groundwater extraction system, the groundwater treatment facility, the site cap, and the groundwater monitoring system. Operations and maintenance is estimated to cost approximately $860,000 annually (in 2010 dollars), and replacement costs for the various components multiple times over hundreds of years would also yield significant costs. The cost to complete construction of the containment remedy, plus the costs for long-term operation and maintenance and replacement of components will likely exceed $155 million (in 2010 dollars) after only 100 years of operation.

The containment remedy limits the use of the Former Process Area for hundreds of years, as it requires space for treatment equipment, as well as periodic access for maintenance and replacement of the remedy's components. Replacement of a new sheetpile wall approximately every 50 years in this area would halt using this area as a public park during construction. Periodic replacement or significant maintenance of the site cap would also result in significant disruptions to park usage. Integrating the containment remedy into the park design would constrain the design and potential use of the park.

Resources will also be consumed for hundreds of years, such as energy for running the extraction and treatment system. The ability for society to meet these long-term stewardship requirements hundreds of years into the future is fully uncertain.

3.5.2 Concerns Regarding Remedy Effectiveness

The current effectiveness of the containment remedy is uncertain. Evidence exists of leakage pathways as NAPL has already penetrated the Aquitard through localized sand layers within the

[7] The chemicals that comprise creosote, primarily PAHs, break down via biotic and abiotic degradation at extremely slow rates. PAHs are not expected to undergo hydrolysis in the environment due to the lack of hydrolysable functional groups. PAHs with three or more rings in the NAPL phase are extremely resistant to biotic and abiotic degradation even in an aquatic environment.
The calculation provided in Appendix B estimates it would take almost 500 years to degrade low molecular weight PAHs (LPAHs), which make up approximately 85 percent of the total PAHs present in the NAPL. High molecular weight PAHs (HPAHs), which make up the other approximately 15 percent of the total PAHs, would be much slower to degrade relative to the LPAHs, and therefore would last much longer in the subsurface.

Aquitard in the center of the site (refer to Figure 2.4). NAPL was also recently found in the Lower Aquifer in the northeast portion of the Former Process Area and the groundwater elevations in this location indicate there is hydraulic connection between the Upper and Lower Aquifers (CH2M HILL 2009a, 2009b).

Given the heterogeneity of geologic deposits, there are areas of more-permeable materials that connect the contaminated soils in the Former Process Area with Eagle Harbor sediments. The potential for permeable pathway occurrences are seen in the central site area aquitard (at CW-12, refer to Figure 2.4) and are suggested by the matching water level fluctuations in the new wells VG-2U/VG-2L. Data collected during the pilot test also suggests that inflow from the Lower Aquifer is likely through an unidentified hole (or holes) in the Aquitard (USACE 2006). It is difficult to locate and trace all permeable pathways in heterogeneous deposits such as these. The ramification is that there may be preferential pathways for release that are unknown, which further threaten the effectiveness of the containment remedy.

In the center of the site, systematic offsets in geologic contacts that occur between boreholes OB-12 and 99CD-MW02 (shown in Figure 2.4) suggest it is possible that a fault with about 10 to 13 feet of vertical displacement has ruptured the Aquitard in one or two locations. USEPA has also noted this portion of the Aquitard has a serious structural flaw that may be the result of seismic activity (USEPA 2002). Fault rupture surfaces can disrupt the continuity of the Aquitard and create conduits for preferential migration of groundwater and DNAPL. Further discussion of the site’s location relative to earthquake hazards is discussed below in Section 3.5.3.

There is also concern about the integrity of the sheetpile walls. Sheetpile walls can leak through joint seals and/or may not be fully inserted into a low-permeability aquitard. Broad comparisons of the aquitard contours and construction monitoring data indicate that the existing wall was embedded at least 1 foot into the Aquitard; however, a detailed review of embedment depths and stratigraphy by sheetpile has not been completed. Other factors that can affect the embedment integrity of the wall include gravelly layers, which can bend the sheet drive shoes, or cause a false impression that the dense glacial soils comprising the Aquitard have been encountered. It was recently determined that the sheetpile wall is not inserted into the Aquitard in the southeast corner of the Former Process Area, as the Aquitard is not present in this area.

Even with hydraulic containment in place, DNAPL can be and is found to continue to migrate downward or through more permeable pathways. A large DNAPL volume/mass provides a degree of risk for significant migration of DNAPL over a very long period of time. At some point the contaminant mass (for more mobile chemicals like naphthalene) may reach equilibrium in the Lower Aquifer such that the sediments no longer adsorb the migrating chemicals and contaminant breakthrough to the sediment surface could occur.

It will be very difficult to monitor remedy effectiveness due to the existing conditions. A large amount of NAPL already exists outside of the Former Process Area in the marine environment at depth, so it will be difficult to know if a contaminant occurrence is due to a recent release or a past release. Likewise, as contamination has already been identified in the Lower Aquifer beneath the Former Process Area, it will be difficult to know when and where a release may be occurring. Monitoring of the Lower Aquifer has only recently begun and only one sampling event has been conducted with the newest suite of monitoring wells placed on the boundary areas of the Former Process Area.

3.5.3 Long-term Risks of Failure

The containment remedy relies on maintaining the physical containment and hydraulic containment system in perpetuity. If either the physical or hydraulic components of the system fail, contaminants would migrate into the harbor sediments and eventually surface on the harbor floor. Given the large amount of creosote present in the harbor sediments, there is limited ability for contaminants migrating from the Former Process Area to attenuate before discharging to the harbor. Contaminant transport modeling has confirmed the potential for releases of the major chemicals comprising the NAPL without containment (URS Greiner and CH2M HILL 2004). Without the physical containment structures (the sheetpile wall, the low-permeability cap, and the upgradient cutoff wall), pumping would not be able to reliably capture contaminated groundwater. If just the physical containment structures are in place and no pumping is performed, groundwater leakage into the area via upland recharge and precipitation would force contaminated groundwater out of the Former Process Area downward (through the Aquitard) and laterally (through sheetpile joints or areas where the sheetpile is not imbedded in the Aquitard). This creates the need for a continuous groundwater extraction system to prevent additional contaminant migration to the harbor sediments and the surface water. Because there is substantial and widespread sediment contamination present in sediments outside of the Former Process Area, it is not possible to accurately monitor containment effectiveness within the Former Process Area. This creates the potential that the remedy could fail without being recognized and corrected.

Creosote has already migrated through the Aquitard and into the Lower Aquifer. In the absence of significant source reduction, additional creosote migration to the Lower Aquifer is likely to continue for many years even during active containment, because the downward movement of creosote is not halted by the groundwater extraction system. As described above, substantial levels of contamination in harbor sediments will make it difficult to monitor the impact to sediments and surface water of uncontrolled creosote migration to the Lower Aquifer.

In its 20 years of life the groundwater extraction system has shown itself to have frequent operational problems, and has been replaced twice. There have been months when the entire system is off-line, frequent pump and pipe repairs needed, and there are currently plans to completely overhaul the wells and pumps. It is likely that frequent well redevelopment, pump replacements, and well replacements will be needed to optimally operate an effective extraction system.

Over the long-term, a large earthquake could result in a failure of the containment remedy and possibly result in a significant and potentially catastrophic release of creosote to the environment. Seismic hazards can come from regional and local sources. New local and regional studies suggest that seismic hazards at the Wyckoff Site are significantly greater than those incorporated into past and current design codes (Kelsey et al. 2008).

Earthquakes from the Cascadia subduction zone occur on the order of every 500 years (the last one was 300 years ago) and are associated with several minutes of strong shaking. In addition to the Seattle fault (described below), there are several other active shallow crustal faults in the Puget Lowland including the Hood Canal fault, Tacoma fault, Olympia fault, and Southern Whidbey Island fault that are capable of producing strong shaking and other seismic hazards at the Wyckoff Site.

The Wyckoff Site lies within the zone of active deformation (folding and faulting) associated with the Seattle fault (Haugerud 2005). The Seattle fault has ruptured about every 1,000 years or less during the late Holocene (the last was 1,100 years ago). An earthquake on the Seattle fault would cause very strong shaking for up to a minute or more. This type of shaking can cause surficial ground ruptures, liquefaction and lateral spreading of sediments, and subaerial and submarine landslides. One mapped Holocene fault lies less than ½ mile south of the site with two more present within 2 miles of the site (Haugerud 2005).

A large earthquake could further affect the integrity of the Aquitard and the perimeter containment system. It is unlikely that the current sheetpile containment wall has been designed to retain the existing integrity of the system against major seismic activities. However, no formal earthquake or geotechnical evaluation of the containment remedy has occurred to date.

Over the long-term, shoreline erosion coupled with a rise in water level[8] is expected near the Former Process Area. The potential increase in waterfront development on Bainbridge Island may have the long-term effect of reducing sediment available for transport and beach nourishment. Decreasing sediment supply can result in accelerated erosion of beaches. Beach erosion and increased wave action could require that significant modifications would need to be made to the containment remedy in hundreds of years.

In summary, there are significant concerns with the protectiveness of the proposed containment remedy. The 2000 USEPA ROD selected thermal remediation as the appropriately protective remedy for the Former Process Area, stating that a containment strategy has no defined endpoint and the pump and treat system would have to be operated and maintained in perpetuity to maintain the integrity of the containment option and to prevent migration of contaminants into Eagle Harbor. The ROD also stated that a containment alternative presents a risk of failure or need for replacement over the very long-term (USEPA 2000a). The Generational Remedy Evaluation supports this perspective.

[8] Potential sea-level rise in Puget Sound over the next 100 years is estimated at approximately 13 inches above current mean sea level (medium estimate of change), with a low probability of a very high potential sea level rise of 50 inches (University of Washington Climate Impacts Group and Ecology 2008).

4.0 Generational Remedy Alternatives

The Generational Remedy Evaluation process has resulted in the identification of multiple remedial options for the Former Process Area, which are viable and remove, treat, and/or immobilize the NAPL currently contained within this area. These generational remedy options would significantly reduce the risk of a large-scale release of contamination, the costs for long-term operations and maintenance, and the need for rebuilding the remedial components over time. These generational remedy options also allow for more options in future design and use of the site as a park, as planned by the City and Park District. These options are capable of meeting all of Ecology's guiding principles for a Generational Remedy, briefly noted above, and presented in the Generational Remedy Evaluation Project Objectives document included as Appendix A (Ecology 2009).

This section of the report describes three possible generational remedy alternatives that could be applied within the Former Process Area. Each of these alternatives addresses remediation of the entire Upper Aquifer contained within the Former Process Area. These three alternatives are not the only generational remedy options available for this area, but they provide an idea of the most promising current technologies that could be implemented to reduce or remove contamination within this area. Other combinations of the ideas put forth in these three alternatives could also be considered.

The development of potential generational remedy alternatives through this Generational Remedy Evaluation process is described below, followed by conceptual level descriptions of the three generational remedy alternatives that were selected for further evaluation and costing. This section of the report also presents a comparison of the three generational remedy alternatives described here and a summary of how each of these alternatives meets the generational remedy guiding principles.

4.1 DEVELOPMENT OF THE ALTERNATIVES

4.1.1 Expert Panel Formation

The Generational Remedy Evaluation process began with the development of the Generational Remedy Evaluation Project Objectives by Ecology and the steering committee in fall 2009 (Ecology 2009). Following the development of these objectives, Ecology and its consultants for the Generational Remedy Evaluation process, Floyd|Snider and Aspect Consulting, formed a panel of eight technical experts to assist with the identification and evaluation of innovative alternatives that focused on source removal or mobility reduction of the contamination within the Former Process Area.

The expert panel selection process began with identifying potential technical candidates to contact from around the United States and Canada. The initial list of potential candidates was generally based on recommendations from colleagues, identification of companies or individuals with prior experience on wood-treatment sites or with coal tar NAPLs, people that have participated on DNAPL remediation panels or workgroups in the past, people that provided input on the Wyckoff Site in the past by participating on the USEPA's In-Situ Thermal Technologies Advisory Panel (ITTAP), and people that have experience on large construction projects in challenging or constrained environments. Everyone on the initial list was sent a letter from Ecology that described the Generational Remedy Evaluation process, the role of the expert panel in the process, and an invitation to submit a letter of interest with a statement of qualifications. Follow-up calls were made to each person on the initial list of candidates to help identify other potential candidates. Multiple recommendations for additional potential candidates were received during these calls and Ecology's letter was distributed to these recommended individuals.

This candidate identification process was broadened by inviting various organizations (e.g., Northwest Environmental Business Council (NEBC) and Interstate Technology and Regulatory Council (ITRC)) to post a short announcement describing the formation of the expert panel on their websites or on their list-serves as a way to reach other interested parties. A short announcement was posted to multiple list-serves through this effort. Interested parties were provided with Ecology's letter.

A total of 43 submittals were received by the deadline from a variety of vendors, contractors, consultants, and academics. The following general criteria were used in selecting eight panelists from these submittals:

- Create a panel that included experts with a variety of experiences and perspectives from a mixture of different fields.
- Create a panel of experts that were able to speak on multiple potential technologies and alternatives for the site, preferably from direct experience with creosote, wood treating, and/or manufactured gas plant (MGP) sites.

The eight expert panelists selected by Ecology, with input from their consultants and the steering committee, comprised the following individuals:

- Ralph Baker, Ph.D., TerraTherm, Inc., Fitchburg, MA—Co-founder of a firm specializing in in-ground remediation technologies to treat contaminated soil and water. Over 30 years experience using thermal remediation, thermochemical solidification, soil vapor extraction, and air sparging.
- Michael D. Basel, Ph.D., P.E., Haley & Aldrich, Inc., Lenexa, KS—Over 20 years experience in the private sector, applying innovative technologies for remediating wood-treatment facilities. Focused on thermal technologies as well as chemical oxidation, enhanced biodegradation, free product recovery, and extraction technologies.
- Eva L. Davis, Ph.D., U.S. Environmental Protection Agency, Ada, OK—Leads USEPA work group on effectiveness of containment remedies for sites with NAPLs, such as the Wyckoff Site. Experienced in a range of thermal remediation techniques, including evaluation of the earlier Wyckoff thermal remediation pilot study effort.
- Edward C. Hicks, P.E., Black & Veatch, Alpharetta, GA—With 24 years experience in engineering design and construction, Mr. Hicks' focus on remediation of sites with challenges similar to the Wyckoff Site have made him an expert on all aspects of construction and maintenance, including excavation, pumping, and solidification. He has current field experience with two wood preserving sites in USEPA Region 4.
- Michael C. Kavanaugh, Ph.D., P.E., B.C.E.E., Malcolm Pirnie, Inc., Emeryville, CA—Decades of experience in environmental engineering provides Dr. Kavanaugh with deep knowledge in remediation, including work on three wood-treatment facilities and numerous other challenging sites. He teaches a course on soil and groundwater

remediation through the Princeton Remediation courses, and co-chaired a USEPA panel on removing DNAPL source areas.

- Frank B. Kellogg III, DCI Environmental, Inc., Savage, MN—Mr. Kellogg's firm focuses on source removal at remedial sites, using batch-plant thermal treatment, including application to at-depth DNAPL. Recently, he used DNAPL degradation and accelerated recovery at a USEPA demonstration program at the Ashland Superfund site.
- Ken Preston, General Construction Company, Seattle, WA—Bringing over 30 years experience in construction in marine and near-shore environments, Mr. Preston addresses options for physical removal and/or physical containment of contaminated material. As a Bainbridge Island resident and long-time contractor in the region, he has considerable familiarity with site conditions.
- Kent S. Udell, Ph.D., University of Utah, Salt Lake City, UT, and (Emeritus) University of California, Berkeley, CA—Dr. Udell advised USEPA on innovative thermal technologies as part of an early 1990s advisory panel, and brings broad experience nationally in remediation of DNAPLs, thermal technologies, and a focus on long-term heat and mass transfer in porous media, relevant to the generational fate of creosote products at the Wyckoff Site.

4.1.2 Expert Panel Workshop

The eight technical expert panelists were brought together January 12-14, 2010 for a three-day workshop on Bainbridge Island to explore and advise Ecology on potential effective generational remedy alternatives for the Former Process Area. Participants in the workshop included the expert panelists, the steering committee, Ecology, and Ecology's consultants. The community was also invited to attend the workshop.

The first day of the workshop the expert panelists presented their perspectives for how to remove the contamination source or reduce the mobility of contaminants within the Former Process Area. The second day of the workshop focused on the participants identifying, evaluating, and brainstorming conceptual level generational remedy alternatives. The conceptual alternatives developed on the second day were presented by the expert panelists at a community meeting held by Ecology that same evening (for additional information refer to Section 4.1.3). The last day of the workshop included further discussion of remedial alternatives, as well as discussions on how to move forward to complete the Generational Evaluation Process and identifying items requiring further evaluation. To provide a record of the primary input received from the expert panelists and other participants, a summary of the expert panel workshop was prepared (Floyd|Snider 2010).

During the workshop, there was agreement from the expert panelists that there are multiple potential generational remedy alternatives that could be applied within the Former Process Area. Conceptual level alternatives and applicable technologies are presented in detail in the Expert Panel Workshop Summary (Floyd|Snider 2010). The alternatives identified by the experts used a combination of in-situ thermal treatment, excavation and ex-situ thermal treatment, and stabilization to address the majority of the creosote contamination within the Former Process Area. Other treatment technologies, such as DNAPL recovery and bioremediation, were discussed but not identified as potential primary treatment technologies because they were not expected to greatly reduce the time to restore the area and would require long-term operation and maintenance, similar to the containment remedy.

The expert panelists agreed that the Aquitard underlying the contamination is imperfect and heterogeneous, and at a minimum, the Aquitard would need reinforcement in order to contain all the NAPL within the Upper Aquifer over the long-term. Ideas put forth by the expert panelists for better containment of the contamination included an upgradient groundwater barrier wall, jet grouting of the Aquitard where there are known holes or pathways, an impermeable site cap, and an improved perimeter barrier wall. Significant site uncertainties were raised during the workshop that question the functionality of a long-term containment remedy.

4.1.3 Community Involvement

A key goal for the General Remedy Evaluation was to involve as many interested community members as possible in the discussions, and to use a range of information-sharing tools to allow the community convenient access to the process, and the opportunity to provide their perspectives. The steering committee was involved in determining appropriate methods for informing and involving the public, and participated in community activities. Ecology engaged EnviroIssues to assist in developing information, structuring and facilitating community events, and analyzing community questions and input for consideration in the Generational Remedy Evaluation process. The materials developed as background for the experts, the results of the expert panel workshop, and steering committee materials and documentation, are all available on the project website (www.ecy.wa.gov/programs/tcp/sites/wyckoff/wyckoff_hp.htm). Two community meetings were held by Ecology to provide the community with information on the evaluation process, remedial options being considered, and the long-term advantages of implementing a generational remedy over the planned containment remedy. The community meetings were broadly publicized through project and community organization websites, posters in the community, display advertisements in local newspapers, mailing and e-mailings to identified distribution lists, ferry announcements, local access cable station, and media releases. The details regarding community involvement in the Wyckoff Generational Remedy Evaluation are included in Appendix C.

The first community meeting was held in January 2010, in conjunction with the expert panel workshop. Remedial options for the site that were developed during the workshop were presented to the attendees by the expert panelists. The attendees were able to ask questions about the alternatives presented and the evaluation process and were able to talk directly with the expert panelists about these remedial options. Comments received from the community were considered in the development of alternatives. The second community meeting was held in late March 2010 to provide details on the development of the three Generational Remedy Alternatives selected by Ecology for further evaluation following the expert panel workshop, as well as additional information on the evaluation process and objectives. Attendees were invited to ask questions and provide their input verbally, through comment forms, or through an online comment mechanism. Community meeting summaries were prepared for both of these events to document the meeting discussion and to capture input that was received from the community (EnviroIssues 2010a and 2010b, included in Appendix C). Questions that were frequently heard were added to the website with Ecology's responses (refer to Appendix C).

4.1.4 Overview of the Generational Remedy Alternatives

Ecology and their consultants selected three remedial alternatives to further document and cost in this report, based on input received from the expert panelists during the expert panel workshop. These three generational remedy alternatives include the following:

- **In-situ thermal treatment.** This alternative would heat in place all contaminated soil and groundwater within the Former Process Area in order to mobilize and remove subsurface contamination.
- **Excavation and ex-situ thermal treatment.** This alternative would excavate all contaminated soil within the Former Process Area and treat it on-site using heat to destroy the contaminants. Treated soils would be placed back into the excavated area.
- **Shallow excavation and ex-situ thermal treatment with in-situ thermal treatment or stabilization at depth.** This alternative would excavate and thermally treat shallow contaminated soils on-site. Below the excavated area, the deeper contaminated soils would be treated in place using either in-situ thermal treatment, similar to the first alternative listed above, or by immobilizing the contamination through mixing of contaminated soils with cement and binding agents.

These three generational remedy alternatives are described in more detail in the following sections (Sections 4.2 through 4.4) at a conceptual level of design. Further detailed consideration and additional analyses would be required before any of these alternatives could be evaluated fully or implemented. At a conceptual level, each of these alternatives is implementable within the Former Process Area and each one meets the guiding principles of a Generational Remedy (the guiding principles are included in Appendix A). Each alternative significantly reduces the environmental risk of a future release from the site and none of these alternatives will require the long-term pumping and treatment of groundwater following implementation.

There is no hierarchy in the order in which the three alternatives are presented in the report.

4.2 ALTERNATIVE 1—IN-SITU THERMAL TREATMENT

In Alternative 1, contaminated soil and groundwater within the Former Process Area would be heated in place. Heating would significantly increase the mobility of contaminants, which would then be removed from the ground and destroyed or disposed of off-site. Heating would be applied to the area of soil containing creosote inside the existing sheetpile wall (approximately 9 acres), from the ground surface to the base of the Lower Aquifer (maximum depth of approximately 80 feet). The total soil volume to be treated is approximately 650,000 cubic yards.

This alternative would remove most of the mass of contamination[9]. After treatment is completed, soil containing residual contamination, consisting of primarily adsorbed high molecular weight

[9] In-situ thermal remediation within the Former Process Area is based on the use of high pressure steam combined with thermal conduction heating to strip the creosote from the Upper Aquifer. In-situ thermal remediation has been found to be effective in removing the majority of the LPAHs from creosote, along with some of the HPAHs. Since the LPAHs comprise approximately 85 percent of the total PAHs (a primary component of the creosote), this results in significant mass removal. Thermal remediation decreases the overall amount of creosote in the soil pores to less than the residual saturation point, so that the creosote can no longer flow under gravity, and removes the

polycyclic aromatic hydrocarbons (HPAHs) (which are poorly soluble in water), would be covered with imported clean soil. The Former Process Area would be graded to slope towards the beach and the top portions of the containment walls would be cut off to below ground surface. The subsurface portions of the containment walls left in place would prevent recontamination of the Former Process Area from adjacent contaminated sediments. These walls would not need to be replaced over time.

Under this alternative, active thermal treatment is expected to take approximately 5 years, but the treatment time could range between 3 and 10 years, depending on the availability of power and the rate of heating. After heating is completed, the Former Process Area could be restored to partial use, with limited activity to continue to treat groundwater while the area cools down (2 to 5 years). Complete implementation and restoration of the Former Process Area would occur in approximately 7 to 20 years, depending on the availability of power.

The conceptual level of design cost for this alternative is estimated to range from $96 million, without contingencies, to $123 million, with significant contingencies.

This alternative would meet the Generational Remedy Objectives as follows:

- Removes most of the contaminants (the thermally strippable contamination), including creosote and its volatile and leachable constituents
- Eliminates the need for long-term operation and maintenance of an active pumping system
- Eliminates the risk of future releases of contaminants from the Former Process Area
- Allows use of the Former Process Area to its full potential in less than one generation

The conceptual design of this alternative, including construction and treatment methods, schedule, and costs, is described in detail below.

4.2.1 Alternative Components

This alternative involves three primary components:

- A heating system to heat contaminated soil and groundwater
- A fluid extraction and treatment system to remove creosote and contaminated vapor and groundwater and destroy contaminants
- A hydraulic and thermal control system to minimize the entry of cool water into the treatment area and to prevent migration of contaminants out of the treatment area

These components are described below. Plan and profile views of conceptual alternative components are illustrated on Figures 4.1 and 4.2, respectively.

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water soluble PAHs, resulting in a residual of the more insoluble PAHs. Once the soil has cooled following treatment, the residual insoluble PAHs are adsorbed to the soil and are poorly soluble in groundwater.

A treatability study completed by the USEPA that examined the use of steam injection for NAPL recovery on the Wyckoff Site, determined that steam injection alone would recover significant amounts of the creosote in the subsurface (Davis 2002).

4.2.1.1 Soil and Groundwater Heating

Soil and groundwater within the Former Process Area may be heated using a number of methods including the following:

- Injection of steam into the subsurface through wells
- Thermal conduction heating, in which electric heaters are installed in wells and heat travels outward from the well
- Electrical resistive heating, in which voltage is applied to subsurface electrodes and the electrical resistance of the soil creates heat

Steam is typically the cheapest method of heating, particularly in permeable soils. Steam also physically displaces creosote from soil, leading to better creosote recovery. Thermal conduction using electrical heaters is more expensive than steam but distributes heat more evenly than steam in heterogeneous soils. Electrical resistivity is often more effective than steam in low-permeability soils, but is inefficient at sites where resistivity is low or where soils are coarse. Low resistivity is expected in some areas of the Former Process Area where saline groundwater is present.

The conceptual design for in-situ thermal treatment at the Former Process Area previously developed by the USACE called for steam injection, supplemented with thermal conduction heating in areas where steam effectiveness may be low (e.g., in the Aquitard and near the base of the Upper Aquifer). At the Generational Remedy Evaluation Expert Panel Workshop, the expert panelists indicated that a combination of steam injection and thermal conduction wells would be the most cost-effective design to achieve the generational remedy objectives.

The soil heating system would include the following:

- A steam plant, to generate steam that is injected into the ground
- Steam injection wells and piping from the wells to the steam plant
- Thermal conduction wells containing electric heaters

A preliminary estimate by a thermal remediation vendor indicated that approximately 320 steam injection wells, spaced approximately 40 feet apart, and 750 thermal conduction heating wells, spaced approximately 25 feet apart, would be required to heat the Former Process Area. Spatial and temporal progress of the subsurface heating would be monitored with a network of approximately 175 temperature monitoring points (Baker 2010a). A photograph of a typical well and piping network for thermal remediation is provided in Figure 4.3.

A preliminary estimate for the energy required to heat the soil above the Aquitard in the Former Process Area using thermal conduction heating is approximately three megawatts for a five year period, or 1.3×10^8 kilowatt-hours (Baker 2010a). The preliminary estimate for the energy required for steam generation within this area is approximately 8.8×10^7 kilowatt-hours. Faster treatment could be provided if more energy is available, and because of a reduced time for heat loss to occur, would consume less overall energy. For this alternative, it is assumed that heat for thermal conduction heating would be supplied using available electricity from the grid and that steam generation would be supplied using propane.

Electrical energy could be supplied either from the electrical grid, from an on-site generating plant fueled by propane, diesel, or biomass, or from a combination of these. Based on data from

Puget Sound Energy[10], sufficient electrical capacity from the grid is available most of the year except during periods of unusually cold weather[11]. A "smart" controller for the in-situ heating system could temporarily reduce power use during peak community demand without significantly lengthening the treatment duration. Using electrical energy from the grid for the thermal conduction heating would avoid capital costs for constructing a temporary electrical power generating system on the property.[12] Electricity could also be used for steam generation, but burning fuels such as propane, diesel, or biomass is typically more efficient for generating heat compared to electricity.

4.2.1.2 Fluid Extraction and Treatment System

The heating system described above would heat contaminated media to the boiling point of water[13]. At this temperature, the viscosity of creosote decreases, the solubility of creosote in groundwater increases, and volatile compounds are vaporized and partition into the steam that sweeps through the soil (i.e., "steam stripping"). Contaminants would then be removed by pumping vapors and liquids from extraction wells in the treatment area. The extraction and treatment system would include the following:

- Extraction wells with pumps to extract creosote, groundwater, and vapors.
- Heated piping from the wells to a treatment plant.
- A treatment plant to separate and treat contaminated fluids, as follows:
  - Creosote would be disposed of off-site.
  - Vapors would be treated by a propane-fueled thermal oxidizer.
  - Groundwater would be treated using activated carbon sorption and discharged. Spent activated carbon would be regenerated or disposed of off-site.

A preliminary estimate indicates that approximately 115 vapor extraction wells, 95 steam extraction wells, and 40 multi-phase extraction wells may be required over the Former Process Area (Baker 2010a).

The existing treatment plant could likely be used to separate and treat creosote and contaminated groundwater. The groundwater flow rate extracted during thermal treatment is expected to be less than the 70 gpm capacity of the existing treatment plant[14]. Modifications to

[10] Average electricity demand on Bainbridge Island is approximately 30 MW, but can vary between 16 and 80 MW throughout the year (based on Puget Sound Energy load data from June 2008 to March 2010; Rehm 2010).

[11] Large spikes in energy demand occur on Bainbridge Island when temperatures drop below 25 degrees Fahrenheit (Puget Sound Energy FAQ for Bainbridge Island (March 2010), http://www.pse.com/community/yourneighborhood/Pages/KitsapCounty2.aspx).

[12] Capital costs for an electricity generating plant within the Former Process Area could be offset by continuing to operate the plant for power generation and selling power to the community. However, this option was not included since a power plant may not be consistent with the planned future site use as a park.

[13] Thermal conduction heating has been used at other sites to reach temperatures greater than the boiling point of water and achieve more complete removal/destruction of high-molecular weight contaminants; however, the ability to achieve this level of heating in a cost-effective manner at this location is questionable and was not recommended by either the earlier design panel or the most recent expert panelists.

[14] Flow rates will be based on maintaining an inward and upward gradient while thermal treatment is occurring (currently flow rates with the containment remedy are about 35 gpm on average), removal of mobile contamination, and from the relatively small volume of water added by steam injection. Hydraulic control improvements for this alternative, discussed in Section 4.2.1.3, will also decrease the volume of groundwater requiring extraction to maintain an inward and upward gradient.

the plant would be necessary to accommodate changes in the influent[15] under heated conditions.

4.2.1.3 Hydraulic and Thermal Control during Treatment

During in-situ thermal treatment, controls would be implemented to reduce heat loss resulting from the inflow of cold groundwater into the treatment area and to prevent migration of contaminants outside the treatment area. Contaminant migration would be controlled by maintaining an inward gradient with the groundwater extraction system described above. Additional containment measures would be implemented to control heat loss as described below.

For thermal treatment to be effective, heat loss from the treatment area must be controlled. The energy used to achieve and maintain treatment temperatures is a significant portion of the technology cost, and high rates of heat loss can result in very high operating costs and energy usage. Furthermore, if heat losses are too large, target temperatures may not be maintained.

The primary uncertainty in regulating heat is the rate of groundwater flow into the treatment area. As described in Section 3.0, some leakage past the existing sheetpile wall occurs, and without enhancement of this wall, groundwater exchange during tidal cycles would act as a heat sink. To reduce potential heat losses, this alternative includes several containment measures not currently installed at the Former Process Area.

Components for hydraulic and thermal control would include the following:

- Contaminated groundwater would be extracted at a sufficient flow rate to maintain a net hydraulic gradient into the treatment area.
- A low-permeability surface cap would be installed over the treatment area to trap vapors, minimize heat loss, and reduce rainwater infiltration.
- An improved perimeter barrier wall would be installed just inside the existing sheetpile wall. Several construction methods for this wall are possible, including slurry wall and secant wall techniques. For the purposes of this report, it is assumed that the wall would be composed of a series of overlapping columns (i.e., a secant wall) that are drilled with a large-diameter auger drill. The columns would be imbedded into the Aquitard to form a continuous barrier. The wall could be composed of cement or a mixture of cement and bentonite clay to further reduce its permeability.
- The perimeter barrier wall would be extended along the south edge of the treatment area as necessary to key into the Aquitard. This would reduce groundwater inflow from the area upland of the Former Process Area. The wall would include a drainage system on the upgradient side to relieve hydraulic pressure. Because the depth to the Aquitard is relatively shallow in this area, these segments of the wall could be constructed by less expensive techniques (e.g., excavating a trench and backfilling with bentonite slurry) than the secant wall along the shoreline. The alignment of the perimeter barrier wall along this southern border would be based on additional investigation into the location of the Aquitard in this area.

[15] For instance, higher temperatures requiring cooling and increased loading of contaminants.

- Groundwater exchange through the Aquitard could be reduced by two methods: sealing the portions of the Aquitard with leaks by jet-grouting (i.e., focused injection and mixing of cement to "plug" holes), or by maintaining a "hot-floor" by extending heater wells into the Aquitard. For the purposes of this evaluation, it is assumed that the "hot-floor" method would be implemented to reduce exchange across the Aquitard.

Heat losses at the edge of the treatment area along the shoreline may also heat sediment adjacent to the Former Process Area. Based on the USACE Thermal Pilot Study, elevated temperatures may extend several feet past the treatment area. If creosote is present in the sediments at the time of treatment (i.e., at the East Beach), elevated temperatures could increase the mobility of creosote. To mitigate this concern, the secant wall described above would be constructed several feet thick to act as an insulator to minimize increasing temperatures outside the wall.

4.2.2 Site Restoration

Heating, extraction, and treatment would continue until treatment objectives are achieved (i.e., the removal of the thermally strippable NAPL from the Former Process Area). Some components of creosote that are insoluble and have boiling points much higher than water, such as HPAHs, would remain in place after treatment. These compounds would be adsorbed to soil or would remain within a matrix of residual creosote with minimal leachability (Baker 2010b). Residual contamination would be characterized by post-treatment soil sampling. There is the potential that some level of continued leaching of contaminants from the soil to groundwater could occur following treating; however, groundwater leaving the Former Process Area is expected to be at levels protective of water quality and sediment at the mudline following implementation of this alternative. Long-term pumping and treating of groundwater is not expected to be necessary.

At the end of the treatment period, the treated soil and groundwater would take approximately 2 to 5 years to cool down (Baker 2010a). During this period, extraction and treatment of contaminated groundwater would continue since continued leaching of higher molecular weight contaminants is possible as long as groundwater temperatures are elevated. Groundwater treatment would cease after the Former Process Area has cooled to ambient temperatures. Since residual contamination would be left in the treated soil, a soil barrier would be placed above the treated soil to prevent uncontrolled human contact. After cooling down, the Former Process Area would be restored as follows:

- Heating and extraction wells would be decommissioned.
- Aboveground piping, the treatment plant, and steam generation plant would be removed.
- The top portions of the sheetpile wall and the improved perimeter wall would be cut down to below ground surface[16] and the Former Process Area graded to slope towards the beach and to minimize erosion. Soil behind the walls near the shoreline would be placed further upland, in a manner that meets regulatory requirements. Alternatively, a shoreline revetment may be installed to control erosion and reduce the amount of grading.

[16] The sheetpile wall could be cut down after the secant wall is installed if the design of the secant wall and low-permeability cap allows. This could improve the aesthetics of the beach area during the treatment period.

- The low-permeability surface cap would be removed and replaced with a permeable soil cap that meets regulatory requirements[17].

Creosote that has already migrated into or through the Aquitard may remain in place after treatment. However, creosote in the Aquitard would be decreased by use of the "hot floor" during the in-situ thermal remediation treatment. During treatment, removal of some of the thermally strippable contamination in the Aquitard would have the effect of decreasing its mobility as a NAPL by increasing its viscosity and would also decrease its impact on groundwater by removing the more soluble components. Additionally, by removing the vast majority of the creosote above the Aquitard, the risk associated with potential migration and leaching of contaminants from the Former Process Area would be greatly reduced. The subsurface containment structures (sheetpile wall and secant wall) would remain in place, to provide passive containment of these treated soils, as well as to prevent the recontamination of the treated soil from the adjacent contaminated sediments.

Cleanup remedies that leave contaminated material in place typically require a confirmation monitoring program to demonstrate that the remedy is protective. After completion of treatment and restoration of the Former Process Area, groundwater monitoring would continue to confirm the effectiveness of the remedy and demonstrate that residual contamination beneath the Former Process Area does not present a future threat for discharge to Puget Sound. It is not known what the conformational monitoring network would look like following treatment; however, it would likely have a minimal impact on park development within the Former Process Area.

4.2.3 Uncertainties

When in-situ thermal treatment was originally proposed within the Former Process Area in the 2000 ROD, it was considered an emerging technology. The results of the thermal pilot study conducted at the Former Process Area in 2003 indicated that significant contaminant removal was possible, but the test was truncated prematurely due to funding constraints and major equipment problems, as described in Section 2.1.3.1 (USACE 2006).

A recent review of this technology indicated that in-situ thermal treatment has been implemented at 182 sites, with approximately half of those projects conducted in the last 10 years (Basel 2010). At the Generational Remedy Evaluation Expert Panel Workshop, the expert panelists with experience in applying thermal remediation regarded in-situ thermal treatment as a likely method of achieving the Generational Remedy Objectives.

Uncertainties in this remedy include the following:

- **Availability of power.** Based on discussions during the Generational Remedy Evaluation Expert Panel Workshop, it appears that sufficient power to implement this remedy is available on the grid when coupled with smart controllers to maximize efficient energy use. However, the schedule and total energy use depends strongly on how much power is available. With an adequate power supply, the treatment time for this remedy could be shortened by as much as 8 years. Additional research needs to be conducted to more accurately determine power availability, power sources, and project schedule.

[17] It may be possible to leave portions of the low-permeability surface cap in place, depending on specific design details and grading of the future park.

- **Nature of residual contamination.** Based on post-treatment monitoring at other thermally-treated sites, even when the vast majority of mass is removed there is the potential for small pockets of creosote to remain (Davis 2010). It is also possible that some leachable pentachlorophenol may remain after treatment (Udell 2010). However, a USEPA study on DNAPL remediation sites indicates that cleanup goals have been successfully met using in-situ thermal remediation treatment on other wood-treatment sites (USEPA 2009). It is not expected that localized residual contamination would require active treatment; rather, that natural attenuation of groundwater would be protective of the marine environment. Furthermore, the barrier wall would remain in place after implementation, providing passive containment of soil within the Former Process Area.

4.2.4 Schedule

Implementing this alternative would take approximately 7 to 20 years from initial design to complete site restoration, as follows:

Component	Schedule in Years
Design	1 to 2
Construction	1 to 2
Operation—Thermal Treatment	2 to 10
Operation—Cool Down	2 to 5
Site Restoration	1

Figure 4.4 includes a timeline for this alternative.

4.2.5 Community Impacts

This alternative would benefit the community by allowing full use of the Former Process Area for a park in less than 20 years and by greatly reducing the risk of future releases from this area. At the end of the cool down period, all remediation structures and equipment, including the aboveground portion of the sheetpile wall, would be removed. In addition, long-term activities are anticipated to be limited to groundwater monitoring.

Potential community concerns during construction and operation of the treatment system may include the following:

- Noise during construction, including: drilling of more than 1,300 new wells, drilling and trenching to install barrier walls, installation of the surface cap, and construction of the steam plant and treatment system.
- Noise from operation of the steam plant during thermal treatment and from operation of the treatment plant during thermal treatment and the cool down phase.
- Noise from site restoration construction activities, including: removal of the thermal treatment system infrastructure, cutting down the barrier walls to mudline, regrading the area, and placement of the soil cap.
- Traffic from construction equipment, delivery of propane for the steam plant and the vapor treatment system, removal of recovered creosote, and soil brought to the site for site restoration.

- Visual impact of surface cap and aboveground piping and equipment covering the Former Process Area during the treatment period and the cool down phase.
- High electrical demand during operation.

4.2.6 Costs

The overall cost for this alternative is estimated to range from $96 million to $123 million. These are conceptual levels costs, where the cost for $96 million does not include any contingencies and the cost for $123 million includes significant contingencies (refer to Appendix D). It is assumed that there are no long-term active operations and maintenance costs for this alternative. Costs for groundwater monitoring following implementation of this alternative are not included.

Estimated costs for individual elements of this alternative, with and without contingencies, and tax are summarized in the table below. Supporting cost information is included in Appendix D.

Alternative 1 Costs

Element	Estimated Cost (in Millions)
Construction Costs	
Secant Wall	$9.5 to $12.3
Upgradient Cutoff Wall	$0.2 to $0.3
In-situ Thermal Treatment System	$19.1 to $24.8
Groundwater Treatment Plant (Upgrade Existing Plant)	$2.0 to $3.0
Low-permeability Cap	$3.2 to $3.7
Operating Costs	
Thermal Heating and Treatment Systems	$37.9 to $47.4
Treatment Plant During Cool Down Period	$1.2 to $1.5
Creosote Disposal	$1.2 to $1.6
Restoration Costs	
Site Restoration	$1.5 to $2.1
Well Decommissioning and Equipment Removal	$4.0 to $5.3
Permeable Cap	$1.2 to $1.6
Design, Permitting, and Site Preparation Costs	
Design and Construction Oversight	$5.1 to $6.6
Permitting	$1.7 to $2.2
Site Preparation	$0.1 to $0.2
Tax	
9.5%	$8.4 to $10.7

4.3 ALTERNATIVE 2—EXCAVATION AND EX-SITU THERMAL TREATMENT

In Alternative 2, contaminated soil within the Former Process Area would be excavated and treated aboveground by heating the soil up to 1,100 degrees Fahrenheit (°F). The excavated area would be backfilled with the treated soil.

The area of soil to be excavated includes the area containing creosote inside the existing sheetpile wall (approximately 9 acres), from the ground surface to the base of the Upper Aquifer (maximum depth of 80 feet). The total excavated soil volume would be approximately 650,000 cubic yards.

This alternative would destroy both mobile and immobile contaminants. After completion, the Former Process Area would be graded to slope towards the beach and the top portions of the containment walls would be cut off to below ground surface. Subsurface containment walls left in place would prevent recontamination of the Former Process Area from adjacent contaminated sediments.

Under this alternative, treatment would be completed and the Former Process Area restored in approximately 4 to 7 years.

The conceptual level of design cost for this alternative is estimated to range from $89 million, without contingencies, to $107 million, with significant contingencies.

This alternative would meet the Generational Remedy Objectives as follows:

- Destroys contaminants in soil, likely to less than cleanup levels[18]
- Eliminates the need for future containment, including long-term operation and maintenance of an active pumping system
- Eliminates the risk of future releases of contaminants from the Former Process Area
- Allows use of the Former Process Area to its full potential in less than 10 years

The conceptual design of this alternative, including construction and treatment methods, schedule, and costs, is described in detail below.

4.3.1 Alternative Components

This alternative involves three primary components:

- Install a shoring wall along the perimeter of the treatment area
- Install and operate a dewatering system to allow excavation to occur in relatively dry conditions to the extent practicable
- Excavate approximately 650,000 cubic yards of soil, thermally treating contaminated soil in aboveground facilities to destroy contaminants, and replacing the clean soil as backfill in the excavation

These components are described below. Plan and profile views of conceptual alternative components are illustrated on Figures 4.5 and 4.6, respectively.

4.3.1.1 Install Shoring Wall

To excavate to the base of the Upper Aquifer a structural shoring wall would be constructed along the existing sheetpile wall alignment. A number of shoring methods could be used, including modification of the existing sheetpile wall (e.g., placing a frame of embedded, steel-

[18] Except for residual remaining at depths where excavation is performed in saturated conditions.

reinforced concrete columns and whalers welded along the inside of the wall, or installation of a separate concrete slurry or secant-pile wall). For costing this alternative, it is assumed that a secant wall with tiebacks would be installed along the existing sheetpile wall alignment. The secant wall columns would be reinforced with steel beams and imbedded into the underlying Aquitard soils.

Along the south boundary of the treatment area, shallower excavation depths (typically 20 to 30 feet) would allow other less expensive construction methods. Along the south boundary, it is assumed that a non-structural slurry wall would be installed to reduce groundwater inflow, and sloped excavation sidewalls (sloped at a ratio of approximately 1.5 horizontal to 1 vertical (1.5H:1V)) would be used rather than shoring. Shoring may be required adjacent to the groundwater treatment plant. The alignment of the barrier wall along this southern border would be based on additional investigation into the location of the Aquitard in this area. The groundwater cutoff wall may not be needed in areas where the Aquitard is present at depths above seasonal groundwater levels.

4.3.1.2 Install and Operate Dewatering System

Dewatering would be performed in advance of the excavation to drain as much porewater as possible, render the soils more amenable to aboveground treatment, and allow excavation to occur with cut slopes where possible. The existing sheetpile wall and the new shoring wall would help prevent inflow to the Former Process Area. A sheetpile or slurry low-permeability wall on the south side of the Former Process Area would further limit upland and surface water inflow around the existing sheetpile wall. The south flow barrier wall might be considered as an additional component to the dewatering system described below.[19]

A conceptual dewatering system includes the following:

- The Upper Aquifer would be dewatered using a network of dewatering wells, supplemented with sumps and pumps internal to the excavation. The Upper Aquifer would be dewatered to an approximate depth of 60 feet.
- Pressure relief wells would likely be needed in the Lower Aquifer to minimize uplift pressures acting on the Aquitard.
- Excavation of soils in the deepest portion of the Former Process Area (northern quarter) would be performed in saturated conditions. The lower portion of the Upper Aquifer in this area would not be dewatered to avoid high uplift pressures on the Aquitard. During excavation under saturated conditions, some residual creosote suspended in the water column is expected to be left behind, but the majority of contamination (including mobile creosote) would be removed.[20]
- Water removed by the dewatering system would be treated using the existing treatment system. During the initial pumping period when higher groundwater extraction rates would be required to lower the water table within the excavation area, temporary equipment would be used to provide additional capacity. Groundwater removed from the Lower Aquifer might not require treatment, although it would need to be collected and tested before it could be determined if it could be directly discharged to surface water.

[19] A cost-benefit analysis of extending the cut-off wall versus higher dewatering flow rates would be performed during design.
[20] Similar to residuals remaining after dredging of contaminated sediments.

Initial pumping rates of 100 to 200 gpm in the Upper Aquifer would be used to deplete aquifer storage. Once the aquifer is drained, in approximately 3 to 6 months depending on the total flow rate, the steady state flow rate is expected to be low, about 25 gpm over the entire area. Individual cell rates would be even lower, and the dewatering may be accomplished with just sumps and ditch pumps at this time. Pumping of the Lower Aquifer however, would need to be maintained throughout the excavation and backfill period. During excavation, surface water runoff would be redirected away from the excavation area to minimize increases in dewatering volumes during rain events.

It is assumed that the maximum depth of dewatering is approximately 60 feet, and that up to 20 feet of soil in the north end of the Former Process Area would be excavated in saturated conditions. To excavate all contaminated soil above the Aquitard under dewatered conditions would require much greater depressurization of the Lower Aquifer to prevent blowout of the Aquitard. There is limited data available to estimate the flow requirements for Lower Aquifer depressurization; however, using the data provided by previous modeling efforts, flow rates to depressurize the Lower Aquifer to allow full dewatering of the Upper Aquifer could be 1,000 gpm or more (URS Greiner and CH2M HILL 2004).

4.3.1.3 Excavation, Treatment, and Backfill

Excavation and treatment would involve the following:

- Soil would be excavated sequentially in several cells to reduce dewatering rates and to allow room for stockpiling and treating soil prior to treatment. For the purpose of this alternative, it is assumed that the cleanup would be accomplished in 3 cells of approximately 3 acres per cell. Cells would be separated by temporary sheetpile walls with internal bracing.
- Soil would be screened for contamination during excavation. If an area of soil is potentially not contaminated, this soil would be segregated and tested. Clean soil would not be treated.
- Contaminated soil would be processed by propane-fired thermal desorption units that would heat up soil to approximately 1,100°F to destroy contaminants.
- Treated and clean soil would be stockpiled on-site and moisture-adjusted to assist future compaction.
- As excavation proceeds, treated and clean soil would be used to backfill completed areas.
- Backfilled areas would be pre-loaded (temporarily overburdened with several feet of additional soil) to compact replaced soils.

For costing this alternative, it was assumed that 10 percent of the soils are clean and do not require treatment. Two propane-powered thermal desorption units could process approximately 700 cubic yards per day, which is also a feasible rate of excavation and backfilling. The thermal desorption units consume approximately between 15 and 25 gallons of propane per ton of soil (Kellogg 2010). At this rate, treating 585,000 cubic yards of soil would take approximately 2.5 years and consume between 14 and 23 million gallons of propane. A typical thermal desorption unit in operation is shown in Figure 4.7.

4.3.2 Site Restoration

After the Former Process Area is treated and backfilled, the top portion of the existing sheetpile wall would be removed or cut down to below ground surface. Additional shoring structural elements implemented under this remedy extending above ground surface would also be removed[21]. The Former Process Area would be graded to slope towards the beach. Alternatively, a shoreline revetment could be installed to control erosion and reduce the amount of grading.

Aboveground thermal treatment of soil is expected to reduce contaminant levels to less than the Wyckoff Site soil cleanup levels, so a soil cap to prevent contact with shallow soil would not be necessary. Clean shallow soil would act as a barrier to contact with residual contamination remaining in deeper soil. However, thermal treatment would also remove any natural organic matter present in the soil. To restore the Former Process Area for future park use, a layer of topsoil would be placed to allow vegetation to establish.

Creosote that has already migrated into or through the Aquitard would remain in place after treatment. Also, some residual contamination is expected to be left in place deep in the Upper Aquifer where excavation is performed in saturated conditions. However, by aggressively removing the source in the Upper Aquifer, no new contamination would enter the Aquitard. The risk associated with potential migration and leaching of residual contaminants at depth would be greatly reduced, as conditions would slowly improve over time through adsorption of PAHs onto soils and through slow biodegradation. Because of the low volume of creosote left in place and the long distance from the Aquitard to surface sediments, contamination left in place under this alternative is not expected to be of concern. The subsurface containment structures (sheetpile wall and secant wall) would remain in place, preventing recontamination of the treated soil within the Former Process Area from the adjacent contaminated sediments. After treatment is complete and the area is restored, groundwater monitoring would continue to ensure that residual contamination beneath the Former Process Area does not present a future threat for discharge to Puget Sound. The infrastructure for confirmation groundwater monitoring following treatment would likely have minimal impacts on park development within the Former Process Area.

4.3.3 Uncertainties

This alternative would use conventional engineering methods to excavate, treat, and replace contaminated soils. Treatment of creosote-contaminated soils using thermal desorption has achieved strict cleanup levels at many sites. Uncertainties in this remedy are primarily related to potential construction costs and include the following:

- Need for vapor controls to address potential dioxin emissions from thermal treatment. Dioxins, associated with pentachlorophenol, have been detected in soil within the Former Process Area, and may also be produced from high-temperature heating of soils containing chlorinated phenols.
- Success of dewatering at depth and the amount of residual contamination left behind when excavating in saturated conditions at depth.

[21] It is likely that the top of the shoring wall could remain below beach grade or be designed for easy removal when work is complete.

- Identification of potential remediation levels that would achieve Generational Remedy Objectives but reduce the volume of soil needing treatment.

To address these uncertainties, conservative assumptions have been made for these uncertainties in developing costs. Costs are provided in Section 4.3.6, below.

4.3.4 Schedule

Implementing this alternative would take approximately 4 to 7 years from initial design to complete site restoration, as follows:

Component	Schedule in Years
Design	1 to 1.5
Construction—Shoring and Dewatering	0.5
Construction—Excavation, Treatment, Backfill	2.5 to 3.5
Site Restoration	0.5 to 1

Figure 4.4 includes a timeline for this alternative.

4.3.5 Community Impacts

This alternative would benefit the community by allowing full use of the Former Process Area in less than 10 years and greatly reducing the risk of future releases from the Former Process Area. All remediation structures and equipment, including the aboveground portion of the sheetpile wall, would be removed. Long-term activities are anticipated to be limited to groundwater monitoring.

Potential community concerns during construction may include the following:

- Noise from the construction of the barrier walls and sheetpile cell walls, and from installation of the dewatering system.
- Noise from construction equipment for excavation, stockpiling, and backfilling work (occurring during normal working hours) and from the operation of the two thermal desorption units (operated 24 hours a day, 7 days a week). Thermal desorption units produce approximately 65 decibels (db) of noise at a 100-foot perimeter (Kellogg 2010).
- Noise from site restoration activities, including removal of the groundwater treatment plant, cutting down the barrier walls to mudline, and placement of topsoil across the Former Process Area.
- Traffic from construction equipment, delivery of propane to the thermal treatment units, and soil brought to the site for site restoration.
- Visual impacts of active construction work for 3 to 4 years.
- Creosote odors released during excavation of contaminated material.
- Air emissions from thermal desorption units.

4.3.6 Costs

The overall cost for this alternative is estimated to range from $89 million to $107 million. These are conceptual levels costs, where the cost for $89 million does not include any contingencies and the cost for $107 million includes significant contingencies (refer to Appendix D). It is assumed that there are no long-term active operations and maintenance costs for this alternative. Costs for groundwater monitoring following implementation of this alternative are not included.

Estimated costs for individual elements of this alternative, with and without contingencies, and tax are summarized in the table below. Supporting cost information is included in Appendix D.

Alternative 2 Costs

Element	Estimated Cost (in Millions)
Construction Costs	
Secant Wall	$11.9 to $15.4
Upgradient Cutoff Wall	$0.2 to $0.3
Dewatering System	$1.1 to $1.4
Excavation and Segregation	$9.6 to $11.7
Ex-situ Thermal Treatment Mobilization/Demobilization	$0.5 to $0.6
Backfilling and Compaction	$4.9 to $6.4
Operating Costs	
Treatment Plant for Dewatering Water	$0.5 to $0.6
Thermal Treatment Units for Soil	$43.9 to $50.5
Dewatering	$0.3 to $0.4
Restoration Costs	
Site Restoration	$0.8 to $1.1
Well Decommissioning and Equipment Removal	$0.8 to $1.2
Soil Placement	$0.7 to $0.8
Design, Permitting, and Site Preparation Costs	
Design and Construction Oversight	$4.2 to $5.5
Permitting	$1.4 to $1.8
Site Preparation	$0.1 to $0.2
Tax	
9.5%	$7.7 to $9.3

4.4 ALTERNATIVE 3—SHALLOW EXCAVATION AND EX-SITU TREATMENT WITH IN-SITU THERMAL TREATMENT OR STABILIZATION AT DEPTH

In Alternative 3, contaminated soil within the Former Process Area would be treated by a combination of in-situ and ex-situ treatment. Under this approach, soil would be treated as follows:

- Shallow contaminated soil would be excavated, treated aboveground by heating to destroy contaminants, and replaced.

- Deep contaminated soil would be treated in place to reduce contaminant mobility, by one of two potential methods:
  - o Using in-situ thermal technology (described above in Section 4.2, Alternative 1)—Treatment Option A, or
  - o Stabilization, by immobilizing contaminants by mixing in cement and contaminant binding agents—Treatment Option B.

The volume of soil to be excavated includes the area containing creosote inside the existing sheetpile wall (approximately 9 acres) from the ground surface to a depth of approximately 30 feet below ground surface (or to the depth of the Upper Aquifer base where it occurs at depths shallower than 30 feet). The total excavated soil volume would be approximately 400,000 cubic yards. The volume of soil to be treated in place would be the area containing creosote after excavation of the upper 30 feet (approximately 7 acres) from the base of the excavation (at a depth of 30 feet) to the base of the Upper Aquifer (maximum depth 80 feet). The total volume of soil to be treated in place would be approximately 250,000 cubic yards.

This alternative would destroy both mobile and immobile contaminants in shallow soil and either remove most of the contamination (using in-situ thermal treatment) or immobilize the contamination (using stabilization) in deep soil. After completion, the Former Process Area would be graded to slope towards the beach and the top portions of the containment walls would be cut off to below ground surface. Subsurface containment walls left in place would prevent recontamination of the Former Process Area from adjacent contaminated sediments.

Under this alternative, treatment would be completed and the Former Process Area restored in approximately 4 to 20 years. The treatment time would depend on whether stabilization or in-situ thermal treatment is implemented for deeper soil and on the availability of power if in-situ thermal treatment is implemented.

The conceptual level of design cost for this alternative if in-situ thermal treatment is used is estimated to range from $126 million, without contingencies, to $158 million, with significant contingencies. If soil stabilization is used for this alternative, then the conceptual level of design cost is estimated to range from $101 million, without contingencies, to $125 million, with significant contingencies.

This alternative would meet the Generational Remedy Objectives as follows:

- Destroys contaminants in shallow soil, likely to less than cleanup levels
- Removes or immobilizes mobile contaminants, including creosote and its volatile and leachable constituents in the deep soil
- Eliminates the need for long-term operation and maintenance of an active pumping system
- Greatly reduces the risk of future releases of contaminants from the Former Process Area
- Allows use of the Former Process Area to its full potential in less than one generation

The conceptual design of this alternative, including construction and treatment methods, schedule, and costs, is described below.

4.4.1 Alternative Components

This alternative involves the following components:

- Install an impermeable shoring and groundwater cutoff wall along the perimeter of the treatment area
- Excavate, treat, and backfill of shallow soil to a depth of 30 feet
- Treat contaminated soil below 30 feet deep in place, using one of two treatment options:
  - In-Situ Thermal Treatment, to remove and destroy mobile contaminants—Treatment Option A, or
  - Stabilization, using cement and binding agents to immobilize contaminants—Treatment Option B.

These components are described below. Plan and profile views of conceptual components for this alternative with the in-situ thermal treatment option are illustrated on Figures 4.8 and 4.9, respectively. Plan and profile views of conceptual components for this alternative with the stabilization option are illustrated on Figures 4.10 and 4.11, respectively.

4.4.1.1 Install Impermeable Shoring and Barrier Walls

Impermeable shoring and groundwater barrier walls, similar to that described in Alternative 1, would be installed at the perimeter of the treatment area. Several construction methods for these walls may be used. For the purposes of this alternative, it is assumed that the wall installed inside the existing sheetpile wall would be constructed of overlapping concrete columns (a secant wall) and imbedded into the Aquitard. Unlike Alternative 1, the wall would include reinforcement to provide shoring for shallow excavation. The purpose of this wall would be to:

- reduce groundwater leakage into the Former Process Area to minimize dewatering during excavation and minimize cooling during in-situ thermal treatment
- provide structural support to allow excavation of vertical sidewalls in shallow soil at the perimeter of the area
- provide a thermal buffer in deep soil between the heated zone and potentially contaminated sediments outside the sheetpile wall, to minimize mobilization of contaminants outside the treatment area

Along the south boundary, a non-structural slurry wall would be installed as necessary into the Aquitard to cut off groundwater flow from the uplands to the treatment area. The alignment of the barrier wall along this southern border would be based on additional investigation into the location of the Aquitard in this area. Sloped excavation sidewalls (sloped at a ratio of approximately 1.5H:1V) would be used rather than shoring along this southern boundary.

4.4.1.2 Excavation of Shallow Soil

Shallow soil would be excavated, treated aboveground using thermal desorption, and backfilled on-site. This approach would treat the contaminated soil located closest to potential receptors (future park users and the adjacent sediments and surface water) to likely less than cleanup levels. Because excavation becomes more expensive below depths of 30 feet due to increased dewatering and shoring needs, deeper soils would be treated in place by other methods in this alternative.

As in Alternative 2, dewatering would be performed in advance of excavation to drain as much water as possible, render the soils more amenable to aboveground treatment, and allow excavation to occur with cut slopes where possible. The impermeable shoring and barrier walls described above would limit the rate of inflow into the excavation area. The Upper Aquifer would be dewatered using sumps and pumps internal to the excavation. Pressure relief wells in the Lower Aquifer would not be needed for this alternative. Groundwater would be treated using the existing groundwater treatment system.

Excavation and treatment would be conducted in a manner similar to Alternative 2, and involve the following:

- Excavation would be accomplished in cells that would allow room for a perimeter dewatering system, and areas for storing contaminated soil awaiting thermal treatment, and clean soil ready for backfilling. For the purpose of this alternative, it is assumed that the cleanup would be accomplished in 3 cells of approximately 3 acres per cell. Cells would be separated by temporary sheetpile walls with internal bracing.
- During excavation soil would be screened for contamination. If an area of soil is potentially not contaminated, this soil would be segregated and tested. Clean soil would not be treated to reduce treatment costs.
- Contaminated soil would be processed by propane-fired thermal desorption units that heat soil to approximately 1,100°F to destroy contaminants.
- Treated soil would be stockpiled on-site and moisture-adjusted to assist future compaction. As excavation proceeds, the treated soil would be used to backfill completed areas.

For costing this alternative, it was assumed 10 percent of the soils are clean and do not require treatment. Two propane-powered thermal desorption units could process approximately 700 cubic yards per day, which is also a feasible rate of excavation and backfilling. As stated earlier, thermal desorption units consume approximately between 15 and 25 gallons of propane per ton of soil, therefore treating 400,000 cubic yards of soil would take approximately 18 months and would consume between 10 and 16 million gallons of propane.

4.4.1.3 Treatment Option A: In-situ Thermal Treatment of Deep Soil

For deep soil Treatment Option A, in-situ thermal treatment of contaminated soil below 30 feet in depth would be accomplished using the techniques described in Alternative 1, and would include the following:

- A low-permeability cap would be placed at the base of the excavation (30 feet in depth). This cap would trap contaminants mobilized during thermal treatment and prevent recontamination of the shallow soils.
- A soil heating system, including a steam plant, steam injection wells, and thermal conduction wells containing electric heaters, would be installed to heat soil between the base of the excavation and the base of the Upper Aquifer.

- A fluid extraction and treatment system comprising: fluid extraction wells, pumps to extract creosote, groundwater, and vapors, heated piping from the wells to a treatment plant, and a treatment plant to separate and treat contaminated fluids.

As in Alternative 1, hydraulic and thermal controls would be implemented during in-situ thermal treatment to prevent contaminant migration outside the treatment area and to minimize heat loss due to cold groundwater inflow. Contaminant migration would be controlled by maintaining an inward gradient with the fluid extraction system. Groundwater inflow would be controlled by the impermeable perimeter wall described above, the low-permeability cap installed at the base of the excavation, and at the bottom of the treatment zone by maintaining a “hot floor” during treatment. The perimeter barrier wall would also provide a thermal buffer to minimize the potential for mobilization of creosote in sediments outside the treatment area.

Fewer heater wells and extraction wells would be used in this alternative compared with Alternative 1, because the treatment area (7 acres) is slightly reduced. The existing treatment plant would be modified to be used for the fluid extraction and treatment system. Energy use would be less than for Alternative 1 because of the lower volume of soil (200,000 versus 650,000 cubic yards) requiring treatment. However, the treatment time would be slightly longer because of the higher ratio of perimeter surface area to treatment volume (i.e., a higher rate of cooling; Baker 2010a).

4.4.1.4 Treatment Option B: Stabilization of Deep Soil

For deep soil Treatment Option B, creosote below 30 feet in depth would be immobilized by mixing cement and chemical stabilizers such as activated carbon into the soil. Creosote would be bound in an impermeable matrix that would greatly reduce or eliminate movement and leaching of contaminants. Stabilization could be accomplished by several construction techniques, including auger mixing and jet-grouting. For the purpose of this alternative, it is assumed that mixing would be performed with large-diameter (e.g., 8-foot) augers. Stabilization of deep soils would be performed at the base of each excavation cell prior to backfilling.

This alternative would increase the total volume of soil at the Former Process Area due to the addition of cement. It is assumed that this additional soil volume could be incorporated into the future park grading plan. If necessary, treated soil could be used as fill or disposed of off-site.

4.4.2 Site Restoration

After the Former Process Area is treated and backfilled, the top portion of the existing sheetpile wall would be removed or cut down to below ground surface. The portion of the shoring wall extending above ground surface would also be removed. The Former Process Area would be graded to slope towards the beach. Alternatively, a shoreline revetment may be installed to control erosion and reduce the amount of grading.

Aboveground thermal treatment of soil is expected to reduce contaminant levels to less than the Wyckoff Site soil cleanup levels, so a soil cap to prevent contact with shallow soil would not be necessary. Clean shallow soil would act as a barrier to contact with residual contamination remaining in deeper soil. Because ex-situ thermal treatment of the shallow soils would remove any natural organic matter present in the soil, a layer of topsoil would be placed to allow vegetation to establish.

Creosote that has already migrated into or through the Aquitard would remain in place after treatment. However, by removing or immobilizing all contamination above the Aquitard, the movement of new NAPL into the Aquitard and Lower Aquifer would be eliminated and the risk associated with potential migration and leaching of residual contaminants at depth would be greatly reduced. Additionally, in Treatment Option A, creosote in the Aquitard would be decreased by use of the "hot floor" during the in-situ thermal remediation treatment. For both treatment options, the barrier wall placed around the perimeter of the Former Process Area would also contain residual contamination left in place and prevent recontamination of the treated soils from adjacent contaminated sediments. After treatment is complete and the Former Process Area is restored, groundwater monitoring would continue to ensure that residual contamination beneath the Former Process Area does not present a future threat for discharge to Puget Sound. The infrastructure for confirmation groundwater monitoring following treatment would likely have minimal impacts on park development within the Former Process Area.

4.4.3 Uncertainties

The components of this alternative, including excavation, ex-situ thermal treatment, in-situ thermal treatment, and soil stabilization, have been implemented successfully at similar sites.

Uncertainties for this alternative include the following:

- As with Alternative 2, the need for vapor controls to address potential dioxin emissions from thermal treatment of shallow excavated soils should be evaluated. Dioxins, associated with PCP, have been detected in soil within the Former Process Area, and may also be produced from high-temperature heating of soils containing chlorinated phenols.
- As with Alternative 1, the availability of power for in-situ thermal treatment is a significant factor in the schedule and cost for operating the treatment system, and would require additional evaluation.
- As discussed in Alternative 1, the residual contamination from in-situ thermal treatment is expected to be generally non-mobile and non-leachable, but localized areas of creosote or leachable constituents may remain.
- Soil stabilization has been successful at immobilizing creosote at many sites, but some studies have shown a potential for some leaching of residual creosote that was not fully incorporated into the cement-soil matrix, and the long-term stability of the mixture is still unknown.

It is expected that either of the two deep soil treatment alternatives would greatly reduce the mobility of residual contamination, and that the impermeable barrier wall would add further redundancy in passively preventing future migration of contaminants from the treatment area.

4.4.4 Schedule

Implementing this alternative using deep thermal treatment would take approximately 8 to 19 years from initial design to complete site restoration, as follows:

Component	Schedule in Years
Design	1 to 2
Construction—Shoring and Dewatering	0.5
Construction—Excavation, Treatment, Backfill	1 to 2
Construction—Thermal Treatment System	1
Operation—Thermal Treatment System	3 to 10
Operation—Thermal Treatment System (Cool Down)	1 to 3
Site Restoration	0.5

Implementing this alternative using deep soil stabilization would take approximately 4 to 6 years from initial design to complete site restoration, as follows:

Component	Schedule in Years
Design	1 to 2
Construction—Shoring and Dewatering	0.5
Construction—Excavation, Treatment, Backfill	1 to 2
Construction—Soil Stabilization	1
Site Restoration	0.5

Figure 4.4 includes timelines for this alternative with both deep thermal treatment options.

4.4.5 Community Impacts

This alternative would benefit the community by allowing full use of the Former Process Area in less than 6 years if soil stabilization is implemented or in less than 20 years if in-situ thermal treatment is implemented. Additionally, this alternative greatly reduces the risk of future releases from the Former Process Area. At the conclusion of treatment, all remediation structures and equipment, with the exception of the lower portions of the shoring wall and the sheetpile wall, would be removed. Long-term activities are anticipated to be limited to groundwater monitoring.

Potential community concerns with this alternative implementing either deep soil treatment option include the following:

- Noise from the construction of the barrier walls and sheetpile cell walls and installation of the dewatering system.
- Noise from construction equipment for excavation, stockpiling, and backfilling work (occurring during normal working hours) and from the operation of the two thermal desorption units (operated 24 hours a day, 7 days a week). As stated earlier, thermal desorption units produce approximately 65 db of noise at a 100-foot perimeter.
- Noise from site restoration activities, including removal of the groundwater treatment, cutting down the barrier walls to mudline, and placement of topsoil across the Former Process Area.
- Traffic from construction equipment, delivery of propane to the thermal treatment units, and soil brought to the site for site restoration.
- Visual impacts of active construction work (excavation and backfilling) for up to 2 years.
- Creosote odors released during excavation of contaminated material.
- Air emissions from thermal desorption units.

The potential community concerns specific to Treatment Option A: In-situ Thermal Treatment of Deeper Soil, include the following:

- Noise during construction of the thermal treatment system, including drilling more than 1,000 new wells and construction of the steam plant and treatment system.
- Noise from the operation of the steam plant during thermal treatment and from the operation of the treatment plant during thermal treatment and the cool down phase.
- Traffic from construction equipment, delivery of propane to the steam plant and vapor treatment system and the removal of recovered creosote.
- Visual impact of aboveground piping and equipment covering the Former Process Area during the in-situ thermal treatment period and the cool down phase.
- High electrical demand during thermal treatment operations.

The potential community concerns specific to Treatment Option B: Stabilization of Deeper Soil, include the following:

- Traffic from the delivery of cement required for the soil stabilization.
- Increased duration of the visual impacts of active construction work to complete the stabilization, approximately 1 year.

4.4.6 Costs

The overall construction cost for this alternative with in-situ thermal treatment at depth is estimated to range from $126 million to $158 million. The overall construction cost for this alternative with soil stabilization at depth is estimated to range from $101 million to $125 million. These are conceptual level costs, where the costs at the lower end of the range do not include any contingencies and the costs at the upper end of the range include significant contingencies (refer to Appendix D). For this alternative with either treatment option, it is assumed there are no long-term active operations and maintenance costs. Costs for groundwater monitoring following implementation of this alternative are not included.

Estimated costs for individual elements of this alternative with in-situ thermal treatment at depth (Treatment Option A), with and without contingencies, and tax are summarized in the table below. Supporting cost information is included in Appendix D.

Alternative 3 with Treatment Option A Costs

Element	Estimated Cost (in Millions)
Construction Costs	
Secant Wall	$10.4 to $13.5
Upgradient Cutoff Wall	$0.2 to $0.3
Dewatering System	$0.7 to $1.0
Excavation and Segregation	$6.1 to $7.4
Ex-situ Thermal Treatment Mobilization/Demobilization	$0.5 to $0.6
In-situ Thermal Treatment System	$16.1 to $20.9
Groundwater Treatment Plant (Upgrade Existing Plant)	$2.0 to $3.0
Backfilling and Compaction	$3.0 to $3.9
Low-Permeability Cap at Base of Excavation	$2.2 to $2.5
Operating Costs	
Thermal Heating and Treatment Systems	$32.0 to $40.0
Treatment Plant During Cool Down Period	$1.0 to $1.3
Creosote Disposal	$0.6 to $0.8
Thermal Treatment Units for Soil	$27.0 to $31.1
Dewatering	$0.4 to $0.5
Restoration Costs	
Site Restoration	$0.8 to $1.1
Well Decommissioning and Equipment Removal	$3.4 to $4.5
Soil Placement	$0.7 to $0.8
Design, Permitting, and Site Preparation Costs	
Design and Construction Oversight	$6.2 to $8.0
Permitting	$2.1 to $2.7
Site Preparation	$0.1 to $0.2
Tax	
9.5%	$11.0 to $13.7

Estimated costs for individual elements of this alternative with soil stabilization at depth (Treatment Option B), with and without contingencies, and tax are summarized in the table below. Supporting cost information is included in Appendix D.

Alternative 3 with Treatment Option B Costs

Element	Estimated Cost (in Millions)
Construction Costs	
Secant Wall	$10.4 to $13.5
Upgradient Cutoff Wall	$0.2 to $0.3
Dewatering System	$0.7 to $1.0
Excavation and Segregation	$6.1 to $7.4
Ex-situ Thermal Treatment Mobilization/Demobilization	$0.5 to $0.6
Soil Stabilization	$31.3 to $39.1
Backfilling and Compaction	$3.0 to $3.9
Operating Costs	
Thermal Treatment Units for Soil	$27.0 to $31.1
Treatment Plant for Dewatering Water	$0.3 to $0.4
Dewatering	$0.2 to $0.3
Restoration Costs	
Site Restoration	$0.8 to $1.1
Well Decommissioning and Equipment Removal	$0.5 to $0.8
Soil Placement	$0.7 to $0.8
Design, Permitting, and Site Preparation Costs	
Design and Construction Oversight	$7.8 to $10.2
Permitting	$2.6 to $3.4
Site Preparation	$0.1 to $0.2
Tax	
9.5%	$8.8 to $10.8

4.5 COMPARISON OF THE GENERATIONAL REMEDY ALTERNATIVES

A detailed comparison of the generational remedy alternatives is provided in Table 4.1 using the following categories:

- Site Restoration Following Treatment
- Long-term Requirements
- Schedule
- Cost
- Community Impacts
- Uncertainties
- Risk Reduction
- Implementability and Construction Risks

Figure 4.4 illustrates potential timelines for the generational remedy alternatives.

4.6 GENERATIONAL REMEDY ALTERNATIVES SUMMARY

At a conceptual level, the three generational remedy alternatives presented above all meet the generational remedy guiding principles.

These remedies remove and/or immobilize the contamination located within the Upper Aquifer of the Former Process Area, so that no long-term operations and maintenance are required once implementation of the alternative has been completed. These generational alternatives are anticipated to be completed somewhere between 4 and 20 years, depending on which alternative is implemented and how the alternative is implemented. All of the generational remedy alternatives are implementable. No alternative has been put forth that cannot be constructed.

Each of these generational remedy alternatives eliminates the risk of a large-scale and unrecoverable release from the Former Process Area over time with the removal or immobilization of the contamination within the Upper Aquifer of the Former Process Area.

These remedies also allow for open use of the Former Process Area for park use, as planned by the City and Park District, following implementation.

5.0 Comparative Evaluation

In this section, USEPA's proposed containment remedy is compared to an "average" generational remedy. Although the generational remedy alternatives employ different methods and have a range of costs, community impacts, and restoration timeframes, they have much in common. In Table 5.1, the characteristics of these remedies relating to the following seven categories are collectively compared to the containment remedy:

- Site Restoration
- Long-term Requirements
- Schedule
- Cost
- Community Impacts
- Uncertainties
- Risk reduction
- Implementability and Construction Risks

A summary of these comparisons is provided below.

5.1 SITE RESTORATION

Both a generational remedy and the containment remedy would allow restoration of the Point for its intended use as a public park, but to different degrees.

Park use and design options following construction of the containment remedy would be restricted. The groundwater extraction system and treatment plant would remain as permanent features at the park, and the groundwater treatment plant, extraction wells, piping, site cap, and containment walls would require periodic access, maintenance, and replacement. The anticipated replacement of several of these components, such as the site cap and the sheetpile wall, would result in major disruptions to use of the park in this area.

Under a generational remedy, aboveground remediation elements would be removed after the remedy is complete. The entire Point would be available for park use with a wider-range of design options available. A generational remedy would allow for the restoration of the natural structure, functions, and processes of the Point shoreline.

5.2 LONG-TERM REQUIREMENTS

Under the containment remedy, long-term active operations and maintenance of the groundwater extraction and treatment system and containment wall, water level and water quality monitoring, and periodic replacement of its components, would continue in perpetuity.

For a generational remedy, the only component requiring long-term maintenance would be monitoring wells. These wells would be used for a period of time following completion of the treatment to document remedy effectiveness. No long-term active operations and maintenance would likely be required following implementation of a generational remedy.

5.3 SCHEDULE

Figure 4.4 illustrates potential timelines for the generational remedy alternatives and the containment remedy.

Finishing implementation of the containment remedy would likely take approximately 4 to 5 years, after which the Former Process Area could be developed as a park. Operation and maintenance of the containment remedy would be performed in perpetuity. Additionally, construction would be required on a periodic basis in perpetuity to replace aging components of the containment remedy.

Implementation of a generational remedy (including operation and removal of thermal treatment systems, if applied) would likely take between 4 and 20 years, depending on the specific alternative and the availability of power (for thermal treatment options). Following implementation of a generational remedy the Former Process Area could be developed as a park. Groundwater monitoring to document remedy effectiveness would continue into the foreseeable future.

5.4 COST

When calculating capital and operation and maintenance costs for remedial alternatives, care must be taken to ensure that the financial mechanism employed for such comparison is appropriate and germane to those paying for the cleanup. In particular, when government is a responsible party, or when the State has a financial obligation at fund-lead sites, the cost comparisons of different remedial alternatives must account for the laws, regulations, and budgetary practices of government. The State budgeting process is governed by RCW 43.88.

In comparing alternative costs for the Former Process Area in the past and in making remedial action decisions, the USEPA has used a Net Present Value (NPV) analysis, which takes into account the time-value of money and assumes that money that is not spent today can be invested and receive a higher rate of return than the rate of inflation over the same time period. The net rate of return is called the discount rate. However, using NPV for estimating the costs of remedial alternatives is not consistent with actual and realistic funding options and therefore provides a false basis for a remedial action decision. For government-financed long-term cleanup obligations such as the Wyckoff Site, state and local governments do not establish interest earning fiduciary or trust accounts to “front” fund these types of obligations. Additionally, other federal agencies do not front fund these types of activities through interest-bearing accounts, in particular the Departments of Defense, Energy, or Interior. Furthermore, it is the exception that private sector cleanups use these financial instruments to pay for long-term operation and maintenance costs. Importantly, funds appropriated at the state level are based on anticipated revenue and projected expenditures that will be incurred during a 2-year budgetary period. Local governments adopt operating and capital budgets on an annual or biennial basis depending on each local government’s fiscal period. Using the previous NPV analyses prepared by USEPA significantly underestimates the long-term costs of the containment remedy to the State.[22]

The actual cost to the State of the containment remedy, in 2010 dollars and not accounting for inflation, is estimated to be approximately $280 million after 200 years of operation, maintenance, and component replacement and $539 million after 400 years of operation, maintenance, and component replacement[23]. The cost of a generational remedy is estimated to be between $107 and $158 million (including contingencies), depending on the alternative. The costs for the generational remedy alternatives and the containment remedy (including contingencies) are summarized in the table below. For completeness in providing comparisons of costs, NPV calculations for the containment remedy and the generational remedies over time, following USEPA cost estimating guidance are also included in this table (USEPA 2000b). Refer to Appendix D for additional details on the cost calculations.

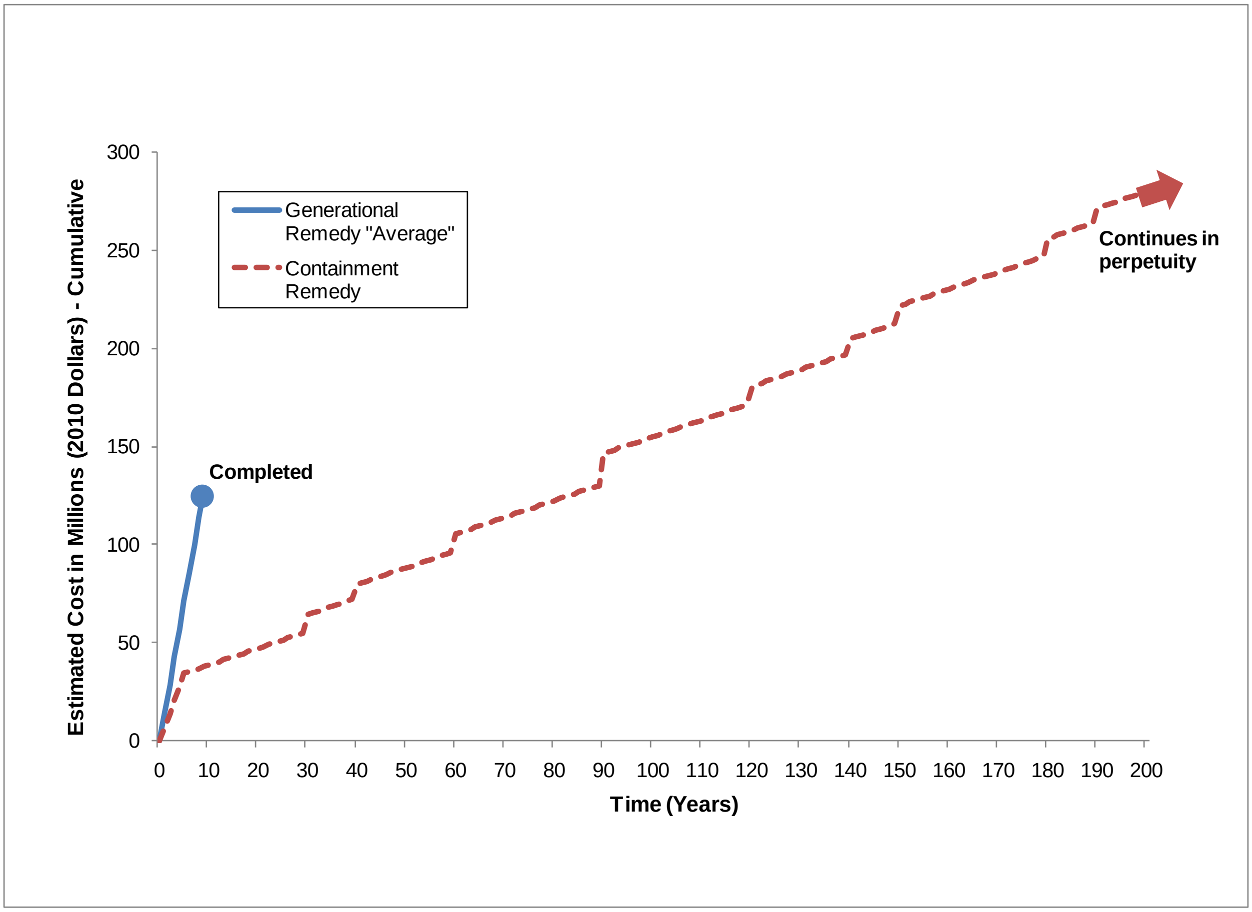
Cost Summary

Remedy	Total Costs over 200 Years (2010 Dollars) in Millions	Total Costs over 400 Years (2010 Dollars) in Millions	NPV using USEPA Guidance (2.7 %) in Millions
Generational Remedy Alternative 1	$123	$123	$103
Generational Remedy Alternative 2	$107	$107	$99
Generational Remedy Alternative 3a	$158	$158	$132
Generational Remedy Alternative 3b	$125	$125	$113
USEPA Containment Remedy	$280	$539	$70

For comparison purposes, the plot below illustrates the estimated cumulative costs in 2010 dollars incurred over a 200-year period for the containment remedy and for an "average" generational remedy (assuming an average construction schedule of 10 years and cost of $128 million). After approximately 90 years, the cost of the containment remedy is estimated to match the cost of implementation of a generational remedy (assuming the average cost).

[22] Additionally, the USEPA NPV analyses used to compare remedial alternatives for the Former Process Area (e.g., in the ROD (USEPA 2000a) and the Engineering Evaluation of Groundwater and Soil Remediation Scenarios Report (CH2M HILL 2005)) used discount rates that were higher than appropriate for a government funded project and used relatively short time periods that did not reflect the full operation and maintenance time periods required for containment.

[23] Because the expected operating lifetime of the containment system is "in perpetuity," the total long-term costs are not calculable, but could potentially greatly exceed these values.



5.5 COMMUNITY IMPACTS

The containment remedy leaves existing contamination in place within the Former Process Area in perpetuity. This limits full utilization of the Point as a park and leaves a stigma regarding this area within the community. The containment remedy continues to leave uncertainties in place regarding health, economic costs, and the burdens that will be left on future generations to continually manage this area.

Over the long-term, the containment remedy will continue to require periodic construction as components of the containment remedy must be replaced in perpetuity to maintain hydraulic and physical containment of the contamination. This will disrupt use and limit the park design potential. Additionally, the containment remedy limits the full use of this area as a park, as the groundwater treatment plant and extraction system must remain within this area and require continuous operation and maintenance in perpetuity.

A generational remedy would benefit the community by greatly reducing the risk of a release of contamination from the Former Process Area following implementation. A generational remedy also removes the need for possible additional remedial actions within the Former Process Area in the future. The containment remedy would leave significant amounts of contamination in place and the risk of a containment release remains in perpetuity. There is a risk that additional remedial actions may be required in the future with the containment remedy if a release of contamination was to occur.

In terms of remedy construction impacting the community, a generational remedy would result in more impacts to the community in the short-term in comparison to the containment remedy. A generational remedy would have increased construction activity and noise, increased traffic to the area, increased power usage, and a longer period of construction relative to the containment remedy before the park can be constructed and opened to the public. There would be some construction required in the short-term for the containment remedy, but this would be relatively minor compared to a generational remedy.

5.6 RISK REDUCTION

The containment remedy leaves behind significant quantities of potentially mobile creosote in perpetuity. Hydraulic control of the contamination within the Former Process Area must be maintained to keep the contamination in place. Risk of future releases under the containment remedy would remain. There is a significant potential for earthquake impacts and continued DNAPL migration through the Aquitard into the Lower Aquifer within the time frame of the remedy.

A generational remedy greatly reduces the risk of future releases or exposure to contaminants from the Former Process Area through the removal, treatment, or reduction in the mobility of the creosote contamination. It is assumed that long-term pumping and treating of groundwater is not needed following implementation, as groundwater leaving the Former Process Area will be at levels protective of water quality and sediment at the mudline.

5.7 IMPLEMENTABILITY AND CONSTRUCTION RISKS

The containment remedy involves conventional construction activities. The construction of the final components of the containment remedy is generally expected to be easily implemented with low risk. Little contaminated material is expected to be generated. Implementation of the containment remedy over the long-term requires restrictions on future park use, as the groundwater treatment plant and extraction system will need to be continually operated and maintained and there will periodically be construction required within the park to replace elements of the containment remedy.

Construction of a generational remedy would also involve conventional construction activities, such as drilling, trenching, excavation, and shoring. Thermal treatment and soil stabilization has been conducted on numerous sites, including wood-treatment sites, and these are considered to be common technologies. It is technically feasible to implement any of the generational remedy alternatives at the Former Process Area. During remedy options that involve excavation, creosote vapors will be liberated that may require engineering controls (such as air purifiers or vapor-reducing foams) to limit the exposure of construction workers. The complexity and risk of implementing a generational remedy is considered moderate. Following implementation of a generational remedy, there should not be impacts on future use of this area as a park.

5.8 UNCERTAINTIES

The primary uncertainty with the containment remedy is its ability to contain contamination in perpetuity. Potential concerns include leakage of DNAPL through the Aquitard, risks associated with long-term changes to site conditions (e.g., due to earthquakes, shoreline erosion, or water level rise), and the availability of funding and resources to maintain active treatment for hundreds of years. The ability to accurately monitor containment effectiveness is also uncertain.

Uncertainties with a generational remedy include details of how it would specifically be implemented, since these remedies have only been developed to the conceptual design stage. There is also uncertainty as to the specific characteristics of the residual material that would be left by in-situ thermal treatment and the potential for leaching from stabilized soil. However, as opposed to the containment remedy, many of these uncertainties can be addressed by testing and design prior to remedy implementation.

6.0 Conclusions

The Wyckoff Point is a very unique property. It is a promontory located in the heart of Puget Sound, forming the entry to Eagle Harbor. It lies adjacent to a sensitive shoreline in an area of significant wave action, exposed to a wide northeasterly fetch and vulnerable to constant ferry wake. It is located adjacent to tribal fishing grounds with established eelgrass beds, precious to the Suquamish Tribe, who have fishing rights reserved under the 1855 Treaty of Point Elliott and are co-managers of the fishery resources within the State. The property is pivotal to the City of Bainbridge Island and Park District plans for Pritchard Park and the adjacent Japanese-American Exclusion Memorial as a showcase regional public open space.

The Wyckoff Site is a CERCLA fund-lead site. As a final cleanup remedy for the Point, the USEPA plans to permanently contain more than 1.2 million gallons of creosote and associated contaminants using barrier walls, a surface cap, and a groundwater extraction and treatment system. As proposed by USEPA, this containment remedy would need to be actively managed and operated in perpetuity.

The USEPA plan would task the State with financial and management responsibility for operation and maintenance of this containment remedy. In the summer of 2009, Ecology declined that responsibility based on significant concerns about the long-term protectiveness of containment and the unlimited generational costs of operation, maintenance, and periodic rebuilding of the remedy.

Following this decision, Ecology conducted the Generational Remedy Evaluation beginning in September 2009. Ecology worked with a steering committee—composed of members from the local government, community groups, and Suquamish Tribe—and nationwide experts to evaluate alternative remedial options that would reduce the mass and mobility of the mobile creosote in this area; remove threats to Puget Sound; and remain protective for multiple generations without relying on active operations, maintenance, and replacement of remedial components.

The Generational Remedy Evaluation identified three mass removal or mobility reduction technologies that meet the objectives of this effort. They include in-situ thermal treatment; excavation with ex-situ thermal treatment; and a hybrid—shallow excavation with ex-situ thermal treatment, combined with in-situ thermal treatment or stabilization at depth. Each of the generational remedy alternatives will remove or immobilize most of the contamination present in the Point, significantly reduce costs over the long-term, and remove the short- and long-term environmental risks posed by this mobile contamination. For any residual contamination left after mass removal, it is anticipated that no active waste management will be necessary, given the expected site conditions.

Given factors that affect government financing, the USEPA containment remedy is actually the most expensive approach to solve this environmental problem. While the cost of each generational remedy is significant; they pale when compared to the long-term costs of the USEPA containment remedy. The short-term capital costs of the generational remedies are estimated to range from $107 to $158 million spent over 4 to 20 years; and operational and maintenance costs following implementation are expected to be minimal. Based on current information provided by USEPA, the short-term capital costs for the USEPA containment remedy are estimated to be $30 million spent over 4 to 5 years; and perpetual operations, maintenance, and infrastructure replacement costs are estimated to be $250 million after 200 years, and more than $500 million after 400 years of operation (all costs presented in 2010 dollars).

Current USEPA regulations utilize cost estimating and comparison techniques that minimize the effect of long-term operational and maintenance costs. Use of these techniques is inappropriate for government-funded cleanup sites that have extended operational and maintenance time frames. The cost estimating techniques used by USEPA only make sense in those instances where investment grade trusts can be established up front to pay for future operations and maintenance costs, whereas governments adopt operating and capital budgets on an annual or biennial basis.

The containment remedy is, in fact, not the USEPA preferred alternative as defined in the administrative record. In 2000, the USEPA ROD for the site selected full thermal remediation as the appropriately protective remedy for the Former Process Area (USEPA 2000a). Containment was selected as a fall back, contingency alternative. The logic in the ROD confirms that a containment strategy has no defined endpoint and the pump and treat system would have to be operated and maintained in perpetuity to maintain the integrity of the containment option and to prevent migration of contaminants into Eagle Harbor. The ROD also states that a containment alternative presents a risk of failure or need for replacement over the very long-term, and that the long-term costs of a containment remedy would make it more expensive than full thermal remediation. The Generational Remedy Evaluation supports this perspective.

The Generational Remedy Evaluation included review of most, if not all, technical and formative decision documents developed by USEPA since the mid-1990s. Included in this review were more recent technical investigations undertaken by USEPA since the 2000 ROD and the 2005 Engineering Evaluation of Groundwater and Soil Remediation Scenarios. Based on this review, the current understanding of site conditions is more fully understood as well as the limitations of that understanding.

There are concerns with the efficacy and effectiveness of containment at this location given the possibility of hydraulic continuity between the Upper and Lower Aquifers. Existing data indicate contaminant leakage is occurring downward toward and into the Lower Aquifer. Groundwater elevations indicate there is hydraulic connection between the Upper and Lower Aquifers. Recent data also indicate the Aquitard is not as continuous as previously thought, includes discontinuities and shows evidence of structural displacement, thereby limiting its effectiveness, even if there was constant upward hydraulic control. Hydrogeological impacts will also occur as a result of expected but unpredictable seismic activity and climate change.

Additionally, because there is substantial and widespread contamination present in sediments outside of the Point, it is not possible to accurately monitor containment effectiveness within the Former Process Area. This creates the potential that remedial failure of a containment system would not be recognized or corrected.

The Generational Remedy Evaluation has determined that there are significant concerns as to whether the USEPA containment remedy would be protective in the long-term, as required by federal law. The containment remedy should be considered an interim remedy and not a permanent remedy, as proposed by USEPA. The ability for society to operate and maintain the containment remedy effectively for hundreds of years into the future is uncertain. This area contains over a million gallons of highly mobile oily wastes with high concentrations of toxic compounds, which if not removed, will present an environmental risk to Puget Sound in perpetuity.

Associated with this evaluation, although not directly part of it, is the concern over the East Beach and North Shoal seeps. Massive amounts of uncontrolled contamination exist outside of the sheetpile wall. Numerous seeps are evident on the beach areas resulting in continuous discharges of toxic material into Puget Sound. These discharges have been ongoing for decades. Implementation of any of the generational remedies for the Point should be undertaken in concert with active remediation of these beach areas.

Environmental decisions today on this unique site have significant consequences for future generations. A generational approach meets multi-generational environmental goals, community values, Suquamish multi-generational values, and sustainability objectives in terms of climate change, protection of Puget Sound, and reduction of risk and obligation for future generations. Broad public support exists for further significant cleanup, even with the understanding of the cost and time involved. This level of engagement with the public must continue, as the decisions made today have significant consequences for future generations.

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The Wyckoff Point
Bainbridge Island, Washington

Generational Remedy Evaluation

Tables

Table 4.1
Generational Remedy Alternatives Comparison

	Alternative 1 In-situ Thermal Treatment (Figures 4.1 and 4.2)	**Alternative 2** Excavation and Ex-situ Thermal Treatment (Figures 4.5 and 4.6)	**Alternative 3 with Treatment Option A** Shallow Excavation and Ex-situ Treatment with In-situ Thermal Treatment at Depth (Figures 4.8 and 4.9)	**Alternative 3 with Treatment Option B** Shallow Excavation and Ex-situ Treatment with Soil Stabilization at Depth (Figures 4.10 and 4.11)
Alternative Description	Heating of the entire contaminated subsurface (to the Aquitard) within the Former Process Area to the boiling point of water to aid in the extraction of contaminants. Probable components include the following: • A heating system—steam plant, steam injection wells, thermal conduction wells, piping. • A fluid extraction and treatment system—fluid extraction wells and pumps, piping, a treatment plant. • Hydraulic and heat loss control systems—groundwater extraction and treatment, temporary surface cap, improved perimeter barrier wall inside the existing sheetpile wall, upgradient perimeter barrier wall, hot floor within the Aquitard.	Excavation and aboveground thermal treatment of the entire contaminated subsurface (to the Aquitard) within the Former Process Area to destroy contaminants. Treated soils would be used as backfill in the excavated area. Probable components include the following: • A perimeter barrier wall inside the existing sheetpile wall for shoring and hydraulic control; • An upgradient perimeter barrier wall and sloped excavation sidewall along the southern boundary of the excavation area. • Dewatering system—sumps, pumps, wells, groundwater treatment system. • Sheetpile walls dividing the site into excavation cells. • Excavation, treatment in on-site thermal desorption units, and backfilling.	Excavation and aboveground thermal treatment of shallow contaminated soils (to a depth of 30 feet) across the Former Process Area to destroy contaminants. Treated soils would be used as backfill in the excavated area. All deeper subsurface soils in the Upper Aquifer within the Former Process Area would be treated using in-situ thermal treatment (see Alternative 1). Probable components include the following: • A perimeter barrier wall inside the existing sheetpile wall for shoring and hydraulic and thermal control. • An upgradient perimeter barrier wall and sloped excavation sidewall along the southern boundary of the excavation area. • Dewatering system for excavated area. • Sheetpile walls dividing the site into excavation cells. • Excavation, treatment in on-site thermal desorption units, and backfilling. • For in-situ thermal treatment—a heating system, a fluid extraction and treatment system, a low permeability cap, hot floor within the Aquitard.	Excavation and aboveground thermal treatment of shallow contaminated soils (to a depth of 30 feet) across the Former Process Area to destroy contaminants. Treated soils would be used as backfill in the excavated area. All deeper subsurface soils in the Upper Aquifer within the Former Process Area would be treated using soil stabilization (mixing in cement and binding agents to immobilize contaminants). Probable components include the following: • A perimeter barrier wall inside the existing sheetpile wall for shoring and hydraulic control. • An upgradient perimeter barrier wall and sloped excavation sidewall along the southern boundary of the excavation area. • Dewatering system for excavated area. • Sheetpile walls dividing the site into excavation cells. • Excavation, treatment in on-site thermal desorption units, and backfilling. • Soil stabilization using large diameter augers.
Site Restoration Following Treatment	Following in-situ thermal treatment, it is estimated to take 2 to 5 years for the site to cool down to ambient temperatures. Groundwater extraction and treatment would continue during this cool down phase. After the cool down phase, the following would occur: • Wells decommissioned and piping, treatment plant, steam generation plant, and temporary surface cap removed. • Sheetpile wall and improved perimeter barrier wall cut down to the mudline and soil behind these walls regraded to create a natural beach profile. • A permeable soil cap would be placed over the treatment area to prevent human contact with residual contamination in the treated surface soil.	After excavation, soil treatment, and backfilling, the following would occur: • Treatment plant and thermal desorption units removed. • Sheetpile wall and improved perimeter barrier wall cut down to the mudline and soil behind these walls regraded to create a natural beach profile. • Topsoil would be placed over the treatment area to allow vegetation to grow.	Following in-situ thermal treatment, it is estimated to take 2 to 5 years for the site to cool down to ambient temperatures. Groundwater extraction and treatment would continue during this cool down phase. After the cool down phase, the following would occur: • Wells decommissioned and piping, treatment plant, steam generation plant removed. • Sheetpile wall and improved perimeter barrier wall cut down to the mudline and soil behind these walls regraded to create a natural beach profile. • Topsoil would be placed over the treatment area to allow vegetation to grow.	After excavation, soil stabilization, soil treatment, and backfilling, the following would occur: • Treatment plant and thermal desorption units removed. • Sheetpile wall and improved perimeter barrier wall cut down to the mudline and soil behind these walls regraded to create a natural beach profile. • Additional soil resulting from the increase in soil volume from the soil stabilization treatment would be graded onto the site. • Topsoil would be placed over the treatment area to allow vegetation to grow.

Table 4.1
Generational Remedy Alternatives Comparison

	Alternative 1 In-situ Thermal Treatment (Figures 4.1 and 4.2)	**Alternative 2** Excavation and Ex-situ Thermal Treatment (Figures 4.5 and 4.6)	**Alternative 3 with Treatment Option A** Shallow Excavation and Ex-situ Treatment with In-situ Thermal Treatment at Depth (Figures 4.8 and 4.9)	**Alternative 3 with Treatment Option B** Shallow Excavation and Ex-situ Treatment with Soil Stabilization at Depth (Figures 4.10 and 4.11)
Long-term Requirements	No long-term active operations and maintenance within the Former Process Area is likely required following in-situ thermal treatment and the cool down phase. Limited groundwater monitoring would continue to occur to confirm that residual contamination beneath the Former Process Area does not pose a threat to Puget Sound.	No long-term active operations and maintenance within the Former Process Area is likely required following ex-situ thermal treatment of the excavated material. Limited groundwater monitoring would continue to occur to confirm that residual contamination beneath the Former Process Area does not pose a threat to Puget Sound.	No long-term active operations and maintenance within the Former Process Area is likely required following ex-situ thermal treatment of the excavated material, in-situ thermal treatment, and the cool down phase. Limited groundwater monitoring would continue to occur to confirm that residual contamination beneath the Former Process Area does not pose a threat to Puget Sound.	No long-term active operations and maintenance within the Former Process Area is likely required following ex-situ thermal treatment of the excavated material and soil stabilization. Limited groundwater monitoring would continue to occur to confirm that residual contamination beneath the Former Process Area does not pose a threat to Puget Sound.
Schedule	Implementation would take between 7 and 20 years, from initial design through site restoration. The wide range in the timeframe is dependent on power availability which determines the rate of in-situ thermal heating and the length of time required for the cool down phase following treatment. • Design: 1 to 2 years • Construction of In-situ Thermal Treatment System: 1 to 2 years • Operation of In-situ Thermal Treatment System (power availability determines treatment duration): 2 to 10 years • Cool Down (Groundwater Treatment): 2 to 5 years • Site Restoration: 1 year	Implementation would take between 4 and 7 years, from initial design through site restoration. • Design: 1 to 1.5 years • Construction—Shoring and Dewatering: 0.5 years • Excavation, Ex-situ Treatment, and Backfill: 2.5 to 3.5 years • Site Restoration: 0.5 to 1 year	Implementation would take between 8 and 19 years, from initial design through site restoration. The wide range in the timeframe is dependent on power availability which determines the rate of in-situ thermal heating and the length of time required for the cool down phase following treatment. • Design: 1 to 2 years • Construction—Shoring and Dewatering: 0.5 years • Excavation, Ex-situ Treatment, and Backfill: 1 to 2 years • Construction of In-situ Thermal Treatment System: 1 year • Operation of In-situ Thermal Treatment System (power availability determines treatment duration): 3 to 10 years • Cool Down (Groundwater Treatment): 1 to 3 years • Site Restoration: 0.5 years	Implementation would take between 4 and 6 years, from initial design through site restoration. • Design: 1 to 2 years • Construction—Shoring and Dewatering: 0.5 years • Excavation, Ex-situ Treatment, and Backfill: 1 to 2 years • Soil Stabilization: 1 year • Site Restoration: 0.5 years
Cost	The cost range presented below includes the estimated construction cost, with and without significant contingencies. There are no long-term active operations and maintenance costs for this alternative. Costs for groundwater monitoring are not included. $96 Million to $123 Million	The cost range presented below includes the estimated construction cost, with and without significant contingencies. There are no long-term active operations and maintenance costs for this alternative. Costs for groundwater monitoring are not included. $89 Million to $107 Million	The cost range presented below includes the estimated construction cost, with and without significant contingencies. There are no long-term active operations and maintenance costs for this alternative. Costs for groundwater monitoring are not included. $126 Million to $158 Million	The cost range presented below includes the estimated construction cost, with and without significant contingencies. There are no long-term active operations and maintenance costs for this alternative. Costs for groundwater monitoring are not included. $101 Million to $125 Million

Table 4.1
Generational Remedy Alternatives Comparison

	Alternative 1 In-situ Thermal Treatment (Figures 4.1 and 4.2)	**Alternative 2** Excavation and Ex-situ Thermal Treatment (Figures 4.5 and 4.6)	**Alternative 3 with Treatment Option A** Shallow Excavation and Ex-situ Treatment with In-situ Thermal Treatment at Depth (Figures 4.8 and 4.9)	**Alternative 3 with Treatment Option B** Shallow Excavation and Ex-situ Treatment with Soil Stabilization at Depth (Figures 4.10 and 4.11)
Community Impacts	Benefits: • Full use of Former Process Area following implementation (between 7 and 20 years) for park use. • Removes mobile contamination and the associated potential risks of a release from the Former Process Area. Noise: • From the installation of over 1,300 wells and piping and from construction of the barrier walls, surface cap, treatment system and steam plant. • From the operation of the steam plant during thermal treatment and the operation of the treatment plant during thermal treatment and the cool down phase. • From site restoration construction activities (thermal treatment system infrastructure removal, partial wall removal, regrading, and soil cap placement). Traffic: • Construction equipment brought to the site. • Delivery of propane for the steam plant and vapor treatment system during treatment. • Disposal of recovered creosote off-site during treatment. • Soil brought to site for site restoration. Visual Impact: • Surface cap and above ground piping and equipment covering the Former Process Area during thermal treatment and the cool down phase. Other: • Energy demand from electrical grid.	Benefits: • Full use of Former Process Area following implementation (between 4 and 7 years) for park use. • Removes most of the contamination and the associated potential risks of a release from the Former Process Area. Noise: • From the construction of the barrier walls and sheetpile cell walls and installation of the dewatering system. • From construction equipment for excavation and backfilling (during normal working hours) and from operation of the thermal desorption units (around the clock). • From site restoration construction activities (groundwater treatment plant removal, partial wall removal, regrading, and soil placement). Traffic: • Construction equipment brought to the site. • Delivery of propane for the thermal desorption units during treatment. • Soil brought to site for site restoration. Visual Impact: • Excavation and backfilling work occurring at the site for 3–4 years. Other: • Creosote odors released during excavation. • Emissions from the thermal desorption units.	Benefits: • Full use of Former Process Area following implementation (between 8 and 19 years) for park use. • Removes most of the contamination in the shallow soils, mobile contamination in the deeper soils, and the associated potential risks of a release from the Former Process Area. Noise: • From the construction of the barrier walls and sheetpile cell walls and installation of the dewatering system. • From construction equipment for excavation and backfilling (during normal working hours) and from operation of the thermal desorption units (around the clock). • From the installation of over 1,000 wells and piping and from construction of the treatment system and steam plant. • From site restoration construction activities (thermal treatment system infrastructure removal, partial wall removal, regrading, and soil placement). Traffic: • Construction equipment brought to the site. • Delivery of propane for the thermal desorption units during ex-situ treatment and for the steam plant and vapor treatment system during in-situ treatment. • Disposal of recovered creosote off-site during in-situ treatment. • Soil brought to site for site restoration. Visual Impact: • Excavation and backfilling work occurring at the site for up to 2 years. • Surface cap and above ground piping and equipment covering the Former Process Area during in-situ thermal treatment and the cool down phase. Other: • Creosote odors released during excavation. • Emissions from the thermal desorption units. • Energy demand from electrical grid.	Benefits: • Full use of Former Process Area following implementation (between 4 and 6 years) for park use. • Removes most of the contamination in the shallow soils, stabilizes mobile contamination in the deeper soils, and removes the associated potential risks of a release from the Former Process Area. Noise: • From the construction of the barrier walls and sheetpile cell walls and installation of the dewatering system. • From construction equipment for excavation, backfilling, and soil stabilization (during normal working hours) and from operation of the thermal desorption units (around the clock). • From site restoration construction activities (groundwater treatment plant removal, partial wall removal, regrading, and soil placement). Traffic: • Construction equipment brought to the site. • Delivery of propane for the thermal desorption units during treatment. • Delivery of cement for the soil stabilization treatment. • Soil brought to site for site restoration. Visual Impact: • Excavation, soil stabilization, and backfilling work occurring at the site for up to 3 years. Other: • Creosote odors released during excavation. • Emissions from the thermal desorption units.

Table 4.1
Generational Remedy Alternatives Comparison

	Alternative 1 In-situ Thermal Treatment (Figures 4.1 and 4.2)	**Alternative 2** Excavation and Ex-situ Thermal Treatment (Figures 4.5 and 4.6)	**Alternative 3 with Treatment Option A** Shallow Excavation and Ex-situ Treatment with In-situ Thermal Treatment at Depth (Figures 4.8 and 4.9)	**Alternative 3 with Treatment Option B** Shallow Excavation and Ex-situ Treatment with Soil Stabilization at Depth (Figures 4.10 and 4.11)
Risk Reduction	Provides a high degree of risk reduction for future releases from the Former Process Area through the removal and treatment of most of the contamination using in-situ thermal treatment. The entire Upper Aquifer within the Former Process Area would be treated. This risk reduction would be accomplished in somewhere between 7 and 20 years. Contamination removed from the subsurface would be destroyed. NAPL recovered during the treatment would be disposed of off-site (burned in an incinerator). Contaminated groundwater and vapors collected would be treated on-site. Following treatment, soils would contain residual contamination (primarily insoluble PAHs adsorbed to soil). The treated soils are not likely to meet soil cleanup levels. To prevent human exposure to residual contamination in site surface soils, a soil cap would be placed over the entire treated area following treatment. Some level of continued leaching of contaminants from soils could occur, but NAPL would essentially be eliminated within the Upper Aquifer. The improved barrier wall would remain in place following treatment to act as a passive containment barrier for the residual contamination still present in the soil. The barrier wall will also prevent recontamination of the treated soils from NAPL contamination that remains in sediment located outside of the treatment area. Groundwater leaving the Former Process Area is expected to be at levels protective of water quality and sediment at the mudline following cool down of the treated soils to ambient temperatures. No long-term pumping and treatment of groundwater is necessary. Contaminants that have already migrated below the upper surface of the Aquitard would not be addressed by this alternative.	Provides a high degree of risk reduction for future releases from the Former Process Area through the removal and treatment of nearly all contamination using excavation and ex-situ thermal treatment. The entire Upper Aquifer within the Former Process Area would be excavated and this soil would be treated on-site to remove contamination. This risk reduction would be accomplished in somewhere between 4 and 7 years. Contamination in the soils would be destroyed through the ex-situ thermal treatment. Contaminated groundwater collected during dewatering of the excavation would be treated on-site. Following treatment, soils would likely meet applicable cleanup levels. The improved barrier wall would remain in place following treatment to prevent recontamination of the treated soils from NAPL contamination that remains in sediment located outside of the treatment area. Groundwater leaving the Former Process Area is expected to be at levels protective of water quality and sediment at the mudline. No long-term pumping and treatment of groundwater is necessary. Contaminants that have already migrated into or through the Aquitard would not be addressed by this alternative.	Provides a high degree of risk reduction for future releases from the Former Process Area through the removal and treatment of nearly all contamination using excavation and ex-situ thermal treatment in the shallow portion of the site and most of the contamination through the removal and treatment of contaminants using in-situ thermal treatment in the deeper portion of the site. The entire Upper Aquifer within the Former Process Area would be treated with either ex-situ or in-situ thermal treatment. This risk reduction would be accomplished in somewhere between 8 and 19 years. Contamination in the shallow soils would be destroyed through the ex-situ thermal treatment. Contaminated groundwater collected during dewatering of the excavation would be treated on-site. Contamination removed from the deeper soils would be destroyed. NAPL recovered during the treatment would be disposed of off-site (burned in an incinerator). Contaminated groundwater and vapors collected from the in-situ thermal treatment would be treated on-site. Following ex-situ thermal treatment, soils in the shallow portion of the site would likely meet soil cleanup levels. Following in-situ thermal treatment, deeper soils would contain residual contamination (primarily insoluble PAHs adsorbed to soil). These deeper treated soils are not likely to meet soil cleanup levels. Some level of continued leaching of contaminants from deeper soils could occur, but NAPL would essentially be eliminated within the Upper Aquifer. The improved barrier wall would remain in place following treatment to act as a passive containment barrier for the residual contamination still present in the deeper soils. The barrier wall will also prevent recontamination of the treated soils from NAPL contamination that remains in sediment located outside of the treatment area. Groundwater leaving the Former Process Area is expected to be at levels protective of water quality and sediment at the mudline following cool down of the treated soils to ambient temperatures. No long-term pumping and treatment of groundwater is necessary. Contaminants that have already migrated below the upper surface of the Aquitard would not be addressed by this alternative.	Provides a high degree of risk reduction for future releases from the Former Process Area through the removal and treatment of nearly all contamination using excavation and ex-situ thermal treatment in the shallow portion of the site and through the immobilization of nearly all contamination using soil stabilization in the deeper portion of the site. The entire Upper Aquifer within the Former Process Area would be treated with either ex-situ or soil stabilization. This risk reduction would be accomplished in somewhere between 4 and 6 years. Contamination in the shallow soils would be destroyed through the ex-situ thermal treatment. Contaminated groundwater collected during dewatering of the excavation would be treated on-site. For the deeper soils, contamination would remain in these soils, but mobility would be significantly reduced through mixing of these soils with cement and chemical binding agents. Following ex-situ thermal treatment, soils in the shallow portion of the site would likely meet soil cleanup levels. Following in-situ thermal treatment, deeper soils would contain immobile contamination and these deeper treated soils would not meet soil cleanup levels. The improved barrier wall would remain in place following treatment to act as a passive containment barrier for the residual contamination still present in the deeper soils. The barrier wall will also prevent recontamination of the treated soils from NAPL contamination that remains in sediment located outside of the treatment area. Groundwater leaving the Former Process Area is expected to be at levels protective of water quality and sediment at the mudline. No long-term pumping and treatment of groundwater is necessary. Contaminants that have already migrated into or through the Aquitard would not be addressed by this alternative.

Table 4.1
Generational Remedy Alternatives Comparison

	Alternative 1 In-situ Thermal Treatment (Figures 4.1 and 4.2)	**Alternative 2** Excavation and Ex-situ Thermal Treatment (Figures 4.5 and 4.6)	**Alternative 3 with Treatment Option A** Shallow Excavation and Ex-situ Treatment with In-situ Thermal Treatment at Depth (Figures 4.8 and 4.9)	**Alternative 3 with Treatment Option B** Shallow Excavation and Ex-situ Treatment with Soil Stabilization at Depth (Figures 4.10 and 4.11)
Implementability and Construction Risks	This alternative uses a common technology that has been applied at other wood treatment facility cleanup sites, as well as many other types of sites. It is technically feasible to implement in-situ thermal treatment at the Former Process Area. All materials and equipment used for construction of this alternative are regionally available. An off-site disposal facility (incinerator) will be required for recovered creosote, which is regionally available. This alternative requires a large amount of electrical power and propane for in-situ thermal treatment. The amount of energy available will largely determine the time required for implementation. The degree of complexity associated with construction activities is moderate, as barrier walls and installation and operation of thermal treatment systems are common. The Former Process Area is accessible for construction activities and construction activities will not impact the existing site use. Implementation will also not cause impacts on future site use.	This alternative uses common technologies that have been applied at many other types of cleanup sites. It is technically possible to shore, dewater, and excavate the Former Process Area to the base of the Upper Aquifer, as well as treat the contaminated soil using ex-situ thermal desorption. All materials and equipment used for construction of this alternative are regionally available. This alternative requires a large amount of propane for the ex-situ thermal treatment. The degree of complexity associated with construction activities is moderate to high, as construction of barrier walls and deep excavations are common. Dewatering this site at depth is feasible, but may be challenging. It is assumed that excavation in the deepest portion of this Former Process Area (greater than 60 feet below ground surface) would occur under saturated conditions. The Former Process Area is accessible for construction activities and construction activities will not impact the existing site use. Implementation will also not cause impacts on future site use.	This alternative uses common technologies that have been applied at other wood treatment facility cleanup sites, as well as many other types of sites. It is technically possible to shore, dewater, and excavate the site to a depth of 30 feet, as well as treat the contaminated soil using ex-situ thermal desorption. It is also technically feasible to implement in-situ thermal treatment at depth in the Former Process Area. All materials and equipment used for construction of this alternative are regionally available. An off-site disposal facility (incinerator) will be required for recovered creosote, which is regionally available. This alternative requires a large amount of electrical power and propane for in-situ thermal treatment. The amount of energy available will largely determine the time required for implementation. This alternative also requires a large amount of propane for the ex-situ thermal treatment. The degree of complexity associated with construction activities is moderate, as barrier walls, excavation, and installation and operation of thermal treatment systems are common. The Former Process Area is accessible for construction activities and construction activities will not impact the existing site use. Implementation will also not cause impacts on future site use.	This alternative uses common technologies that have been applied at many other types of cleanup sites. It is technically possible to shore, dewater, and excavate the site to a depth of 30 feet, as well as treat the contaminated soil using ex-situ thermal desorption. It is also technically feasible to implement soil stabilization at depth in the Former Process Area. All materials and equipment used for construction of this alternative are regionally available. This alternative requires a large amount of propane for the ex-situ thermal treatment. The degree of complexity associated with construction activities is moderate, as barrier walls, excavation, and soil stabilization using large diameter augers are common. The Former Process Area is accessible for construction activities and construction activities will not impact the existing site use. Implementation will also not cause impacts on future site use.
Uncertainties	Uncertainties regarding in-situ thermal treatment: • Power availability—determines treatment time period. • Residual contamination left in place—potential for some leaching to groundwater to continue.	Uncertainties regarding excavation: • Remediation levels that would meet generational remedy objectives, but allow a reduction in soil volume requiring treatment. • Success of dewatering at depth and the amount of residual contamination left behind when excavating in saturated conditions. Uncertainties regarding ex-situ thermal treatment: • Extent of vapor controls to address potential dioxin emissions during thermal treatment.	Uncertainties regarding excavation: • Remediation levels that would meet generational remedy objectives, but allow a reduction in soil volume requiring treatment. Uncertainties regarding ex-situ thermal treatment: • Extent of vapor controls to address potential dioxin emissions during thermal treatment. Uncertainties regarding in-situ thermal treatment: • Power availability—determines treatment time period. • Residual contamination left in place—potential for some leaching to groundwater to continue.	Uncertainties regarding excavation: • Remediation levels that would meet generational remedy objectives, but allow a reduction in soil volume requiring treatment. Uncertainties regarding ex-situ thermal treatment: • Extent of vapor controls to address potential dioxin emissions during thermal treatment. Uncertainties regarding soil stabilization: • Potential leaching or mobility of contamination not fully incorporated into cement-soil matrix and the long-term stability of this mixture.

Notes:
NAPL Non-aqueous phase liquid.

Table 5.1
Generational Remedy Alternatives to Containment Remedy Comparison

	Generational Remedy Alternatives	Containment Remedy
Alternative Description	The generational remedy alternatives remove, treat, and/or significantly reduce the mobility of the contamination contained within the Upper Aquifer of the Former Process Area. Three possible generational remedy alternatives are described in Section 4.0. These alternatives use thermal treatment (in-situ and ex-situ), excavation, and/or soil stabilization. Each generational remedy removes the environmental risk of a future release from the Former Process Area by removing or immobilizing the contamination. Following implementation of these alternatives, no long-term pumping and treatment of groundwater or periodic replacement of remedial components would be required.	The USEPA containment remedy plans to contain the contamination within the Upper Aquifer of the Former Process Area by pumping groundwater to create a net inward and upward hydraulic gradient into this area. Components of the containment remedy include a perimeter wall, a groundwater extraction and treatment system, a site cap, and possibly an upgradient groundwater cutoff wall. The containment remedy is described in Section 3.0. The contamination remains in place with the containment remedy and therefore this remedy requires that the groundwater extraction and treatment system be operated and maintained in perpetuity. The surface cap must also be maintained in perpetuity, and potentially periodically replaced. Additionally, periodic replacement of the perimeter wall, groundwater extraction system, and groundwater treatment plant would be required in perpetuity.
Site Restoration	Following implementation of a generational remedy alternative, the following would occur: • Buildings and infrastructure removed and wells decommissioned. • Top portions of the sheetpile wall and improved perimeter barrier wall would be cut down to the mudline and soil behind these walls regraded to create a natural beach profile. • Topsoil would be placed over the entire site following park regrading. The generational remedy alternatives allow for future use of the Former Process Area as a park, as planned by the City and Park District. The entire area would be available for use. The timeframe until this area is available for park use depends on the length of time for remedy implementation (between 4 and 20 years depending on the alternative and how it is implemented).	Following construction of all the containment remedy components (between 4 to 5 years), a portion of the Former Process Area could be converted for use as a park, as planned by the City and Park District. The groundwater extraction system and treatment plant would remain as permanent features in the Former Process Area and would be off limits to the public. The shoreline protection system could be designed to meet design goals for the park. Hydraulic and physical containment would continue in perpetuity, making it necessary to regularly close portions of the park for maintenance activities or replacement of the containment remedy components in perpetuity as well. The estimated replacement schedule for the components is: • Complete groundwater extraction system replacement approximately every 20 years, with well and pump redevelopment and cleanouts every few years. • Replacement approximately every 30 years for the groundwater treatment plant. • Replacement approximately every 50 years for the sheetpile wall. Replacement of the site cap may also be required; however the frequency has not been estimated.
Long-term Requirements	No long-term active operations and maintenance within the Former Process Area would likely be required following implementation of a generational remedy alternative. Remedy components left in place would not require periodic replacement. Limited groundwater monitoring would continue to occur to confirm that residual contamination beneath the Former Process Area does not pose a threat to Puget Sound.	Long-term active operations and maintenance for the Former Process Area would be required in perpetuity following construction of the containment remedy. Additionally, periodic replacement of the groundwater extraction system, groundwater treatment plant, sheetpile wall, and possibly the site cap would be required in perpetuity. Several types of contaminant compliance monitoring is anticipated to occur in perpetuity, including: • Groundwater level monitoring to confirm that a net inward and upward gradient is maintained. • Contaminant concentration monitoring in the Lower Aquifer to provide early warning of possible and/or increasing contaminant migration through the Aquitard. • Surface water monitoring to evaluate potential impacts to the marine environment.
Schedule	Implementation of a generational remedy would take between 4 and 20 years depending on the alternative implemented and how it was implemented. Timeframes for the alternatives with in-situ thermal treatment are dependent on the amount of power available. The implementation timeframe includes initial design through site restoration.	Several components of the containment remedy have already been constructed (i.e., the groundwater extraction system, the groundwater treatment plant, and the sheetpile wall). Modifications may be made to several of these components. Finishing construction of the remaining remedial components (i.e., new extraction wells, shoreline protection system, site cap, and possibly an upgradient cutoff wall) is estimated at approximately 4 to 5 years, from design through construction. Following this construction, the containment remedy would require operation and maintenance and periodic construction to replace the remedy's components in perpetuity.
Cost	Construction costs (including a significant contingency) for the generational remedy alternatives are estimated to range from: $107 to $ 158 Million There are no long-term active operations and maintenance costs for all the generational remedy alternatives. Costs for groundwater monitoring are not included.	Construction costs (including contingency) for the containment remedy are estimated at: $30 Million Long-term operation, maintenance, and monitoring cost estimate in perpetuity (including replacement costs for extraction wells and pumps and monitoring wells): $0.86 Million annually Potential component replacement cost estimates for select components in perpetuity: $8.5 Million every 30 years for the groundwater treatment plant $6.9 Million every 50 years for the sheetpile wall After approximately 90 years, the estimated cost of the containment remedy (in 2010 dollars) will be equal to the cost of constructing a generational remedy (assuming an average cost of $128 million, with contingency). Containment remedy costs will continue to increase over time.

Table 5.1
Generational Remedy Alternatives to Containment Remedy Comparison

	Generational Remedy Alternatives	Containment Remedy
Community Impacts	The risk of a release of contamination from the Former Process Area is removed. The generational remedy alternatives allow for full use of the Former Process Area for park development following implementation. The implementation timeframes for these alternatives range between 4 and 20 years depending on the alternative and how it is implemented. During implementation of any of these alternatives, there will be the following impacts: • Noise and emissions from the construction and operation activities. • Increased traffic to mobilize construction equipment and personnel to the site, deliver construction materials, to bring fuel to the site, to remove recovered creosote, and to bring in clean topsoil following treatment (No soil will be removed from the Former Treatment Area for any of the alternatives). • Visual impacts, from excavation work and/or from equipment covering the surface of the Former Process Area for in-situ thermal treatment. Some of these alternatives require significant amounts of energy from the electrical grid and others have air emissions resulting from thermal treatment.	The risk of a release of contamination from the Former Process Area remains. The containment remedy allows use of a portion of the Former Process Area for park use following construction of the remedy (estimated to take approximately 5 years). The groundwater treatment plant and extraction system will remain in the Former Process Area permanently, will be off limits to the public, and will require continuous operation and maintenance. These on-site components will limit the design options for a park. The groundwater treatment plant, groundwater extraction system, and sheetpile wall, and likely the site cap will need to be periodically replaced in perpetuity to maintain hydraulic and physical containment of the contamination. Portions of the park or the entire park will need to be closed for the construction of these replacement components. Refer to the estimated replacement schedule for the containment remedy listed above under Site Restoration Following Treatment. During the construction of the remaining elements of the containment remedy and during the construction of replacement components, there will be the following impacts: • Noise and emissions from the construction activities. • Increased traffic to mobilize construction equipment and personnel to the site and for the delivery of materials. • Visual impacts from construction, including installation of new the shoreline protection system, replacement sheetpile walls, replacement groundwater treatment plants.
Risk Reduction	All of the generational remedy alternatives provide a high degree of risk reduction for future release from the Former Process Area following implementation, as these alternatives remove, treat, and/or significantly reduce the mobility of all the contamination contained within the Upper Aquifer of the Former Process Area. This risk reduction would be accomplished in 4 to 20 years depending on the alternative and how it is implemented. Following implementation, most of the contamination within the Upper Aquifer would either be removed or immobilized. There may be some level of continued leaching of contaminants from residual contamination (primarily insoluble PAHs adsorbed to the soil) with in-situ thermal treatment, but NAPL would essentially be eliminated in the Upper Aquifer. There may also be some level of continued leaching from contamination that has been solidified in place, but mobile NAPL would be eliminated. Ex-situ thermal treatment would remove both mobile and immobile contamination. The improved barrier wall included in each of the generational remedy alternatives would remain in place following treatment to act as a passive containment barrier for the residual or immobile contamination still present in the soil. The barrier wall will also prevent recontamination of the treated soils from NAPL contamination that remains in sediment located outside of the treatment area. Groundwater leaving the Former Process Area is expected to be at levels protective of water quality and sediment at the mudline for the generational remedy alternatives. No long-term pumping and treatment of groundwater is necessary. Contaminants that have already migrated below the upper surface of the Aquitard would not be addressed by these alternatives.	Essentially no destruction and no reduction in the mobility of the contamination within the Upper Aquifer of the Former Process Area occurs with implementation of the containment remedy. Only a nominal amount of contamination will be removed as a byproduct of hydraulic containment. Contamination within the Former Process Area (over 1 million gallons of NAPL) will attempt to be controlled in perpetuity by containment through the pumping of groundwater and the enclosure of the Former Process Area with a sheetpile wall. The containment remedy does not provide a high degree risk reduction for future releases from the Former Process Area, due to its reliance on maintaining and operating upward and inward gradients in perpetuity. Additionally, there are concerns about the effectiveness of containment given the site geology. DNAPL may be leaving the Upper Aquifer within the Former Process Area through permeable pathways in the Aquitard even with the containment remedy operating as designed and over a long period of time could result in contaminant breakthrough at the sediment surface in Puget Sound. A large earthquake could result in a failure of the containment remedy and possibly result in a significant release of creosote to the environment. Contaminants that have already migrated below the upper surface of the Aquitard would not be addressed by these alternatives.
Implementability and Construction Risks	The generational remedy alternatives use common technologies that have been applied at many other types of cleanup sites, including wood treatment facility cleanup sites. All materials and equipment used for the construction of these alternatives are regionally available. These alternatives required large amounts of electrical energy and/or propane for implementation. In general, the degree of complexity associated with construction activities for any of the generational remedy alternatives is moderate. The Former Process Area is currently accessible for construction activities and the construction activities will not impact the existing site use. Implementation will also not cause impacts on future site use.	The containment remedy uses a common technology (i.e., pumping of groundwater for hydraulic containment), that has been applied at many other types of cleanup sites, including wood treatment facility cleanup sites. All materials and equipment used for finishing the construction of the containment remedy and for the replacement of the remedy components are regionally available. The degree of complexity for finishing construction of the containment remedy is low. Replacement of the sheetpile wall in the future is likely to have a moderate degree of complexity. Replacement of the extraction system and the groundwater treatment system is likely to have a low degree of complexity. The Former Process Area is currently accessible for construction activities and the construction activities will not impact the existing site use. Implementation of this remedy will cause impacts on future site use as it requires periodic construction in perpetuity to replace components of the containment remedy. Additionally, portions of the Former Process Area containing remedy components will remain off limits to the public. The ability to implement pumping and treatment of groundwater in perpetuity is reliant on constant funding, with funding dependent on fluctuating political and economic climates over time.

Table 5.1
Generational Remedy Alternatives to Containment Remedy Comparison

	Generational Remedy Alternatives	Containment Remedy
Uncertainties	Uncertainties regarding the generational remedy alternatives generally are related to how each alternative would be implemented (e.g., power availability, extent of vapor controls, and specific design elements like shoring). There are uncertainties regarding the residual contamination that would be left in place and the potential for leaching of the material to groundwater following treatment using in-situ thermal treatment or soil stabilization. The long-term stability of the stabilized soil is unknown.	The greatest uncertainty about the containment remedy is its ability to contain the contaminant mass (over 1 million gallons of NAPL) in perpetuity. There are concerns about the effectiveness of this remedy given the site geology. There are known pathways in the Aquitard for DNAPL to migrate out of the Upper Aquifer. It is uncertain what the extent will be of contaminant releases from the Upper Aquifer. The ability to monitor remedy effectiveness is difficult due to the existing conditions. Implementation and effectiveness of the containment remedy over time may be affected by water level rise or beach erosion. It is also uncertain that continuously for hundreds of years into the future that there will available funding and resources to operate and maintain the containment system.

Note:
NAPL Non-aqueous phase liquid

The Wyckoff Point
Bainbridge Island, Washington

Generational Remedy Evaluation

Figures

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The Wyckoff Point
Bainbridge Island, Washington

Figure 2.1
Vicinity Map

File: F:\projects\SAIC-Wyckoff\GIS\MXD\Figure 2.1 (Wyckoff Eagle Harbor Vicinity Map).mxd
Date: 7/9/2010

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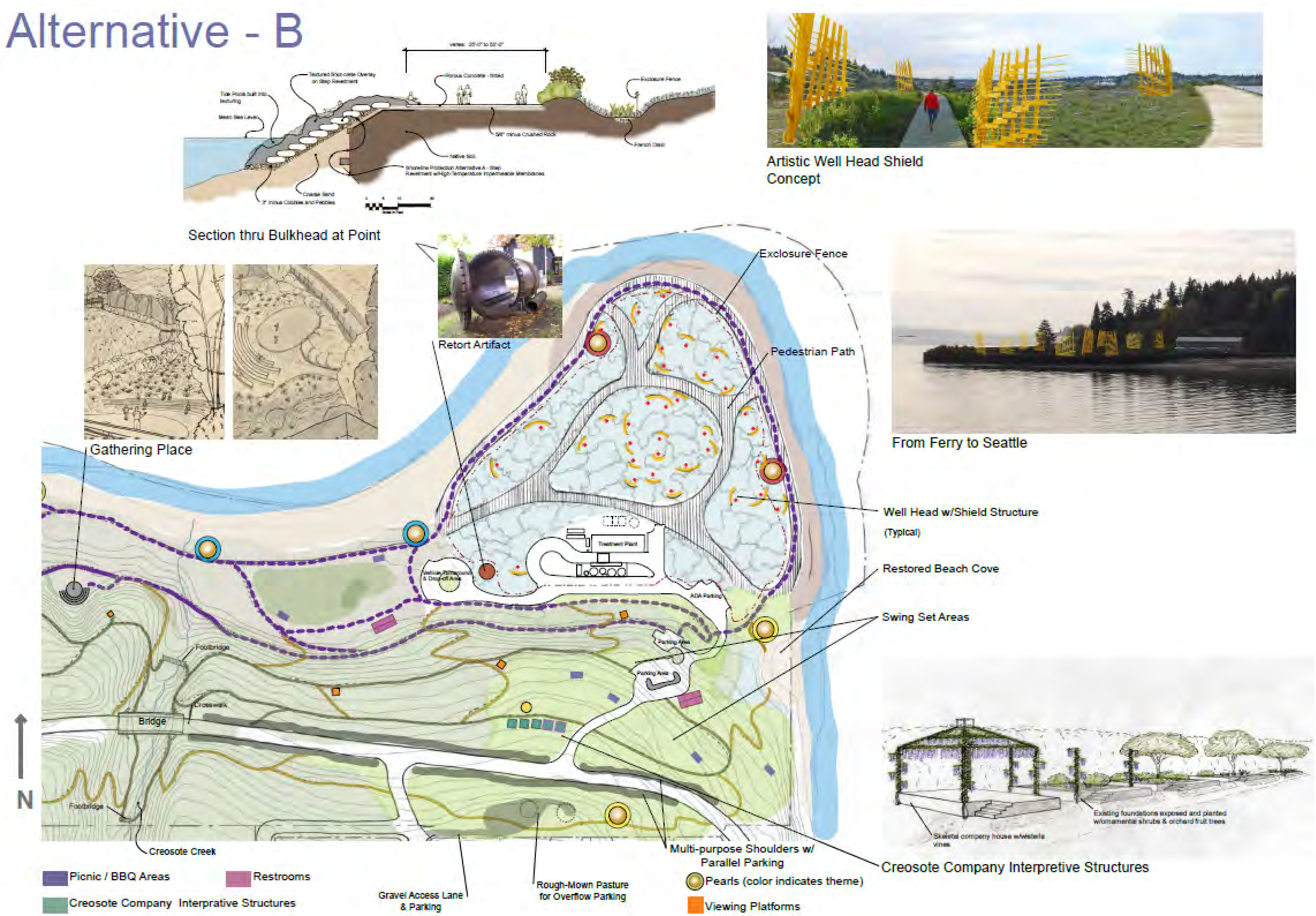
Figure 2.2
Former Process Area Plan

File: F:\projects\SAIC-Wyckoff\GIS\MXD\Figure 2.2 (Former Process Area Plan).mxd
Date: 7/9/2010



Note:
This schematic plan is Figure 3-4 from the Recommended Design for Pritchard Park (Pritchard Park Design Advisory Committee 2008).

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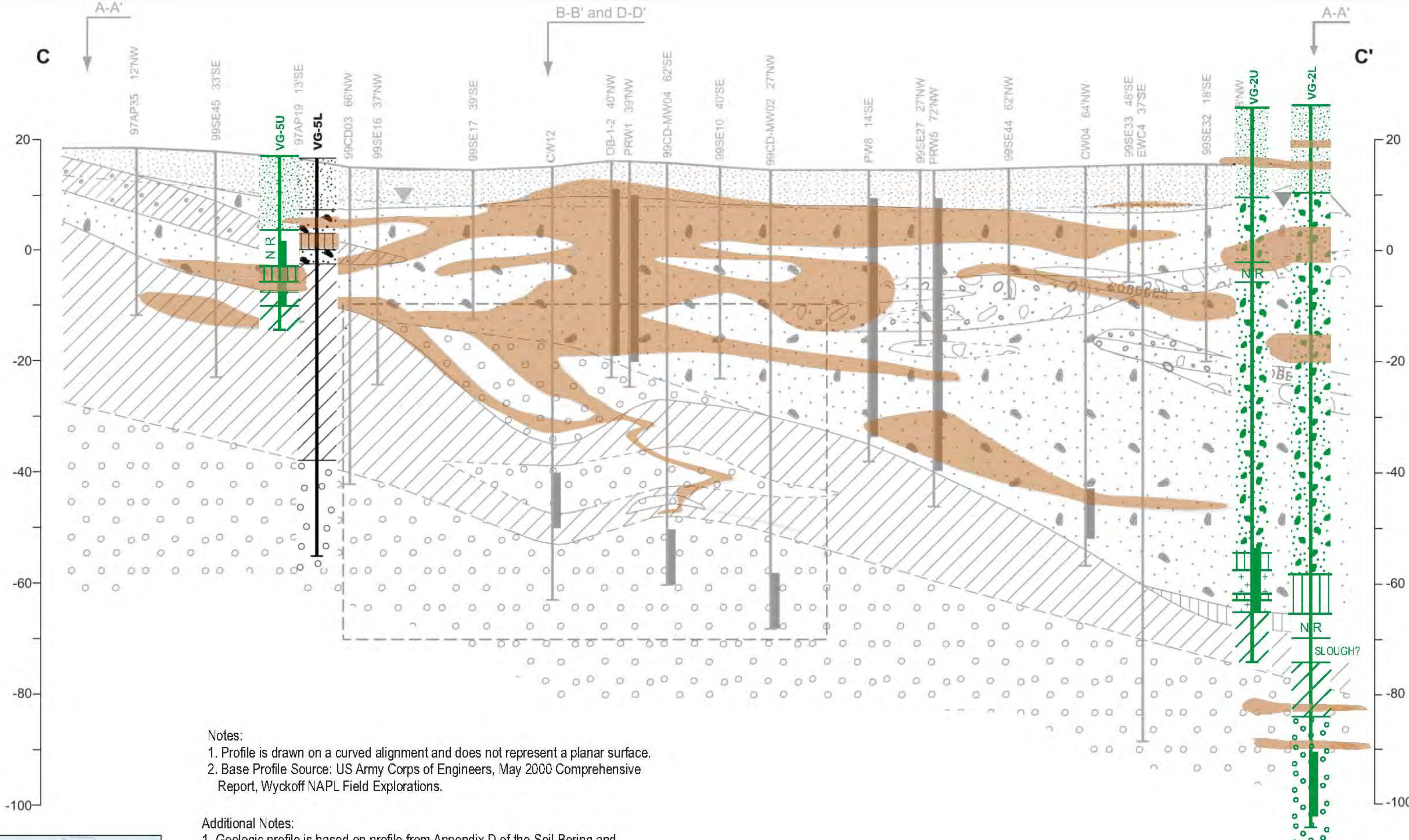
Bainbridge Island, Washington

Figure 2.3
Possible Design Plan for Pritchard Park



GEOLOGIC UNITS

FILL: BROWN, FINE SAND. RARE SHELL FRAGMENTS, WOOD DEBRIS AND MAN-MADE DEBRIS.

NON-MARINE CLAY: GRAY TO BROWN, SOFT TO MEDIUM CLAY WITH PLANT FIBERS, WOOD AND ROOTS, AND BROWN CLAYEY FINE SAND.

MARINE SAND AND GRAVEL: GRAY TO DARK GRAY, LOOSE TO DENSE SAND AND GRAVEL WITH OCCASIONAL COBBLES (COBBLE-RICH AND GRAVEL ZONE SHOWN SEPARATELY), LOW SILT CONTENT AND ABUNDANT SHELL FRAGMENTS.

MARINE SILT: OLIVE-GRAY SILTY SAND (WITH THIN LAYERS OF SAND AND GRAVEL) TO SILT OR CLAY. ABUNDANT SHELL FRAGMENTS.

FLUVIAL SAND: DENSE TO VERY DENSE, GRAY-BROWN TO BROWN, WELL GRADED TO POORLY GRADED SAND WITH VARIABLE GRAVEL AND COBBLES.

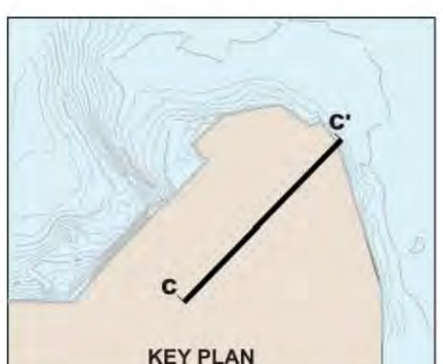
GLACIAL CLAY, SILT AND SAND:
BROWN SILTY SAND: BROWN TO GRAY SILTY SAND WITH GRAVEL AND GRAY-BROWN SILT/CLAY, COMMON OXIDATION, DENSE TO VERY DENSE.
DARK GRAY TO BLUE-GRAY CLAY OR SILT, LITTLE FINE SAND, TRACE GRAVEL, STIFF TO HARD.
DENSE SILTY GRAVEL: GRAY-BROWN TO GRAY-OLIVE SILTY GRAVEL AND SAND WITH OCCASIONAL OXIDIZED CLASTS, EXTREMELY DENSE.

NAPL (SEE DEFINITION IN CONCEPTUAL SITE MODEL TEXT)

N R NO RECOVERY

Notes:
1. Profile is drawn on a curved alignment and does not represent a planar surface.
2. Base Profile Source: US Army Corps of Engineers, May 2000 Comprehensive Report, Wyckoff NAPL Field Explorations.

Additional Notes:
1. Geologic profile is based on profile from Appendix D of the Soil Boring and Monitoring Well Construction Summary—Wyckoff/Eagle Harbor Superfund Site (CH_2MHill 2009).
2. 2008 monitoring well log geologic information has been superimposed on the profile by CH_2MHill (well VG-5L) and Floyd|Snider and Aspect Consulting (wells VG-2U, VG-2L, and VG-5U, shown in green).
3. Coloration to the NAPL in the profile was added by Floyd|Snider and Aspect Consulting.



60' 30' 0 60' 120'
HORIZONTAL SCALE IN FEET
VERTICAL EXAGGERATION = 3X

PW8 14'SE — BORING ID NUMBER AND DISTANCE OF OFFSET FROM ALIGNMENT
WELL SCREEN
APPROX WATER TABLE

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Bainbridge Island, Washington

Figure 2.4
Geologic Profile C-C' (Updated)

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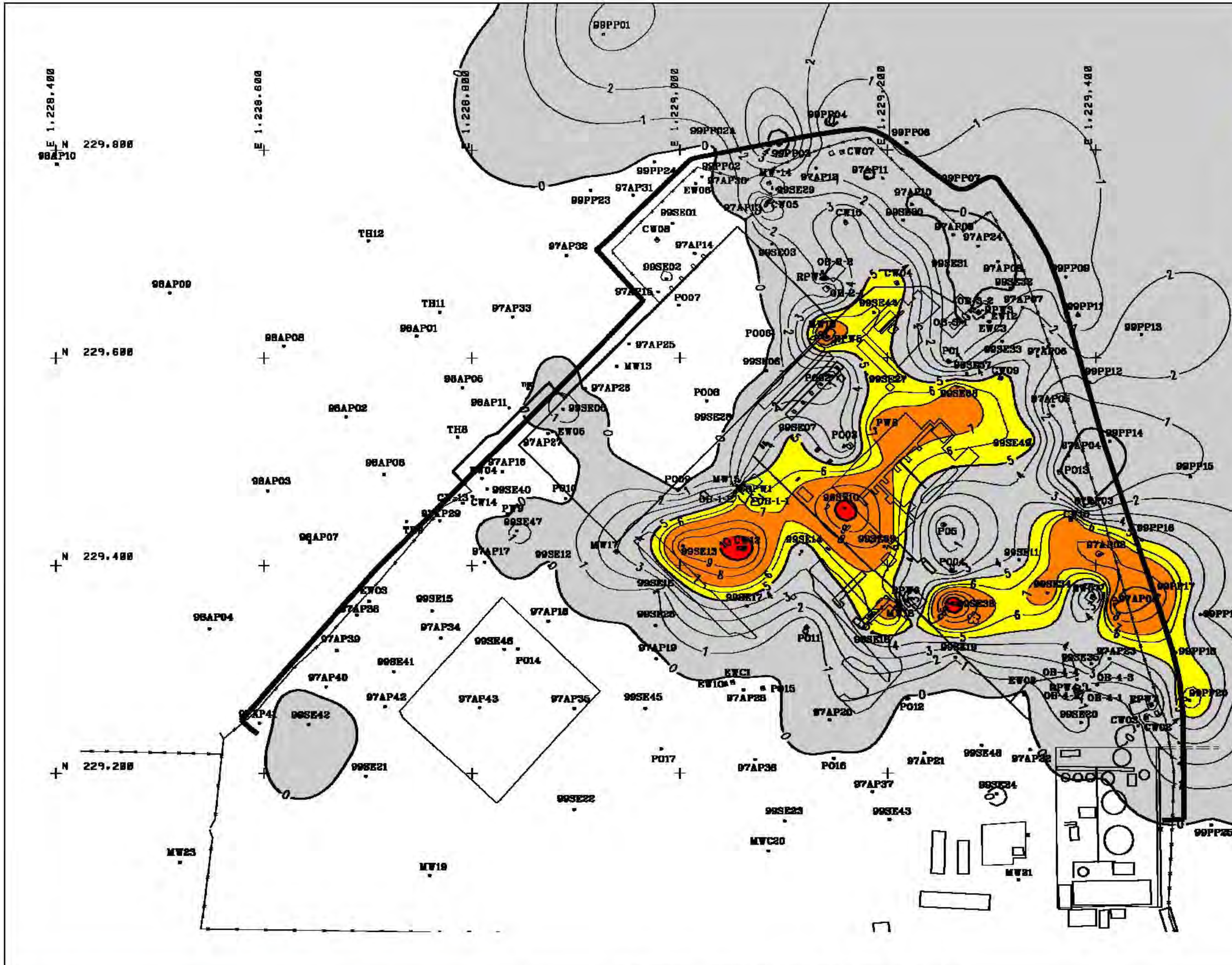

FLOYD|SNIDER AND ASPECT ADDITIONS

LNAPL THICKNESS (IN FEET)

- 0 to 5
- 7 to 10
- 5 to 7
- > 10

ADDITIONAL NOTES:

1. LNAPL THICKNESS MAP IS FIGURE 4-1 FROM THE GROUNDWATER CONCEPTUAL SITE MODEL UPDATE (CH2M HILL, 2007).
2. COLORATION OF THE CONTOURS ON THIS FIGURE WAS ADDED BY FLOYD|SNIDER AND ASPECT CONSULTING.

LEGEND

- SHEETPILE WALL ALIGNMENT

NOTES:

1. CONTOUR VALUES REPRESENT ESTIMATED TOTAL THICKNESS OF SOIL CONTAINING MOBILE LNAPL.
2. CONTOUR INTERVAL IS 1 FEET.
3. CONTOURS WERE COMPUTER-GENERATED BY SURFER USING KRIGING AND LINEAR DRIFT INTERPOLATIONS. CONTOURS ARE BASED ONLY ON DATA POINTS SHOWN AND MAY NOT REPRESENT ACTUAL CONDITIONS NEAR BOUNDARIES OF DRAWING.

0 100' 200'

HORIZONTAL DATUM IS WSPCS NAD83
VERTICAL DATUM IS MLLW

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Bainbridge Island, Washington

Figure 2.5
LNAPL Thickness

DWG NAME: G:\project\Clients\Floyd and Snider\Wyckoff\Wyckoff003.dwg
DATE: 7/9/2010 1:11 PM

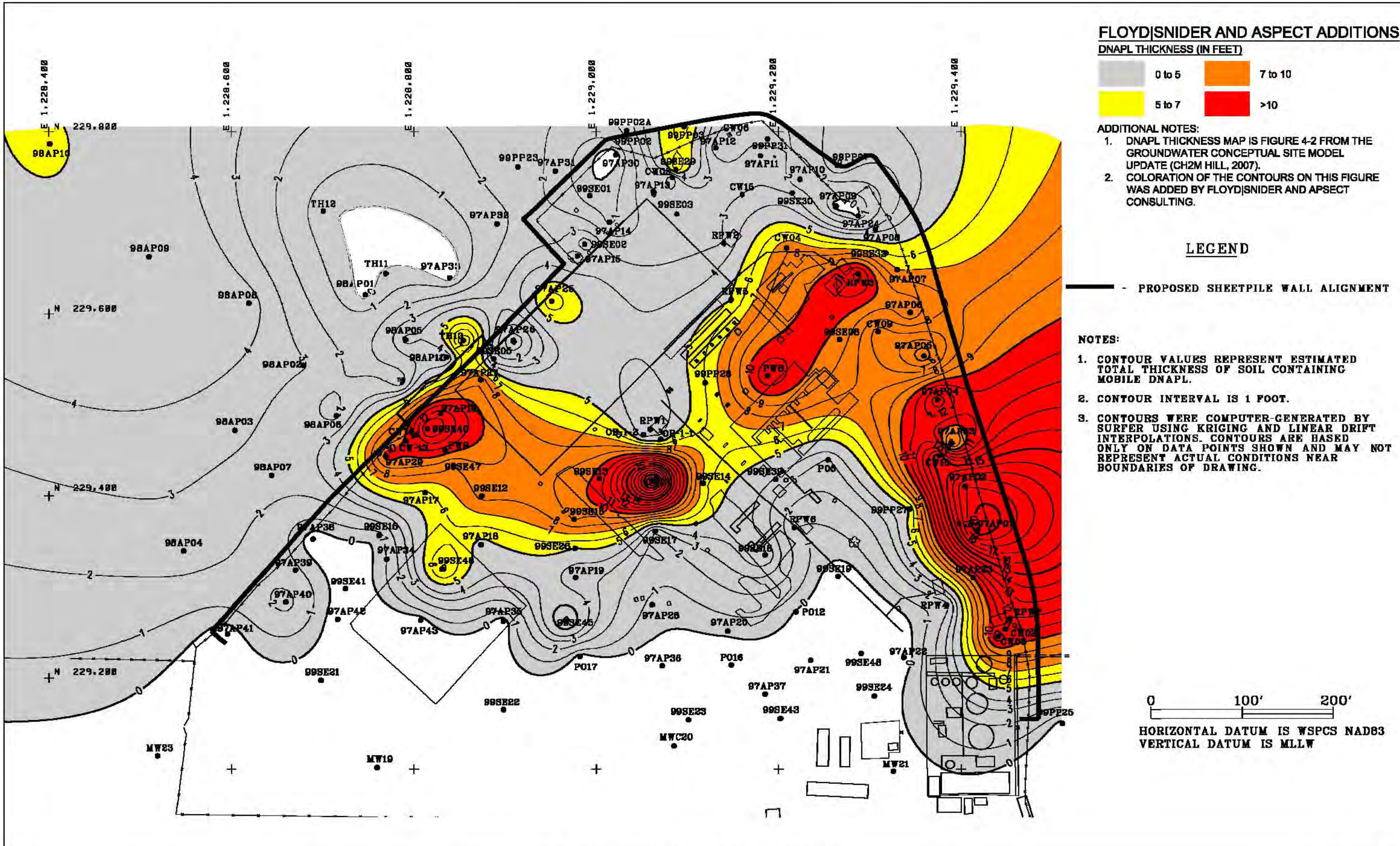

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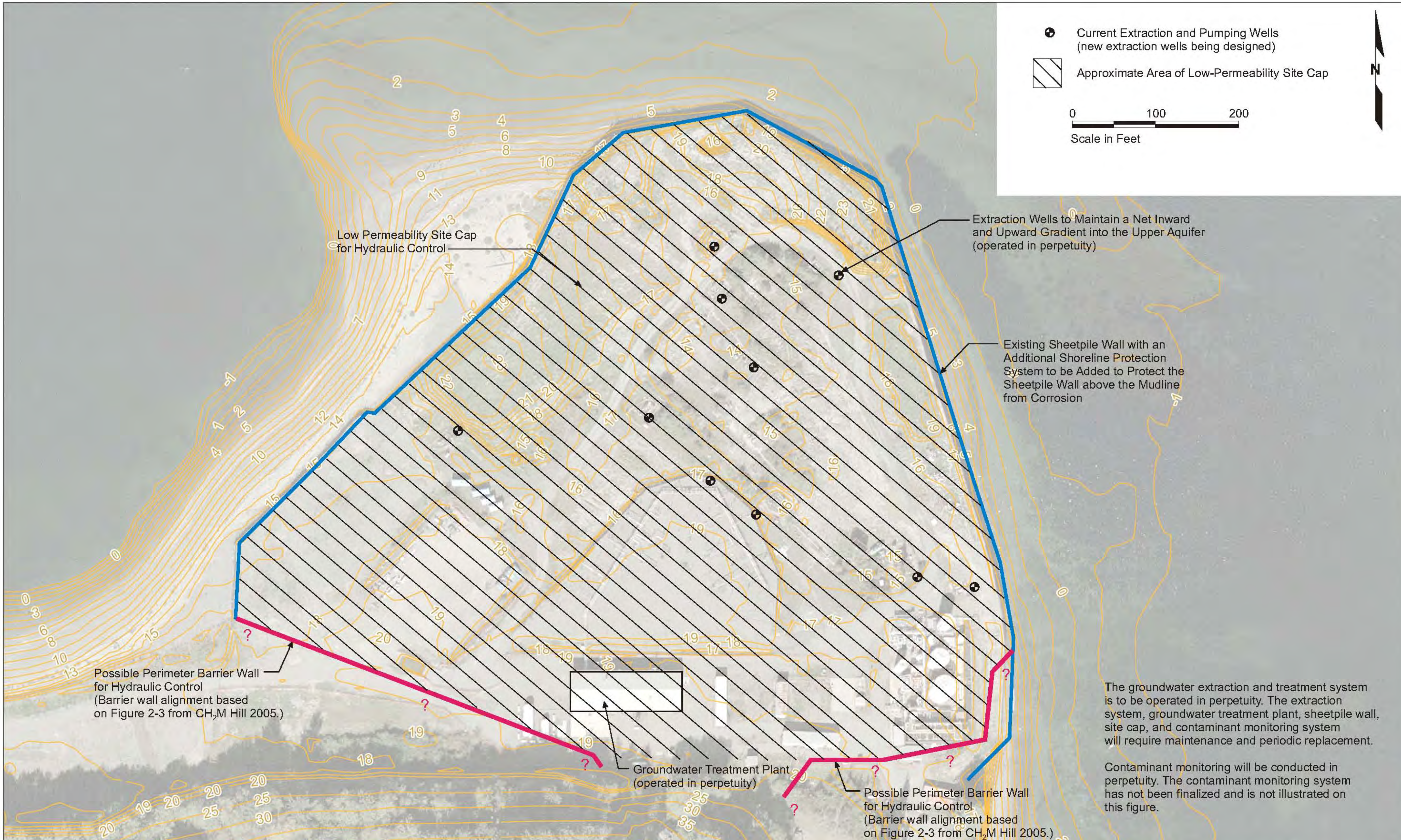
Figure 2.6
DNAPL Thickness

DWG NAME: G:\project\Clients\Floyd and Snider\Wyckoff\Wyckoff004.dwg
DATE: 7/9/2010 1:13 PM



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Generational Remedy Evaluation
The Wyckoff Point
Bainbridge Island, Washington

Figure 3.1
Plan View of USEPA Containment Remedy

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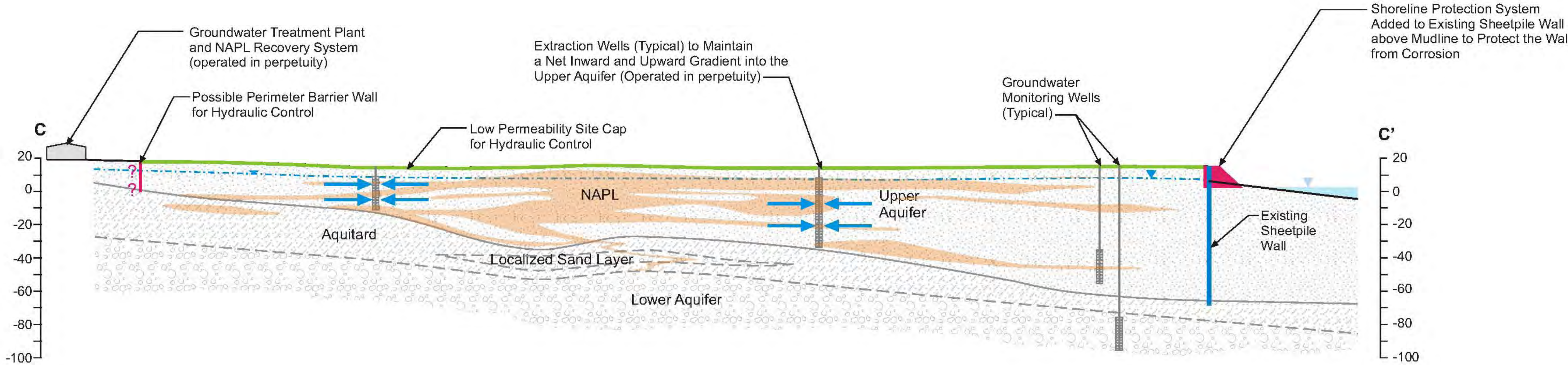

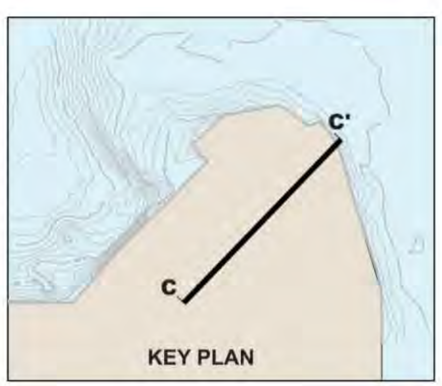

Notes:
Geologic profile is simplified version of the profile in Figure 2.4.

Profile is drawn on a curved alignment and does not represent a planar surface.

Base Profile Source: US Army Corps of Engineers. May 2000. Comprehensive Report, Wyckoff NAPL Field Exploration.

60' 30' 0' 60' 120'
HORIZONTAL SCALE IN FEET

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The Wyckoff Point
Bainbridge Island, Washington

Figure 3.2
Profile View of USEPA Containment Remedy

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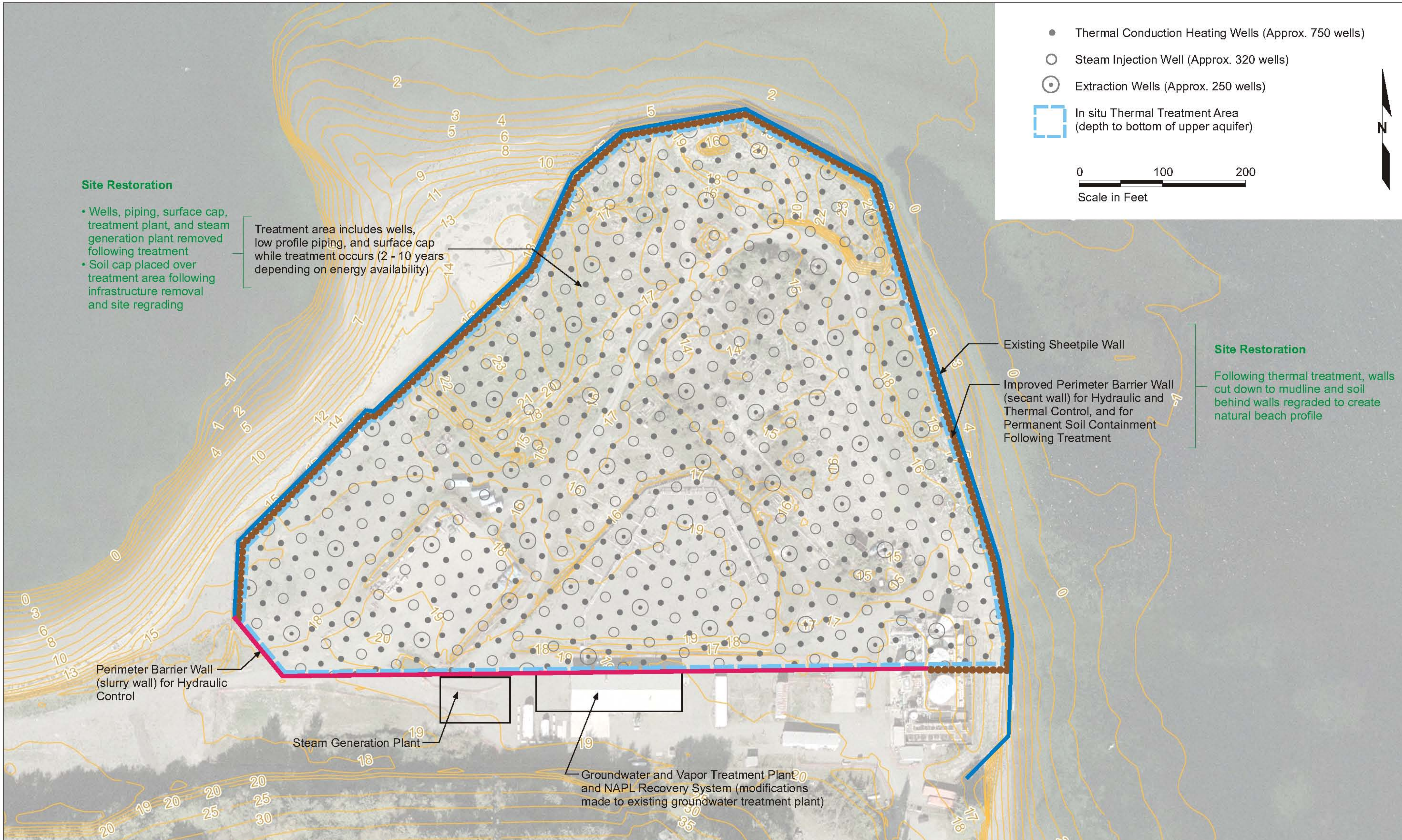

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Generational Remedy Evaluation
The Wyckoff Point
Bainbridge Island, Washington

Figure 4.1
Plan View of Alternative 1

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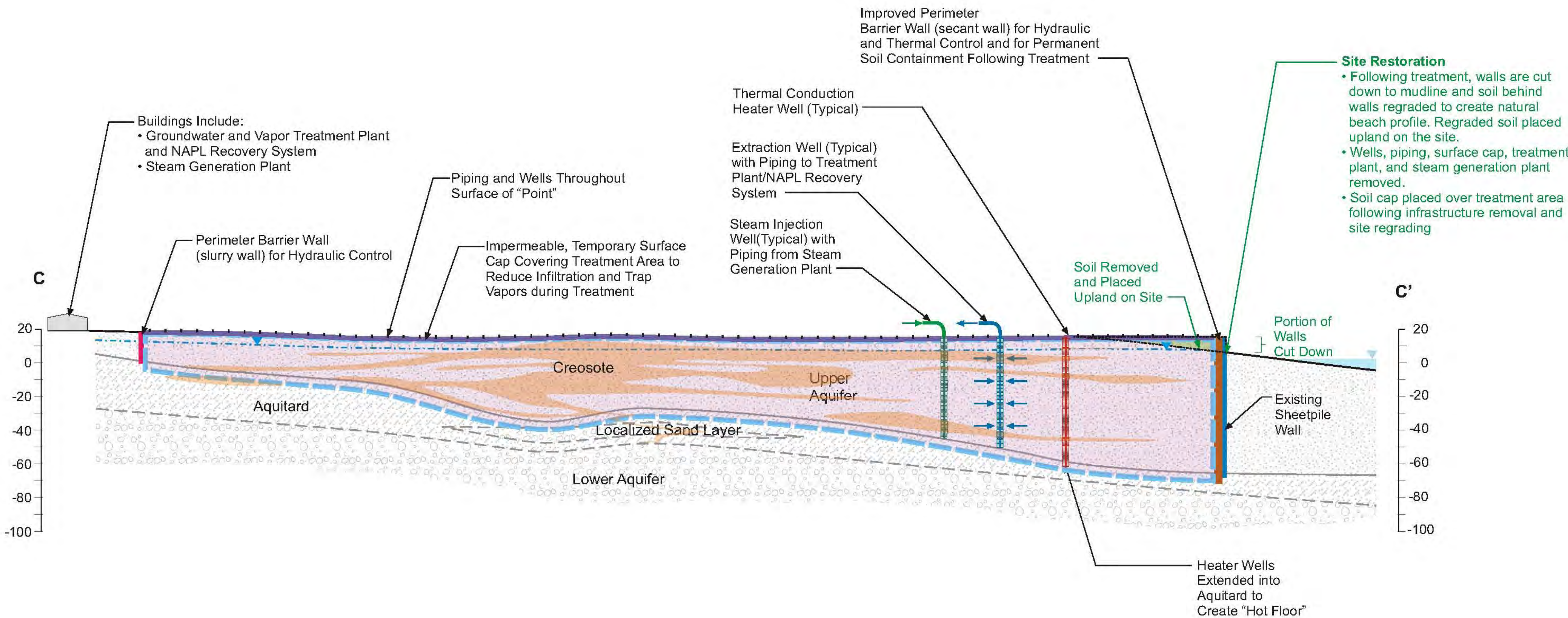

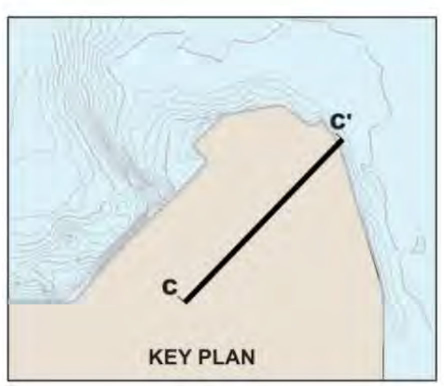

Notes:
Geologic profile is simplified version of the profile in Figure 2.4.

Profile is drawn on a curved alignment and does not represent a planar surface.

Base Profile Source: US Army Corps of Engineers. May 2000. Comprehensive Report, Wyckoff NAPL Field Exploration.

60' 30' 0' 60' 120'
HORIZONTAL SCALE IN FEET

In-situ Thermal Treatment Area

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Bainbridge Island, Washington

Figure 4.2
Profile View of Alternative 1

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Note: Photograph provided by R. Baker, TerraTherm, Inc.

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Bainbridge Island, Washington

Figure 4.3
Photograph of Typical Thermal Remediation Well and Piping Network

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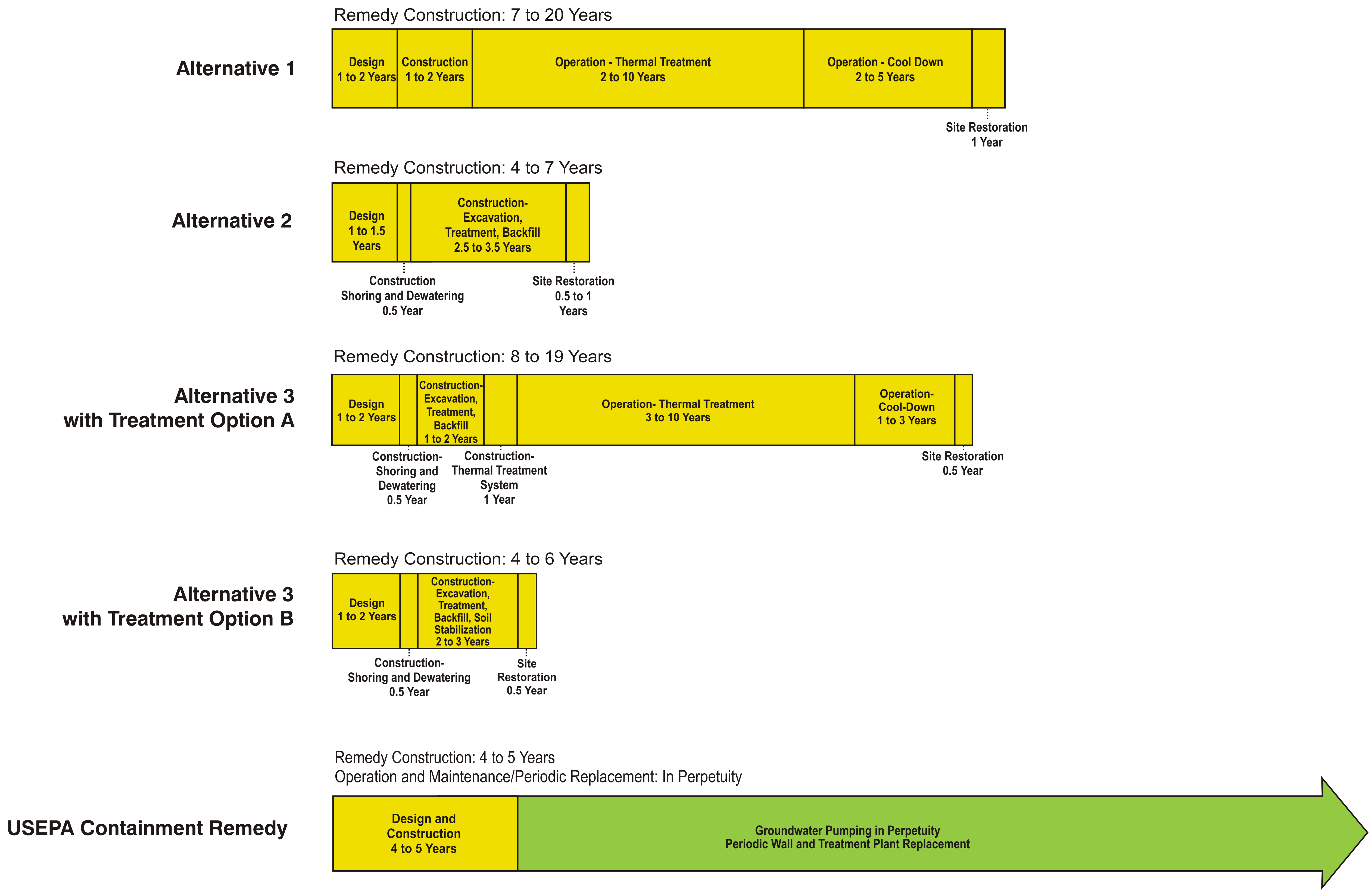

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The Wyckoff Point
Bainbridge Island, Washington

Figure 4.4
Alternative Timelines

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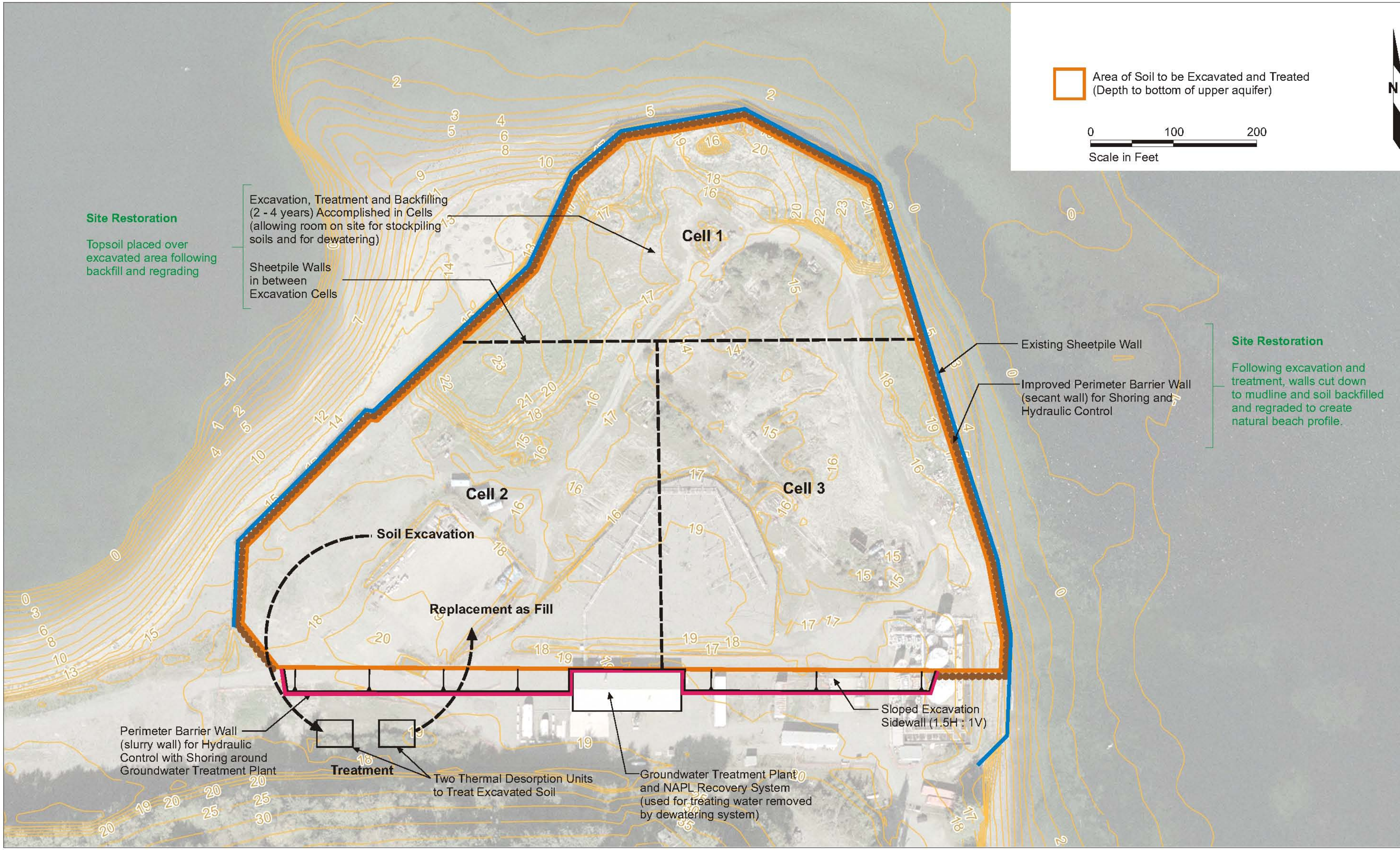

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The Wyckoff Point
Bainbridge Island, Washington

Figure 4.5
Plan View of Alternative 2

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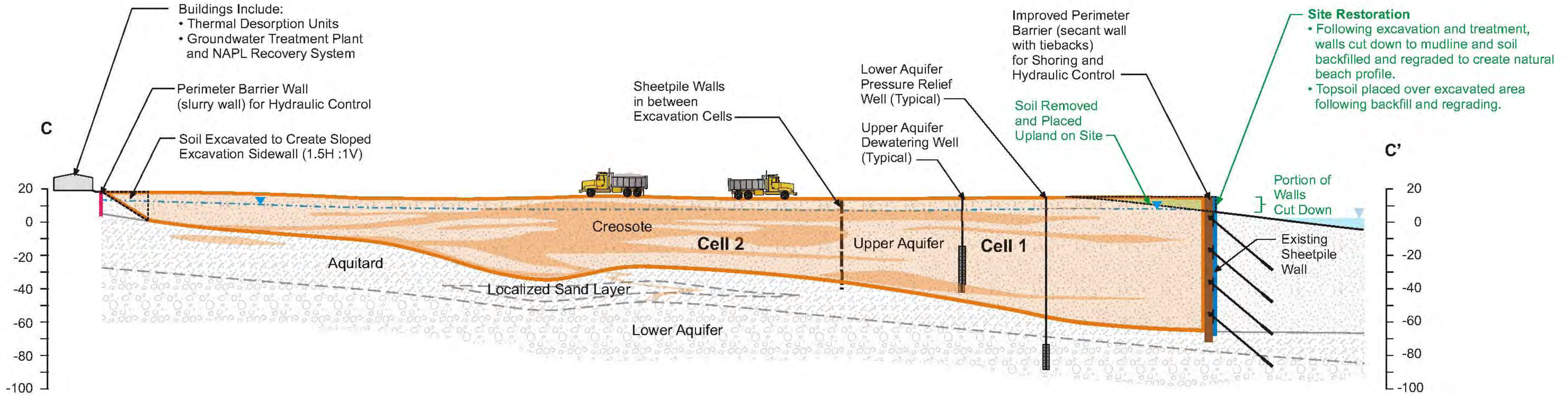
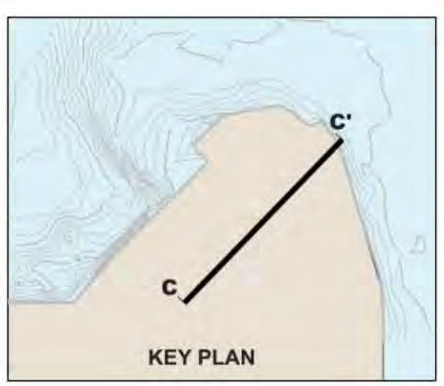


Notes:
Geologic profile is simplified version of the profile in Figure 2.4.

Profile is drawn on a curved alignment and does not represent a planar surface.

Base Profile Source: US Army Corps of Engineers. May 2000. Comprehensive Report, Wyckoff NAPL Field Exploration.

Area of Soil to be Excavated and Treated



60' 30' 0' 60' 120'
HORIZONTAL SCALE IN FEET

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The Wyckoff Point
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Figure 4.6
Profile View of Alternative 2

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Note: Photograph provided by F. Kellogg III, DCI Environmental, Inc.

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The Wyckoff Point
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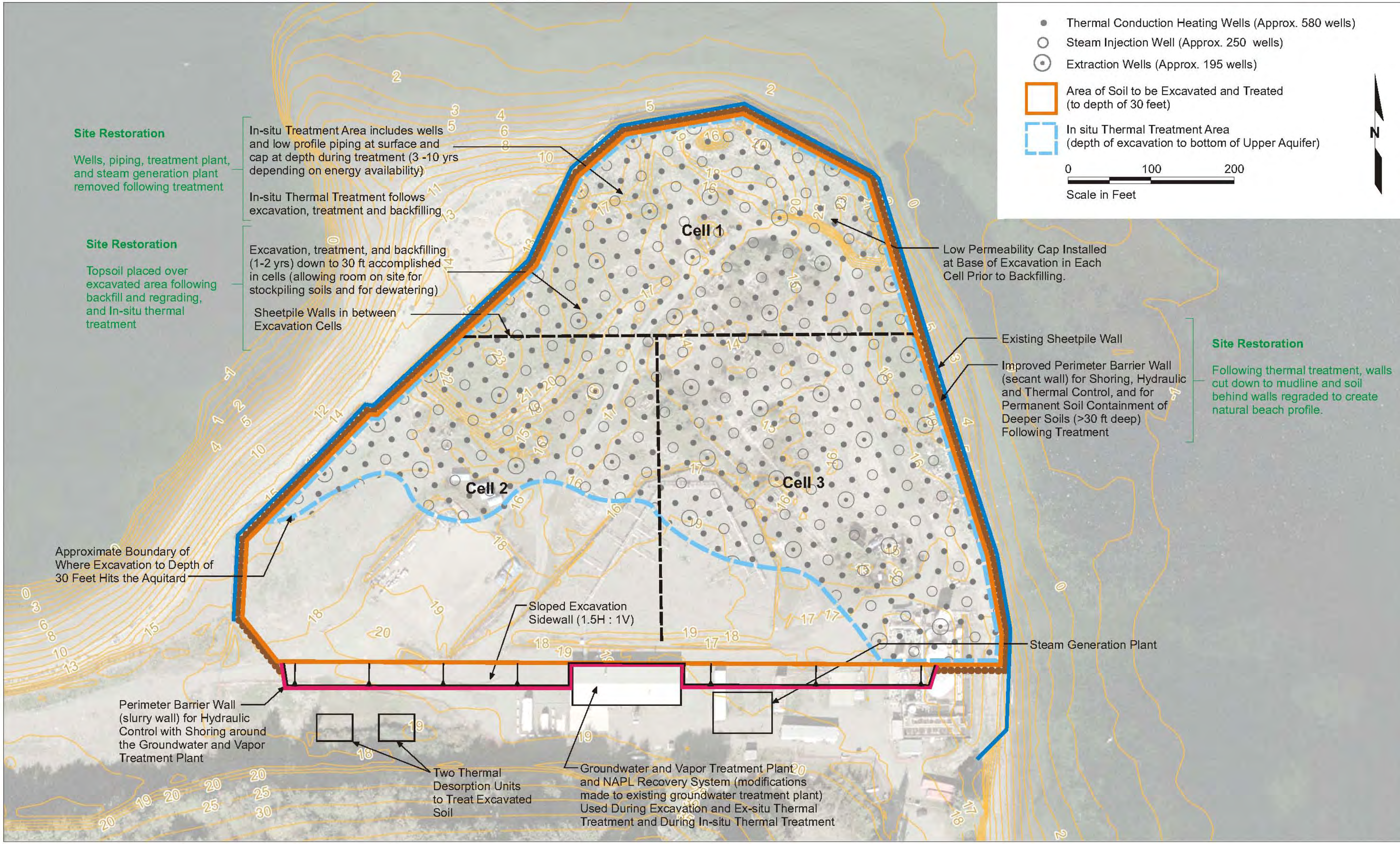
Figure 4.7
Photograph of Thermal
Desorption Unit in Operation



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Generational Remedy Evaluation
The Wyckoff Point
Bainbridge Island, Washington

Figure 4.8
Plan View of Alternative 3 with Treatment Option A

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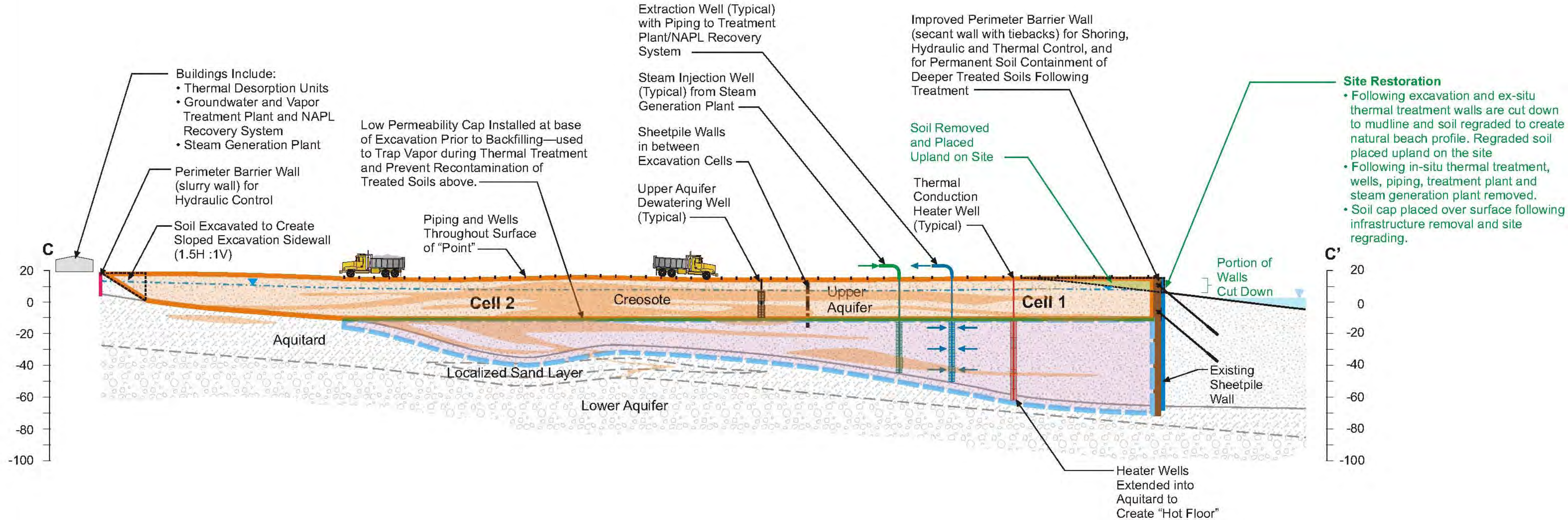

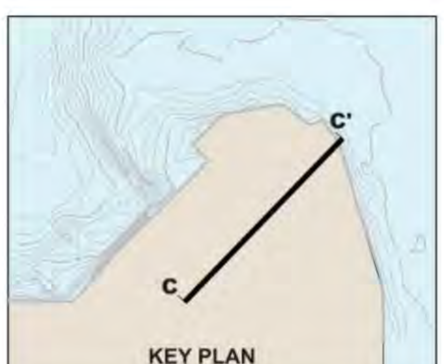

Notes:
Geologic profile is simplified version of the profile in Figure 2.4.

Profile is drawn on a curved alignment and does not represent a planar surface.

Base Profile Source: US Army Corps of Engineers. May 2000. Comprehensive Report, Wyckoff NAPL Field Exploration.

60' 30' 0' 60' 120'
HORIZONTAL SCALE IN FEET

Area of Soil to be Excavated and Treated

In situ Thermal Treatment Area

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Generational Remedy Evaluation
The Wyckoff Point
Bainbridge Island, Washington

Figure 4.9
Profile View of Alternative 3 with Treatment Option A

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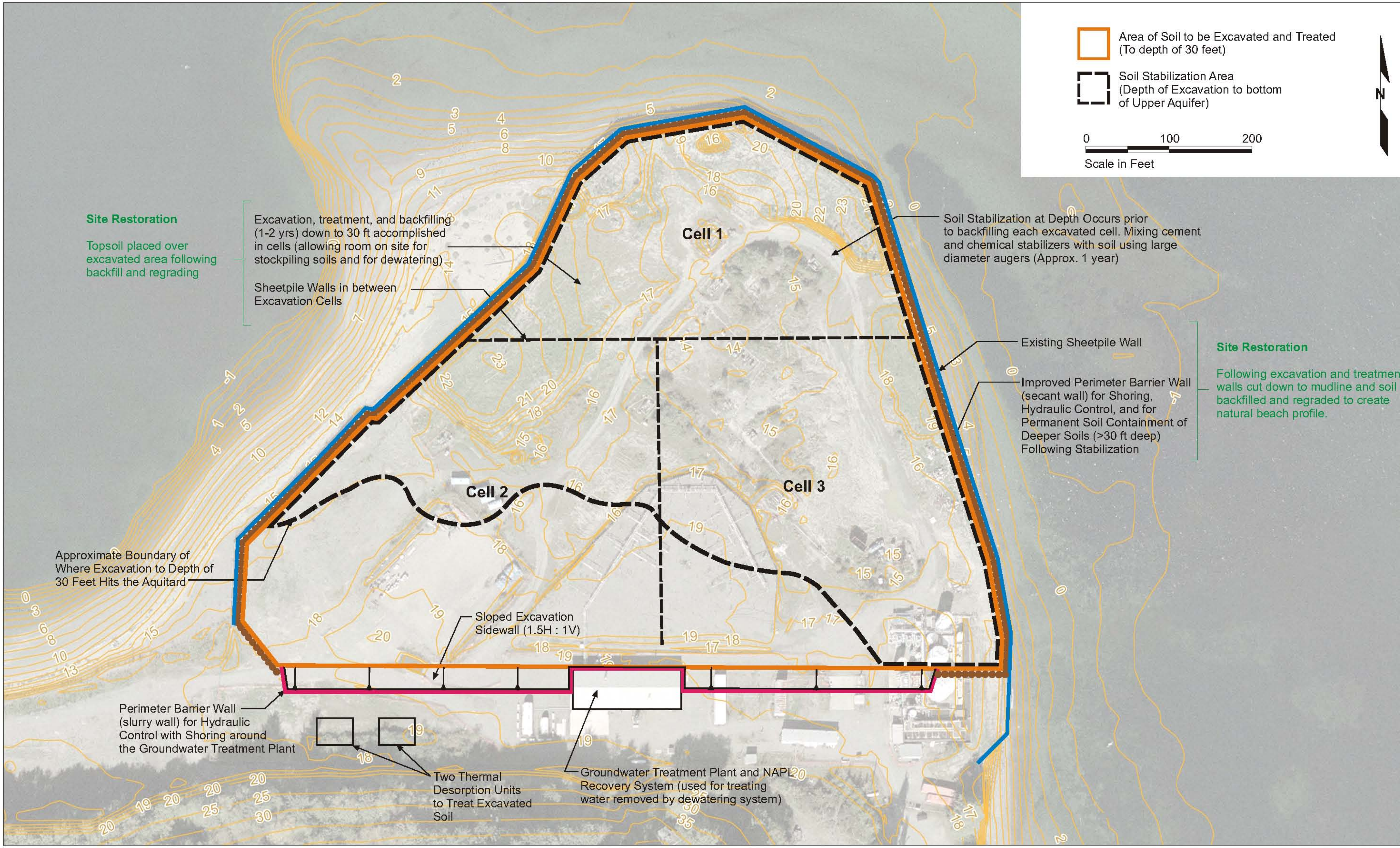

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Generational Remedy Evaluation
The Wyckoff Point
Bainbridge Island, Washington

Figure 4.10
Plan View of Alternative 3 with Treatment Option B

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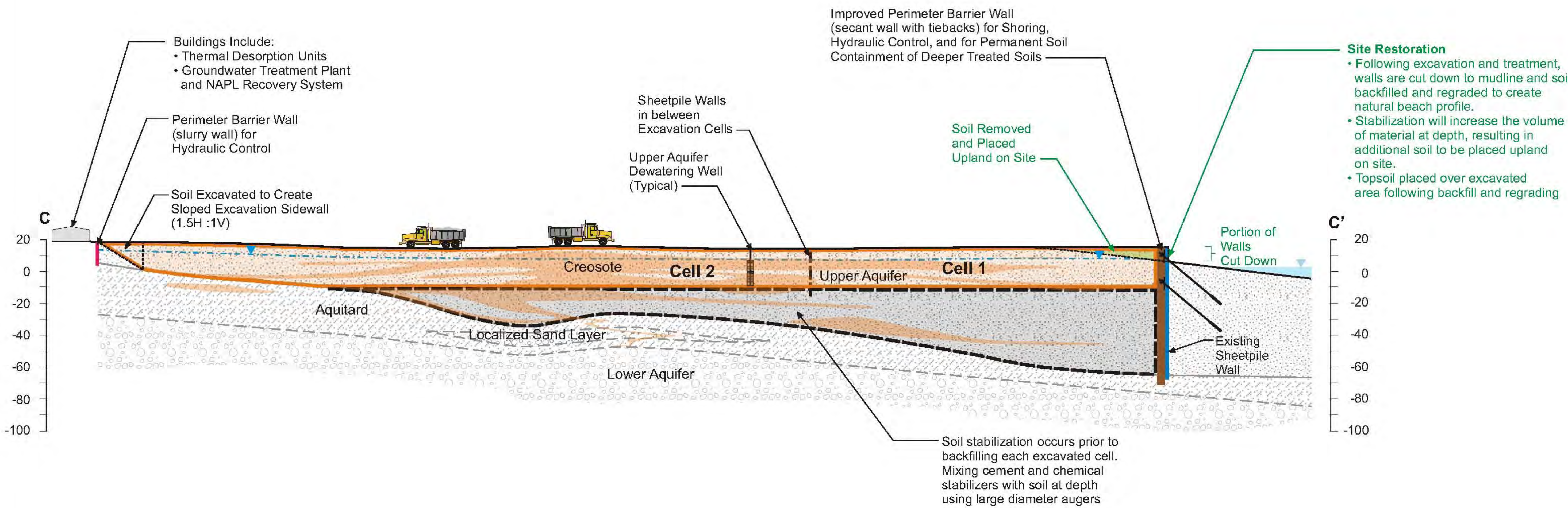

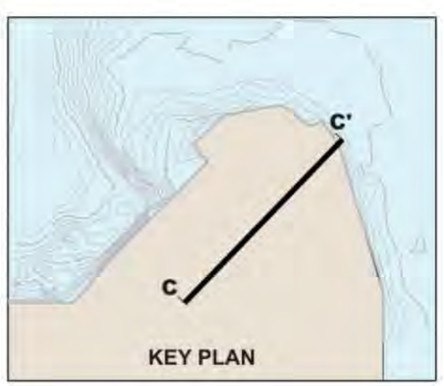

Notes:
Geologic profile is simplified version of the profile in Figure 2.4.

Profile is drawn on a curved alignment and does not represent a planar surface.

Base Profile Source: US Army Corps of Engineers. May 2000. Comprehensive Report, Wyckoff NAPL Field Exploration.

60' 30' 0' 60' 120'
HORIZONTAL SCALE IN FEET

Area of Soil to be Excavated and Treated

Soil Stabilization Area

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Generational Remedy Evaluation
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Figure 4.11
Profile View of Alternative 3 with Treatment Option B

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The Wyckoff Point
Bainbridge Island, Washington

Generational Remedy Evaluation

Appendix A
Generational Remedy Evaluation
Project Objectives

Wyckoff Eagle Harbor
Department of Ecology Generational Remedy Evaluation
Project Objectives

OVERVIEW

EPA is implementing a containment remedy at "the Point" on the Wyckoff Eagle Harbor site under CERCLA (Superfund). The containment remedy includes a perimeter wall, site cap, and groundwater extraction system to contain soil and groundwater contamination and mobile tar compounds. The containment remedy is necessary for near-term control of site contamination and protectiveness of human health and the environment.

The Department of Ecology agrees the containment remedy is necessary, but has concerns regarding the containment remedy that relate to long-term stewardship. Ecology has two primary concerns:

1. The long-term environmental consequence of leaving large amounts of mobile contamination at this site, especially given the important and sensitive location of the site on the shores of Puget Sound; and,
2. The financial burden that this action places on the state – an in-perpetuity obligation for active operation and maintenance, including periodic rebuilding of the remedy containment components such as the groundwater extraction system and perimeter wall.

Therefore, Ecology has made a commitment to evaluate potential remedial alternatives for Wyckoff soil and groundwater that would reduce the source or mobility of the contamination and that would remain protective of humans and the aquatic environment for future generations with little active management over the long term. The goal is that a "generational remedy" would minimize the potential for, and consequences of, a potential future environmental release, and significantly reduce long-term financial obligations to state government and burdens on the local community for future generations.

Ecology will undertake the Generational Remedy Evaluation over an approximate 9-month period in 2009-2010, with the assistance of a panel of regional and national experts, and a Steering Committee with community and tribal representatives. This evaluation process will provide conceptual remedial alternatives for the site, but will not result in a decision. This process is just a first step in a long process. Whatever alternatives are evaluated, they will likely be quite costly, and their implementation would require a sustained funding source. Given questions of funding, responsibility, and schedule, if a viable alternative is identified in this process for pursuit, it would likely take quite a bit of time to develop an implementation strategy.

Objectives are defined below for the 9-month Evaluation process – what Ecology hopes to achieve by the end of the evaluation. Additionally, guiding principles for a "Generational Remedy" are defined – what the characteristics are of a remedy that would reduce environmental risks for multiple generations with minimal on-going operations and maintenance costs. These objectives and guiding principles are intended for use by the steering committee and the expert panel as they work through this evaluation process.

OBJECTIVES FOR THE GENERATIONAL REMEDY EVALUATION PROCESS

Objectives for the evaluation process include the following:

- Evaluate options for a "generational remedy" that could reduce environmental risks for multiple generations with minimal on-going operations and maintenance requirements or costs (see "generational remedy" definition below).
- Work with the community to fully engage and look at the problem in a different way.
    - Form a community-based steering committee with membership from local government, Tribes and the community. The steering committee will provide input to Ecology in structuring the effort, in defining remedy objectives, selecting the expert panel, and reviewing outcomes. The steering committee provides an important reality check and knowledge of local goals.
    - Utilize an expert panel of national and local experts within the environmental cleanup field and other fields, experienced in the remediation of similar sites and large construction projects in challenging or constrained environments.
    - Provide information to the broader Bainbridge community about the generational remedy process, information developed, options under consideration, and resulting recommendations, including integrating public input into Steering Committee meetings, holding several community dialogue events, and providing other informal opportunities for information-sharing within the community as indicated by community interest.
- Recognize that this process is outside the regulatory framework. This is not about meeting regulatory cleanup standards, but about looking at concerns at the site from a viewpoint of future generations.
- The effort is not meant to replace EPA's containment remedy which has been determined to be necessary for near-term control of the site.
- The outcome will be the identification of 1-3 primary alternatives for a "generational remedy", and associated order-of-magnitude costs and schedule information.
- A document will be prepared defining generational remedy alternatives that can be used by agency management and political representatives to consider whether to pursue implementation of generational remedy components to supplement the EPA containment remedy.

GUIDING PRINCIPLES FOR A GENERATIONAL REMEDY

For this initial conceptual evaluation, the guiding principles for a Generational Remedy are described below. Each of the remedial alternatives identified through this evaluation should meet this list of guiding principles.

- The remedy evaluation will focus on the cleanup prism within “The Point” at the site. The 3-dimensional cleanup zone extends vertically to the upper aquitard unit and horizontally to the existing sheet pile wall (or a barrier, just outside of the existing wall). Diagrams will be developed to clarify this definition.
- Evaluate remedies that remove, treat, and/or significantly reduce the mobility of mobile contaminant sources (creosote product and creosote-soaked soils) within the cleanup zone, so that remedy does not depend on long-term maintenance and rebuilding of containment structures or active pumping systems.
- Evaluate remedies that would significantly reduce the risk of a large-scale and unrecoverable release threatening humans and the aquatic environment if active operation and maintenance of systems at the site was terminated or significantly reduced, and no full-scale reconstruction of containment remedy components (extraction/treatment system and containment wall) was conducted.
- In defining such remedies, acknowledge the likelihood of significant earthquake and sea level rise to occur over generational time.
- Allow for open use by the public, including realization of the community’s plan for park use, and a healthy and sustainable terrestrial and marine ecosystem.
- Evaluate remedies that can be implemented at this location given currently available, readily obtainable and constructible infrastructure, including methods for waste transport and disposal.

The Wyckoff Point
Bainbridge Island, Washington

Generational Remedy Evaluation

Appendix B
Estimated Time for Mass Degradation of NAPL within the Former Process Area

Estimated Time for Mass Degradation of NAPL Inside the Former Process Area

Estimated volume of NAPL within the Former Process Area is 1.2 million gallons.

Assume that NAPL is composed of only PAHs.

Based on the DNAPL chemical data (data from Table 4-2 from the Wyckoff Groundwater CSM Update Report (CH2M Hill 2007)), approximately 85 percent of the total PAHs is LPAHs and 15 percent is HPAHs.

LPAHs will degrade faster than HPAHs. The calculations below determines the time for the degradation of the LPAH mass (the fastest fraction).

The average detected concentration of LPAHs (based on the DNAPL chemical data) is 144,512,000 µg/L.

Used the above information to calculate the grams of LPAHs present within the NAPL:

6.6E+08 grams of LPAHs in NAPL

Estimated soil volume in Former Process Area is 650,000 cubic yards. Approximately 500,000 cubic yards is saturated.

Assume a standard porosity of 0.3.

Used the above information to calculate the liters of groundwater within the Former Process Area:

1.1E+08 Liters of Groundwater

Assume Naphthalene is representative of LPAHs (makes up approximately 50 percent of the LPAHs based on DNAPL chemical data).

The maximum concentration of naphthalene during the Upper Aquifer Baseline Characterization Groundwater Sampling in 2002 was 12,600 µg/L (data from Table 4-8 from the Wyckoff Groundwater CSM Update Report (CH2M Hill 2007).

Used the above information to calculate the grams of LPAHs (naphthalene) in groundwater.

1.4E+06 grams of LPAHs in Groundwater

Assume only dissolved LPAHs are biodegradable.

Removal of the LPAHs in the groundwater via biodegradation results in additional dissolution of LPAHs from the NAPL to the groundwater.

Assume dissolution is faster than degradation (i.e., naphthalene is replaced in groundwater as soon as it is degraded).

Assume the half life of naphthalene in anaerobic conditions is 258 days ($t_{1/2}$)[1].

Again assume naphthalene is representative of LPAHs.

To calculate mass degradation, use the following equation: $C_t = C_o * e^{-kt}$

Where: $k = \ln 2 / t_{1/2}$

C_o = the initial concentration

C_t = the concentration at time (t)

Rearranging the equation to solve for time (t): $t = t_{1/2} * -\ln (C_t/C_o)/\ln 2$

Used the equation to determine how much time it takes to degrade the amount of LPAHs in groundwater to 95 percent of the initial concentration in years:

0.052
Time to Degrade 5 Percent of the LPAHs in Groundwater in Years

Calculate the rate of mass removal of LPAHs from groundwater per year by taking the amount removed (5 percent) times the grams in LPAHs in groundwater, and divided by the time to degrade 5 percent of the LPAHs.

[1] Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, E.M. Michalenko. 1991. *Handbook of Environmental Degradation Rates*. Lewis Publishers.

1.38E+06 grams of LPAHs Removed from Groundwater per Year

Dividing the total mass of LPAHs in the NAPL by the rate of mass removal in groundwater gives you an estimate of the amount of time it would take to degrade the LPAH in the NAPL pool.

475
Time to Degrade LPAH in NAPL in Years

Naphthalene has one of the fastest degradation rates and highest solubility rates for the PAHs.

HPAHs that would comprise the remaining 15 percent of the PAHs would degrade slower and have lower solubility rates, and therefore would remain at the site for a much longer duration.

The Wyckoff Point
Bainbridge Island, Washington

Generational Remedy Evaluation

Appendix C
Community Involvement in the Wyckoff Generational Remedy Evaluation

Appendix C.

Community Involvement in the Wyckoff Generational Remedy Evaluation

Introduction

The Bainbridge Island community has been engaged in the future of the entire Wyckoff Site, and especially the Point, for two decades. There are strong interests in the community, tribal and local government, and community groups, to reduce short-term and long-term risk from the site as well as restore the Point as a valuable and prominent shoreline part of Pritchard Park.

As Ecology launched the Generational Remedy Evaluation in the fall of 2009, involving the community was an important priority. Local government, Suquamish Tribe, and community engagement occurred through intensive involvement of the Steering Committee, described in the body of the report. In addition, an integrated process to inform and engage the broader community took place through Ecology's community involvement effort, supported by their contractor, EnviroIssues. This appendix documents that process and the valuable input received that helped the Ecology team develop the content of the evaluation report.

Consultation with the Community

Engaging the Bainbridge community called for distributing information broadly and, based on what the community learned, seeking their ideas, input, and reactions as the evaluation proceeded. That took place in several ways:

- A project-specific website gave community members access to all materials developed as part of the evaluation process (see www.WyckoffGenerationalRemedy.org or www.ecy.wa.gov/programs/tcp/sites/wyckoff/wyckoff_hp.htm). In this way materials including an initial focus sheet and the objectives for the generational remedy evaluation were made available early, along with basic historic background on the site and the site conditions. As the project moved ahead, meetings were announced, draft and final documents posted, and other information provided through the website.

- Steering Committee meetings were announced and were open to public observation and comment, and individual committee representatives communicated with their constituencies about the process as it unfolded.

- The first opportunity to engage the community directly came during the expert panel workshop, described in the body of the report. Concepts for potential generational remedies were developed by the expert panel, and interested people and groups followed the progress of the workshop via online presentations and Twitter and blog commentary. The results of the expert panel deliberations were presented as a "work in progress" to the community at a community meeting at IslandWood in January 2010. The meeting was broadly publicized through project and community organization websites, posters in the community, display advertisements in local newspapers, mailing and emailing to identified distribution lists, ferry announcements, local access cable, and media releases. Attendees at the meeting were briefed on the results of the expert panel work, and asked to provide their input verbally, through comment forms, or through an online comment mechanism. Community members asked great questions, mingled with the experts and the Ecology team, and began to see how a generational remedy might reduce long-term risk and return the Point to community use. The summary of that meeting is attached; also included is a set of frequently-asked questions that resulted, which was posted on the website. These inputs helped shape the development of the three potential alternative remedies.

- A second community event in March 2010 was publicized similarly, and provided more detail on evolving generational remedy alternatives, three of which were selected by Ecology for further evaluation following the expert panel workshop and input from the community. Again, attendees were invited to ask questions and provide input, which is being considered by Ecology as it evaluates those alternatives. The summary of that meeting is attached.

The Ecology team is grateful to the members of the Bainbridge Island community who took time to review materials, attend meetings, and provide their insights on selection of a generational remedy. Ecology's commitment to an interactive community process will continue as generational remedy alternatives are further evaluated and refined, and as decisions about the future of the Point are made.

Wyckoff Generational Remedy
Community Meeting Summary
Wednesday, January 13, 2010
7:00 p.m. – 9:00 p.m.
IslandWood
4450 Blakely Avenue NE, Bainbridge Island, WA

As part of a three-day expert panel workshop to consider generational remedy options for the Wyckoff site on Bainbridge Island, a community meeting was held on January 13, 2010. This document summarizes the meeting discussions and captures input received from the public.

Introduction

Tim Nord, Washington State Department of Ecology, welcomed participants to the meeting and thanked them for coming. Tim explained that Ecology invested in a process that solicited input from national level experts to explore long-term, multi-generational remedy options for the Wyckoff site at Eagle Harbor. Tim explained the three-day expert panel workshop and objectives for the community meeting:

- Provide interested community members information on the generational remedy evaluation process, objectives, and timeline;
- Share ideas generated during the expert panel workshop, answer questions, and obtain input;
- Build interest in following the process through review of draft alternatives and cost estimates in March 2010.

Tim elaborated that the contamination at the Wyckoff "point" could pose significant environmental risks and enormous management obligations over the long term, for multiple future generations. Ecology and the community have decided to consider ideas for reducing and/or stabilizing the contamination slated to remain at the site under EPA's planned containment remedy. Tim said members of the Bainbridge Island community are serving on a Steering Committee that is working with Ecology to consider generational remedy options. Tim noted that additional details regarding the objectives of the project are available on Ecology's web site at www.WyckoffGenerationalRemedy.org.

Ecology introduced participants in the expert panel workshop, including the members of the Expert Panel; Steering Committee; Ecology staff and project consultants from Floyd|Snider, EnviroIssues and Aspect.

Steering Committee

Perry Barrett, Bainbridge Island Parks Department and member of the Steering Committee, explained that the site was purchased by the city through various funding sources in 2006, and will become a public open space (Pritchard Park) upon completion of cleanup.

Rich Brooks, Suquamish Tribe and Steering Committee member, stated that the Tribe looks at Wyckoff site challenges with a multi-generational lens and considers how today's actions will affect our children's children. He said he was impressed by the dialogue among the Steering Committee, Expert Panel and Ecology.

Pat Serie, EnviroIssues, reviewed the evening's agenda and explained her role as facilitator and to help ensure that the public is involved in the process. She said Ecology will be returning in the spring for another community meeting on remedy options. Pat noted that the presentations and materials from the expert panel workshop and from this community meeting are available on Ecology's web site at www.WyckoffGenerationalRemedy.org. She also noted that they were "tweeting" live from the meeting and participants could follow at www.twitter.com/wyckoffgen.

Generational Remedy Options Developed During the Workshop

Kate Snider, Floyd|Snider, introduced eight expert panelists and explained they were selected based on their technical experience with similar sites. Kate said each expert panelist was asked to come to the workshop with a presentation explaining how they would approach cleanup and what technology they would use (presentations on Ecology web site). The first day of the workshop was dedicated to the panelists presenting their ideas and the second day the experts and Ecology team began working together in groups to form alternatives. Kate said they developed three alternatives they would like to present, but reminded participants that the experts only began discussions the previous day so these may not be the only alternatives that may be considered for the site. She elaborated this evening's presentation will give participants an idea of the types of technologies that are being considered.

Containment plus Dig, Treat and Reclaim

Mike Kavanaugh, Malcolm Pirnie, presented the first alternative which would consist of containment, excavation, treatment and reclamation.

Containment Plus Dig, Treat and Reclaim	
Major elements	Soil excavation (50 feet average below surface over nine acres) On-site soil treatment, medium temperature thermal desorption Hydraulic containment • Up-gradient barrier wall • Grout underlying aquitard to reduce leakage Enhanced perimeter wall - cut down to stepped edge Stormwater management to reduce recharge Timeframe of approximately six years
Benefits	Removes over 80 percent of soils containing creosote Virtually eliminates long-term risks Facilitates shutdown of pump-and-treat system
Challenges	Soils and fluids managed on-site Hydraulic containment to eliminate inflowing water
Community issues identified	Transport of fuel for thermal treatment Emissions from equipment Construction noise, lights Duration of operations

Whole Site In-Ground Thermal Treatment

Michael Basel, Haley & Aldrich, presented the next alternative which would consist of in-ground thermal treatment throughout the entire site.

Whole Site In-Ground Thermal Treatment	
Major elements	Thermal system (steam injection and electrical heating) • Heater/injection/extraction wells • Power delivery system • Steam boiler Fluids extraction and treatment Up-gradient barrier Low-permeability cap Re-grade and restore Timeframe of 10 to 20 years
Benefits	Robust creosote removal; eliminates mobile creosote Flexible operation Facilitates shutdown of pump-and-treat after thermal treatment
Challenges	Requires two to three megawatts of power Significant above-ground treatment equipment needs
Community issues identified	Energy demand Low noise expected Low-profile method Duration of operation with access restricted

Containment Plus Focused Treatment and/or Stabilization

Kent Udell, University of Utah, presented the final alternative which would consist of containment, as well as targeted treatment and stabilization.

Containment Plus Focused Treatment and/or Stabilization	
Major elements	Creosote mass removal • Steam remediation in deep soils • Stabilization/thermal treatment in shallow soils Hydraulic containment • South side up-gradient barrier wall • Grout underlying aquitard to reduce leakage Enhanced perimeter wall with natural transition to soften beach • Move adjacent soils to central portion of site Low-permeability cap covered with clean soil Timeframe of approximately seven years

Containment Plus Focused Treatment and/or Stabilization	
Benefits	Reduced mobility for chemicals Possible shut down of pump-and-treat system
Challenges	Ensure integrity of aquitard grout Identify targets for focused treatment Mixing/binding of stabilized volume Energy needs
Community issues identified	Construction noise, light Emissions from boilers and construction equipment

Community Feedback and Questions

Tim Nord and the panelists took questions and answers from the audience and then participants were invited to visit four stations set up around the room, one concept station for each of the alternatives presented and the fourth on site background. Participants were invited to ask questions directly of the Expert Panelists, Steering Committee and Ecology team and give them their thoughts and feedback. Details of comments and questions are included in Appendix A; the issues raised fell primarily into these categories:

- Duration of the project
- Energy source for thermal treatment
- Bioremediation as an option
- Cost of cleanup and who will pay for it
- Seismic risk/proximity to Seattle Fault
- Contamination seepage through containment walls
- History of thermal treatment on site - how is it different now?
- How exact location of contamination will be determined
- Community impacts - noise, ability to walk dogs on beach, kayaking

Appendix A.

The following unedited notes reflect topics, comments and questions raised by participants during the meeting or recorded on flipcharts during visits at the information stations.

- What is it going to cost to clean up and who is going to pay for it?
- Can you define some of the problems that happened with steam in the past and how that is different from what you are proposing today?
- The treatment plant closed in the 1980's and EPA has been there since then. There were varying durations of years where government stepped away for a while. Is there any benefit to cleaning the site quickly? Is one process relatively cleaner than the others?
- The EPA and Corps of Engineers have just completed a multi-million dollar plant on this facility. How does that factor into your plans?
- Have you looked at biological treatments?

Site Background Station:

- Earthquake concern with leaving/relying on any containment wall
- Will redirecting groundwater cause up-gradient pressure problems to slope stability?
- Can we do partial digs and get large portion of the contamination out?
- Divers have seen product, especially pools around the north side of the site
- Will the east beach impact Milwaukee Pier project?
- VHS 55- 250 images on creosote plant

Whole Site In-ground Thermal Treatment Concept Station

- Want natural slope
- What is being left behind?
- Need to better understand risk of release before can support/rationalize time and money for this
- Want soccer field/park at the site but want to be able to use it soon
- Make sure to include multiple heating technologies
- Choose technology that keep remediation jobs local - trickle down - investment good for region
- Impact of an earthquake
- What happens with what comes out of ground?
- See so much government overspending hard to determine where being spent effectiveness
- Power benefit for island
- Co-gen plant, propane, gas, biomass
- Where does power come from now?

- In-ground thermal seems preferable because less impact than lots
- What happens to sheet pile wall? Will it be completely or partially removed?
- Is there a risk of heating the Sound?
- Recommend looking at the power independence options that Vashon Island researched
- Go there a lot and talk to people - want it clean and have patience to do it right - other land trust acquisition is good example - won't get until owner dies but willing to be patient
- What is greatest risk to community from the thermal treatment? Answer: greatest risk is it may not work
- People are skeptical that it can be done
- Do it right, get in clean, avoid risky approaches
- Thought the EPA has been doing thermal all this time
- People were disillusioned when EPA discarded thermal, very happy to see start again
- Propane burning co gen?
- Ample power supply three out of four seasons, power is only an issue during the winter season when people use electrical heat
- Cleanup should take no more than five years- if it takes longer this generation loses this park
- A pilot project was completed that did not work, why will thermal work now if not then?

Contain plus Dig, Treat and Reclaim Concept Station

- Seattle fault is an issue
- Kayaking and dog walking on beach is important
- Does barrier cause impacts to beach south of site?
- How do we determine where packets of contamination are?
- Where does groundwater flow from uphill of site (up-gradient barrier)?
- How does jet-grout work?
- Duration of project already - costs & political atmosphere, is quicker cleanup better?
- Which remedy over time is better?
- Electricity source is a challenge
- How will water diverted around the site be managed?
- Consider community impact of noise during operations especially thermal treatment
- Option is more verifiable in terms of permanence
- Option is more certain than other remedies
- Noise issue
- Like idea of digging, cleaning, putting back clean soil

- Pier would be advantageous for digging equipment - would it be accepted by community after cleanup is completed?

Containment and Focused Treatment and/or Stabilization Concept Station

- Like restoration plan - will other alternatives restore natural beach?
- Consideration for Seattle fault
- Want wall removed because it affects wave action
- Why did former steam pilot fail?
- What would you expect to use to stabilize creosote?
- Do you need more investigation to find hot spots?
- What is more reliable - steam or stabilization? Which has more commonly been used?
- If you seal the bottom and sides, why spend money removing what is inside?
- What are you doing about the seeps outside the wall?
- Can you steam sediments underwater?
- Build a wind farm/solar farm to offset the need for power line currently proposed - make artistic
- Drain behind up-gradient wall to prevent head buildup/blowouts
- Add signs to beach warning about seeps

Other Issues Raised

- Concern about contaminant on east side of the wall
- People could understand the balancing problem of risk/cost/time
- Everyone uses electric heat - use a lot of electricity in winter, but available the other three season
- Annual demand 30 megawatts, varies 16-80 megawatts
- Consider bioremediation

Wyckoff Generational Remedy

Questions and Answers

February 9, 2010

Thanks to all of you who attended Ecology's community meeting for the Wyckoff Site Generational Remedy Evaluation on January 13. Thanks also to those who followed the expert panel workshop, either through Twitter, online at www.WyckoffGenerationalRemedy.org, or in person. The eight expert panel participants worked hard for three days. They produced ideas regarding how creosote slated to remain at the Wyckoff Site could be reduced in volume, stabilized or solidified, or otherwise made more secure for the very long term – over many generations to come.

Concepts discussed included excavating, applying various methods of heat-treating contaminated soils, and using solidification agents in the ground to remove creosote and/or stabilize the Site. People had questions, and here are some of the most frequently asked. If you have further questions or input on the process, please send them to the Ecology team at dhoo461@ecy.wa.gov and we will address them in future materials.

Describe the creosote contamination being managed at the Wyckoff Site.

Creosote is the name used for a variety of products that are mixtures of chemicals. At the Wyckoff Site, historic use of creosote for wood treatment resulted in contamination of soil and groundwater with three chemical contaminants of primary concern: polynuclear aromatic hydrocarbons, pentachlorophenol, and dioxins/furans. These contaminants are found at the Site either in dissolved form or what are called mobile "non-aqueous phase liquids" or NAPL. More information is available at www.WyckoffGenerationalRemedy.org in the Record of Decision, Soil and Groundwater Operable Units.

What are the health concerns from exposure to creosote?

The federal Agency for Toxic Substances and Disease Registry has prepared a health consultation for the Wyckoff Site to determine if exposure to contaminants there presents potential public health concerns. The report is online at: http://www.atsdr.cdc.gov/HAC/pha/Wyckoff-EagleHarborSuperfundSite/Wyckoff-EagleHarborSuperfundSite7-22-09.pdf. Human exposure can happen through direct contact such as inhaling, touching, or ingesting contaminated soil, or drinking contaminated water. Also of concern is exposure of aquatic animals that may come in contact with contaminated runoff, sediments, or surface water. Current status of areas of the Site includes:

- The "Point" has contamination in soils and groundwater, with exposure currently controlled by a piling wall and fencing. The wall will need maintenance and replacement over the long term, with localized corrosion penetrating the steel wall in the splash zone as soon as the next 20 years.

- East Beach is not safe for children due to contaminants in the sediment. Most portions of the North Shoal appear free from hazardous levels of contamination, but play is not recommended in intertidal sediments. Hand washing is recommended if those sediments are handled.
- The federal study indicated that the polynuclear aromatic hydrocarbons in sampled shellfish are very low, and not likely to make people sick. There is not enough information available on cancer risk, however, or on risks from metals and bacteria, to conclude that eating Eagle Harbor shellfish is safe.

*Is the **level of risk** from contaminants at the Wyckoff Site high enough to justify a long, expensive cleanup?*

EPA has removed surface contamination and limited access to the Site with a fence. The Site's containment system currently in place (including a sheet pile wall and a groundwater pump and treatment system), with improvements that EPA plans, is intended to keep contaminants from moving further off site.

Ecology's concern, however, is that there will be large volumes of very mobile contamination left on site. Over time, the integrity of containment will diminish. The ability to rigorously monitor the Site, maintain and replace containment system components for hundreds of years, and achieve reliability, will be very difficult to manage. Ecology's goal is to significantly reduce the risk of future releases and harm to the environment by reducing the volume or mobility of the large amount of creosote EPA plans to contain on site. This would decrease the risk of future exposure to contamination, as well as significantly lower the cost to maintain and periodically rebuild the containment system over time.

*EPA has spent a lot of **money** on cleanup so far, and now Ecology is talking about spending much more on the cleanup. Why would it be so expensive, and who would pay for it?*

The "Point" represents a very complicated cleanup and financial challenge to all of us. The long-term financial burden to the State is disproportionate to the costs EPA has estimated for their containment remedy (approximately $25 million in today's dollars). To maintain and periodically rebuild the containment system, which is what EPA has asked of the State, would cost hundreds of millions of dollars over hundreds of years. These State costs far exceed the costs the federal government will bear for the containment remedy. That is why Ecology is looking at more complete and robust cleanup options that would provide for greater generational safety and reliability and would reduce State financial outlays.

*The community has waited a **long time** for this Site to be cleaned up, and now Ecology is talking about another 5-10 years. Why would it take so long?*

Any of the options brought forward by the Expert Panel would take 1-2 years to design, and then range from 4 to 10 to even 20 years to complete, considering the need to excavate, treat, stabilize, or otherwise address 1.2 million gallons of contamination. These are just early ideas, but the general timeframes are probably good estimates. Ecology is also concerned about how long current cleanup efforts are taking, as well as the time implications of State concerns. We don't yet know the answer, but Ecology and the Expert Panel are convinced that it is worth looking hard at these ideas to assess their generational effectiveness.

*The concepts presented at the meeting use a lot of **energy** – electricity, steam, propane, and diesel. How do the alternatives compare in terms of energy needs, and where would the additional energy come from when Bainbridge Island is already facing some seasonal energy limitations?*

The Expert Panel recognized the energy needs of all the technologies proposed, not all of which would be electricity. Further work is needed to define specific energy needs, but options discussed included tapping into alternative energy sources such as biomass, using waste heat from on-site soil treatment to accomplish further in-ground heating, and coordinating cleanup work with seasonal Bainbridge Island energy use. More discussion of this will happen as the options are analyzed.

*Any of the remedy concepts are likely to impact the community through noise, traffic, etc. What would you do to avoid **community impacts**?*

The Expert Panel discussed the noise, lighting, traffic and emissions effects of the remedy options. Each expert brought experience from many other site cleanups, where they work with communities to minimize noise from pile driving (using vibrating drivers rather than pounding in sheets of metal), truck backup, motors, etc. Lighting impacts can be restricted to on site, and traffic impacts would be small using on-site treatment compared to trucking soil off site for disposal. As options are further detailed, more evaluation of these issues and discussion with the community will be a priority.

*Have you considered **seismic risk** to the remedy, considering the location near the Seattle Fault? What about **sea-level rise**? How would the generational concepts be affected by either?*

Seismic risk is another reason for trying to reduce the volume and mobility of the huge amount of contaminants to be contained on site. By reducing and/or stabilizing the contaminated material, the ability of a future earthquake to cause a release of contamination from the Site would be significantly reduced. Likely there would be a similar benefit in terms of sea-level rise if material was no longer accessible to rising water levels. Generational remedy alternatives will be evaluated to be protective assuming both earthquakes and sea level rise.

Why wasn't the concept of ***bioremediation*** *included in the generational cleanup concepts you described at the meeting?*

The Expert Panel agreed that bioremediation would not work as the primary cleanup mechanism. The amount of creosote at Wyckoff is too huge, and without oxygen, creosote is toxic to the microbes. Bioremediation, using microbes or "bugs" to consume contaminants, is frequently used at sites with dissolved contaminants in groundwater. Wyckoff's contamination is primarily in the form of creosote "free product" rather than dissolved. For Wyckoff, bioremediation could be considered as a polishing or secondary process. The Expert Panel did not consider bioremediation to be workable as a single-action cleanup tool; the other cleanup options described are those that the panel believes justify more evaluation.

How will ***decisions*** *be made about a generational remedy?*

Ecology will have preliminary answers this spring, and can decide whether there are options that bear further evaluation and funding analysis. That discussion will include the Bainbridge community, EPA, and others, with ultimate decisions made by Ecology in terms of its long-term responsibilities for the Site.

Wyckoff Generational Remedy
Community Meeting Summary
Wednesday, March 24, 2010
5:30 p.m. – 9:00 p.m.
IslandWood
4450 Blakely Avenue NE, Bainbridge Island, WA

Introduction

Pat Serie, EnviroIssues, welcomed participants to the meeting and thanked them for coming. Pat reviewed the evening's agenda and explained her role as facilitator and to help ensure that the public is involved in the process.

Tim Nord, Washington State Department of Ecology, thanked everyone for coming to the second Wyckoff Generational Remedy community meeting. Tim explained that Ecology is involved in the Wyckoff site at Eagle Harbor because of the federal – state relationship at the site between the EPA and Ecology. The EPA is responsible for the initial site cleanup and then will turn responsibility over to the State for the long term. Ecology has two concerns about the containment remedy that EPA has selected for the site: leaving a large amount of mobile contamination adjacent to Puget Sound, and accepting the financial burden for maintenance of the site over hundreds of years.

Due to Ecology's long-term concerns about the generational maintenance of the containment remedy, Ecology invested in the Generational Remedy Evaluation, a process that solicited input from the community and from national level experts to explore long-term, multi-generational remedy options for the site. Tim explained that a three-day expert panel workshop was held in January, where eight expert panelists, the local and tribal steering committee and the Ecology team brainstormed ideas and explored alternatives and technologies. A community meeting was held in conjunction with the workshop to share ideas and obtain input.

Tim said that there are several promising options, but this is still a work in progress. He said Ecology is here tonight to inform the community of the progress they have made since January and the next step in the process is to continue to evaluate the alternatives with the input they receive.

Pat Serie introduced the members of the Steering Committee, members of the Bainbridge Island community and Suquamish Tribe with extensive historical knowledge and interest in the Wyckoff site.

Tribal perspectives

Merle Hayes, Suquamish Tribe, told the audience that it was an honor to speak at the meeting and he shared their concerns with this site. Merle said that the Suquamish people think seven generations into the future and he asked the audience to think that far into the future about the legacy that we are leaving our great-grandchildren at this site. Merle elaborated that he believed everyone in the room had a piece of the Sound in them and would like to see the right thing done. He said it is going to take millions of dollars to fix this problem. "Is it worth it?" he asked and answering his own question declared, "Yes, it is."

City of Bainbridge Island role

Libby Hudson, City of Bainbridge Island and Steering Committee member, explained that the Wyckoff site is part of 50 acres that will become public open space (Pritchard Park). The City acquired the land in phases with the help of partners at the city, county, state and federal level.

Pritchard Park background

Perry Barrett, Bainbridge Island Parks Department and Steering Committee member, further elaborated on the City's plan to develop Pritchard Park. He said the community vision for this site is "recognition of human dignity" and noted the unique characteristics of the park include the Japanese American Exclusion Memorial Wall, views (of Mt. Rainier, Mt. Baker, the Olympics, downtown Seattle), shoreline and topography.

Presentation of alternative long-term remedies

Kate Snider, Floyd|Snider, explained that since January the alternatives from the expert panel workshop have been further developed, including a cost benefit evaluation. She said a Generational Remedy Evaluation document is underway and will be available late spring or early summer.

Kate began by explaining the current understanding of EPA's containment remedy based on recent EPA documents. The containment remedy includes: enhancing the containment wall to the mudline; a surface cap; upgrading the extraction well system; and pumping and treating groundwater. It could potentially also include an uphill barrier wall and wall extensions at the south end of the site.

Kate reiterated that Ecology's concern with this remedy is the long-term risks and costs. The design and construction of the remedy would take two to three years but the groundwater would need to be pumped and treated in perpetuity. The pump and treat system and the sheetpile wall would require routine maintenance and also would need to be replaced approximately every 30 to 50 years.

Kate said the goal of the Generational Remedy Evaluation is to explore cleanup alternatives that would remove or immobilize mobile creosote and eliminate the need for long-term groundwater pumping. The following three alternatives were developed:

1. Full in-situ thermal treatment
2. Full excavation with ex-situ thermal treatment
3. Excavate top 30 feet, with ex-situ thermal treatment

   Option A: In-situ thermal treatment below

   Option B: Stabilization with cement below

Alternative 1. Full in-situ thermal treatment

Alternative 1	
Description	Full in-situ thermal treatment of all soil down into the aquitard to remove all mobile creosote
Major elements	Thermal treatment area includes over 1,300 wells, low profile piping, and surface cap while treatment occurs Improved perimeter barrier wall for hydraulic and thermal control during treatment and permanent soil containment following treatment Perimeter barrier wall for hydraulic control on south end of site Steam generation plant Groundwater and vapor treatment plant and NAPL recovery system
Restoration elements	Thermal equipment removed following treatment Soil cap over treatment area with regrading Walls cut down to mudline to create natural beach profile
Timeline	7 to 20 years, power availability impacts timeline

Alternative 2. Full excavation with ex-situ thermal treatment

Alternative 2	
Description	Shoring and deep excavation of all soil down to the aquitard and ex-situ treatment on site and replacement
Major elements	Improved perimeter barrier wall for shoring and hydraulic control Perimeter barrier wall for hydraulic control on south end of site Sloped excavation sidewall on south end of site Sheetpile walls in between excavation cells Excavation, treatment and backfilling Two thermal desorption units to treat excavated soil Dewatering system Groundwater and vapor treatment plant and NAPL recovery system
Restoration elements	Topsoil placed following backfill and regrading Walls cut down to mudline to create natural beach profile
Timeline	4 to 7 years

Alternative 3, Option A. Excavate top 30', with ex-situ thermal treatment and in-situ thermal treatment below

Alternative 3, Option A	
Description	Excavate soil to 30 feet, thermally treat, and replace, below 30 feet in-situ thermal treatment of soil
Major elements	Improved perimeter barrier wall for shoring, hydraulic and thermal control during excavation and treatment and permanent soil containment of deeper soils following in-situ thermal treatment Perimeter barrier wall for hydraulic control on south end of site Sloped excavation sidewall on south end of site Sheetpile walls in between excavation cells Excavation, treatment, and backfilling down to 30 feet Two thermal desorption units to treat excavated soil Dewatering system Groundwater and vapor treatment plant and NAPL recovery system Low permeability cap installed at base of excavation in each cell prior to backfilling for thermal treatment In-situ thermal treatment follows excavation, treatment and backfilling In-situ treatment area includes over 1,000 wells and low profile piping at surface Steam generation plant
Restoration elements	Thermal equipment removed following treatment Topsoil placed following regrading and in-situ thermal treatment Walls cut down to mudline to create natural beach profile
Timeline	8 to 19 years, power availability impacts timeline

Alternative 3, Option B. Excavate top 30', with ex-situ thermal treatment and stabilization with cement below

Alternative 3, Option B	
Description	Excavate soil to 30 feet, thermally treat, and replace, below 30 feet stabilize creosote by mixing with cement
Major elements	Improved perimeter barrier wall for shoring and hydraulic control during excavation and treatment and permanent soil containment of deeper soils following stabilization Perimeter barrier wall for hydraulic control on south end of site Sloped excavation sidewall on south end of site Sheet pile walls in between excavation cells Excavation, treatment, and backfilling down to 30 feet Two thermal desorption units to treat excavated soil

Alternative 3, Option B	
	Dewatering System Groundwater and vapor treatment plant and NAPL recovery system Soil stabilization at depth occurs prior to backfilling each excavated cell, mixing cement and chemical stabilizers using large diameter augers
Restoration elements	Topsoil placed following backfill and regrading Sheetpile walls cut down to mudline to create natural beach profile
Timeline	4 to 6 years

Kate concluded that several viable methods appear to meet generational remedy objectives. She recognized that there are significant up-front costs for the identified remedies but stated that these alternatives would eliminate long-term operations, replacement and risks. She acknowledged that there would be a range of community impacts, including power usage, heavy construction, truck traffic, noise and emissions. She also recognized that the alternatives range in time to implement. Kate said that the next step in the process is to continue to evaluate the alternatives with the community input they receive at the meeting.

Community Feedback and Questions

Tim Nord and Kate Snider took questions and answers from the audience and participants were then invited to visit stations set up around the room, one station for each of the alternatives presented and another on site background. Participants were invited to ask questions directly of the Ecology team and Steering Committee and give them their thoughts and feedback. Details of comments and questions are included in Appendix A; the issues raised fell primarily into these categories:

- Duration and timing of cleanup
- Cost estimates and how they were done
- Energy source for cleanup, specifically thermal treatment
- Community impacts

Appendix A.

The following unedited notes reflect topics, comments and questions raised by participants during the meeting.

- Have you considered the effects global warming may have on the remedy you select? What does that do to your planning if the area is under water?
- Is timing of the essence for this project?
- For alternative 3, option B, in which you suggest mixing cement to stabilize the contamination, is there a risk that the creosote won't bind with the cement?
- Did the cost estimate for alternative 1 include the cost of power or propane?
- From a green perspective, a carbon cost evaluation should be done for each alternative.
- The goal of the Bainbridge Island Energy Challenge is for the Island to be energy free (neutral) by 2030. Have you considered building a renewable energy plant for the power generation you need for cleanup?
- I would like to "meet the dirt" – where can I see a sample of soil that has been treated with ex-situ treatment?
- When will an alternative be selected and when would construction start?
- How much water would be needed for de-watering and treatment for ex-situ thermal treatment? Was this considered in your cost estimate?
- Why did you choose propane as your fuel source?
- You mentioned there are other sites like this across the country – are we ahead of the curve or behind the curve? Can we learn from those sites?
- Currently you are looking at the technical details of cleanup, will you also look at the commercial aspects?
- I have been told my aquifer is underneath the creosote at the site. Would the thermal treatment affect my water?
- What is your confidence level of where the contamination is located?
- What new information do you (Ecology) have to present to EPA that would make them change their minds? I have been involved in this process for many years and EPA has struggled with these same issues.
- Can you talk about the risks of cleanup?
- How did one million gallons of creosote get on the site?

The Wyckoff Point
Bainbridge Island, Washington

Generational Remedy Evaluation

Appendix D
Generational Remedy Alternative Cost Estimates

Alternative 1
In-situ Thermal Treatment

Task #	Description	Units	Quantity	Unit Cost	Additional Costs	Estimated Total Cost	Contingency	Estimated Total Cost with Contingency	Notes	Cost Source
100.0 Construction Costs										
100.01 Secant Wall						**$ 9,471,000**		**$ 12,312,000**		
	Install Secant Wall Adjacent to Existing Sheetpile Wall	VSF	111,240	$ 76	$ 1,017,000	$ 9,471,000	30%	$ 12,312,000	Based on length of 1,854 feet long, average depth of 60 feet (55 feet to aquitard plus 5 feet into the aquitard). Fixed additional costs are $232K for mob/demob, $722K for guide wall, $65K for QC.	Unit cost estimate for 134,750 VSF provided by Joe Lewis at Recon Services, 3/1/10. Cost pro-rated based on design CAD calculations.
100.02 Upgradient Cutoff Wall						**$ 214,000**		**$ 272,000**		
	Perimeter Barrier Wall Extension	VSF	10,700	$ 6	$ 100,000	$ 164,000	20%	$ 197,000	883 linear feet and an average of 12.1 feet deep based on CAD calculations. Cost is for a slurry wall installed via excavation and slurry mixing and installation.	Based on previous project bids from Recon ($5.55/SF) and Envirocon ($3.78/SF) plus $100,000 mobilization/demobilization and quote from Ed Hicks ($8/SF).
	Drainage System on Upgradient Side	LS	1	$ 50,000		$ 50,000	50%	$ 75,000	Assumes gravity drain	Engineer's Estimate
100.03 In-situ Thermal Treatment						**$ 19,140,000**		**$ 24,833,000**	Assumes treatment from 0 to 50 feet bgs (average). Does not have a "hot floor" specifically designed in to prevent downward contaminant migration. So a 30% contingency was added to the drill and install wells item. This means that jet grouting the leaky aquitard is not necessary.	
	Procurement and Mobilization	LS	1	$ 496,000	$ -	$ 496,000	20%	$ 595,000		TerraTherm March 2, 2010 cost estimate
	Power Drop and Transformer	LS	1	$ 156,000	$ -	$ 156,000	30%	$ 203,000		TerraTherm March 2, 2010 cost estimate
	Drill and Install Wells and Down Hole Equipment	LS	1	$ 7,200,000	$ -	$ 7,200,000	30%	$ 9,360,000	Assumes 747 TCH wells, 318 steam injection wells, 115 SVE wells, 94 steam extraction wells, 38 multiphase extraction wells, 175 temperature monitoring wells, 75 pressure monitoring wells.	TerraTherm March 2, 2010 cost estimate
	Electrical Construction	LS	1	$ 386,000	$ -	$ 386,000	30%	$ 502,000		TerraTherm March 2, 2010 cost estimate
	Mechanical Construction (incl. steam plant)	LS	1	$ 2,117,000	$ -	$ 2,117,000	30%	$ 2,752,000		TerraTherm March 2, 2010 cost estimate
	In-Situ Thermal Destruction Power Equipment	LS	1	$ 494,000	$ -	$ 494,000	30%	$ 642,000	Electrical Equipment	TerraTherm March 2, 2010 cost estimate
	Vapor Effluent Treatment System	LS	1	$ 7,955,374	$ -	$ 7,955,000	30%	$ 10,342,000	Includes liquid/vapor separation, thermal oxidization, vacuum extraction blowers, and $1M allowance to tie into the water treatment plant. NAPL disposal costs are in Operating Costs,	TerraTherm March 2, 2010 cost estimate
	Commissioning	LS	1	$ 336,000	$ -	$ 336,000	30%	$ 437,000		TerraTherm March 2, 2010 cost estimate
100.04 Groundwater Treatment Plant (Upgrade Existing)						**$ 2,000,000**		**$ 3,000,000**		
	Groundwater Treatment Equipment	LS	1	$ 2,000,000	$ -	$ 2,000,000	50%	$ 3,000,000	Assumes existing treatment system can handle flow. Need to install cooling tower, etc.	Engineer's Estimate based on CH2M Hill costs (2005 Engineering Evaluation)
100.05 Low-permeability Cap						**$ 3,221,000**		**$ 3,704,000**		
	Site Prep—Clearing and Grading	SF	363,000	$ 2	$ -	$ 726,000	15%	$ 835,000	SF from CAD calculations.	Engineer's Estimate
	Vapor Cover and Installation	LS	1	$ 2,495,000	$ -	$ 2,495,000	15%	$ 2,869,000	Based on 360,000 SF of insulated surface seal made of light aggregate concrete, which also serves as a vapor seal and sheds	TerraTherm 3/2/10 quote—$2.5M for 360,000 SF and Ed Hicks Quote in wrap-up e-mail $3M for 9 acres.
Task 1—Construction Costs Subtotal						**$ 34,046,000**		**$ 44,121,000**		
200.0 Operating Costs										
200.01 Operating Costs of Thermal Heating and Treatment Systems (5.2 years)						**$ 37,905,000**		**$ 47,382,000**		
	Energy Costs to Heat Steam Injection Wells	MM BTU	300,000	$ 22.00	$ -	$ 6,600,000	25%	$ 8,250,000		TerraTherm May 6, 2010 e-mail to Erin Breckel
	Energy Costs to Heat Thermal Conduction Wells	kWh	144,307,000	$ 0.06231	$ -	$ 8,992,000	25%	$ 11,240,000		Based on Puget Sound Energy Large Demand Service Rates (http://www.pse.com/SiteCollectionDocuments/rates/summ_elec_prices_2010_01_01.pdf)
	Groundwater Treatment by Carbon Adsorption	pound	727,810	$ 1.25	$ -	$ 910,000	25%	$ 1,138,000	Usage rate is based on CH2M Hill estimates, Table 6.3 (2005 Engineering Evaluation). Year 1—620 lb/day, Year 2—540 lb/day, Year 3—460 lb/day, Year 4 & 5—170 lb/day, Year 5 applied to Years 5-5.2.	Table 6.3 from CH2MHill 2005 Engineering Evaluation, $1.25/lb.
	Vapor Treatment using Thermal Oxidizer (propane costs)	MM BTU	151,050	$ 22.00	$ -	$ 3,323,000	25%	$ 4,154,000	1 gallon Propane = 91,600 BTU	TerraTherm March 2, 2010 cost estimate is ~$2/gallon. Suburban Propane (360) 377-7647, $1.60/gallon plus rental equipment. Use TerraTherm's quote for conservativeness.
	Maintenance Hardware	LS	1	$ 1,925,000	$ -	$ 1,925,000	25%	$ 2,406,000		TerraTherm March 2, 2010 cost estimate
	Labor, Travel, per diem for Operation and Maintenance of ISTR and Vapor Treatment Systems	LS	1	$ 13,191,000	$ -	$ 13,191,000	25%	$ 16,489,000		TerraTherm March 2, 2010 cost estimate
	Operation and Maintenance of Groundwater Treatment Systems	per year	5.2	$ 200,000	$ -	$ 1,040,000	25%	$ 1,300,000	Based on 1 operator per year ($75,000 per year) plus maintenance $125,000/year.	
	Process Monitoring, Sampling, and Analysis	LS	1	$ 720,000	$ -	$ 720,000	25%	$ 900,000		TerraTherm March 2, 2010 cost estimate
	Reporting	LS	1	$ 244,000	$ -	$ 244,000	25%	$ 305,000		TerraTherm March 2, 2010 cost estimate
	Rental Equipment	LS	1	$ 960,000	$ -	$ 960,000	25%	$ 1,200,000		TerraTherm March 2, 2010 cost estimate
200.02 Operating Costs of Treatment Plant (cool-down period—2 years)						**$ 1,195,000**		**$ 1,495,000**		
	Groundwater Treatment by Carbon Adsorption	pound	124,100	$ 1.25	$ -	$ 155,000	25%	$ 194,000	Usage rate is based on CH2MHill estimates, Table 6.3 (2005 Engineering Evaluation). Year 5—170 lb/day—applied to Years 5.2—7.2.	Table 6.3 from CH2M Hill 2005 Engineering Evaluation, $1.25/lb.

Alternative 1
In-situ Thermal Treatment

Task #	Description	Units	Quantity	Unit Cost	Additional Costs	Estimated Total Cost	Contingency	Estimated Total Cost with Contingency	Notes	Cost Source
	Maintenance Hardware	LS per Year	2	$ 185,096	$ -	$ 370,000	25%	$ 463,000	Assumes 50% of annual rate during heating period and pro-rated for 2 years.	TerraTherm March 2, 2010 cost estimate
	Operation and Maintenance of Groundwater Treatment Systems	per year	2	$ 150,000	$ -	$ 300,000	25%	$ 375,000	Based on 1 operator per year ($75,000 per year) plus maintenance $75,000/year	
	Process Monitoring, Sampling, and Analysis	LS per Year	2	$ 69,231	$ -	$ 138,000	25%	$ 173,000	Assumes 50% of annual rate during heating period and pro-rated for 2 years.	TerraTherm March 2, 2010 cost estimate
	Reporting	LS per Year	2	$ 23,462	$ -	$ 47,000	25%	$ 59,000	Assumes 50% of annual rate during heating period and pro-rated for 2 years.	TerraTherm March 2, 2010 cost estimate
	Rental Equipment	LS per Year	2	$ 92,308	$ -	$ 185,000	25%	$ 231,000	Assumes 50% of annual rate during heating period and pro-rated for 2 years.	TerraTherm March 2, 2010 cost estimate
200.03 Creosote Disposal						**$ 1,200,000**		**$ 1,560,000**		
	Disposal	gallons	600,000	$ 2	$ -	$ 1,200,000	30%	$ 1,560,000	Assumes 1.2M gallons of creosote is present and approximately 50% of that mass will be removed as free product.	TerraTherm March 2, 2010 cost estimate
Task 2—Operating Costs Subtotal						**$ 40,300,000**		**$ 50,437,000**		
300.0 Restoration Costs										
300.01 Site Restoration						**$ 1,466,000**		**$ 2,056,000**		
	Cut-down Sheet Pile Wall	LS	1	$ 750,000	$ -	$ 750,000	50%	$ 1,125,000	Only cut down to below ground surface	Engineers Estimate
	Regrade Site	SF	263,000	$ 2	$ -	$ 526,000	30%	$ 684,000	Assumes 100,000 SF will be regraded with material from contouring beach slope.	
	Contour Beach Slope	CY	25,330	$ 7.50	$ -	$ 190,000	30%	$ 247,000	Cost for Regrading Beach Slope Area	Contractor Estimates of $5-$10/ton and previous bids with excavation costs averaging $9.50/CY (or $6.30/ton)
300.02 Well Decommissioning and Equipment Removal						**$ 4,034,000**		**$ 5,344,000**		
	Decommission Existing Wells	Per Well	100	$ 3,000	$ -	$ 300,000	30%	$ 390,000	Assume overdrilling for existing wells	Table 6.2 from CH2M Hill 2005 Engineering Evaluation
	Decommission New Thermal Treatment Wells	Per Well	1,562	$ 800	$ -	$ 1,250,000	30%	$ 1,625,000	Assume grouting for new wells.	Engineers Estimate
	Decommission Treatment Plant	LS	1	$ 500,000		$ 500,000	50%	$ 750,000		Engineers Estimate
	Demobilization Thermal Equipment	LS	1	$ 1,984,000	$ -	$ 1,984,000	30%	$ 2,579,000		TerraTherm March 2, 2010 cost estimate
300.03 Permeable Cap						**$ 1,190,000**		**$ 1,578,000**		
	Remove Low Permeability Cap	LS	1	$ 500,000	$ -	$ 500,000	50%	$ 750,000		Engineers Estimate
	Install Permeable Soil Cap	CY	40000	$ 15	$ 90,000	$ 690,000	20%	$ 828,000	Assumes geotextile fabric (360,000 SF at $0.25/SF) and 3-feet of top soil.	Engineers Estimate
Task 3—Restoration Costs Subtotal						**$ 6,690,000**		**$ 8,978,000**		
400.0 Design, Permitting, and Site Preparation										
400.01 Design and Construction Oversight						**$ 5,107,000**		**$ 6,640,000**		
	Engineering Design/Project Administration	LS	1	$ 3,404,600	$ -	$ 3,405,000	30%	$ 4,427,000	10% of construction costs	
	Construction Oversight	LS	1	$ 1,702,300	$ -	$ 1,702,000	30%	$ 2,213,000	5% of construction costs	
400.02 Permitting						**$ 1,702,000**		**$ 2,213,000**		
	Permitting/Legal	LS	1	$ 1,702,300	$ -	$ 1,702,000	30%	$ 2,213,000	5% of construction costs	
400.03 Site Preparation						**$ 100,000**		**$ 150,000**		
	Demolition of On-Site Building and Utilities	LS	1	$ 100,000	$ -	$ 100,000	50%	$ 150,000		Engineers Estimate
Task 4—Design, Permitting, and Site Preparation Costs Subtotal						**$ 6,909,000**		**$ 9,003,000**		
	Subtotal					**$ 87,945,000**		**$ 112,539,000**		
	Tax (9.5%)					**$ 8,355,000**		**$ 10,691,000**		
	Total					**$ 96,300,000**		**$ 123,230,000**		

Abbreviations:

bgs	below ground surface
BTU	British thermal unit
CY	Cubic yard
kWh	Kilowatt-Hour
lb	pound
LS	Lump sum
MM BTU	Million British thermal units
NAPL	Non-aqueous phase liquid
QC	Quality Control
SF	Square foot
SVE	Soil vapor extraction
TCH	Thermal conduction heating
VF	Vertical feet

Alternative 2
Full Excavation and Ex-situ Treatment

Task #	Description	Units	Quantity	Unit Cost	Additional Costs	Estimated Total Cost	Contingency	Estimated Total Cost with Contingency	Notes	Cost Source
100.0 Construction Costs										
100.01 Secant Wall						**$ 11,870,000**		**$ 15,431,000**		
	Install Secant Wall Adjacent to Existing Sheetpile Wall	VSF	116,280	$ 95	$ 823,000	$ 11,870,000	30%	$ 15,431,000	Based on length of 1,938 feet long, average depth of 60 feet. Fixed additional costs are $232K for mob/demob, $528K for guide wall, $63K for QC.	Unit cost estimate for 117800 VSF provided by Joe Lewis at Recon Services, 4/29/10. Cost pro-rated based on design CAD calculations.
100.02 Upgradient Cutoff Wall						**$ 211,000**		**$ 268,000**		
	Perimeter Barrier Wall Extension	VSF	10,100	$ 6	$ 100,000	$ 161,000	20%	$ 193,000	862 linear feet and an average of 11.7 feet deep based on CAD calculations. Wall is upgradient from Alt 1 to allow excavation at a 1.5:1 (H:V) slope. Cost is for a slurry wall installed via excavation and slurry mixing and installation.	Based on previous project bids from Recon ($5.55/SF) and Envirocon ($3.78/SF) plus $100,000 mobilization/demobilization and quote from Ed Hicks ($8/SF).
	Drainage System on Upgradient Side	LS	1	$ 50,000		$ 50,000	50%	$ 75,000	Assumes gravity drain	Engineers Estimate
100.03 Dewatering						**$ 1,130,000**		**$ 1,438,000**		
	Mobilization/Demobilization	LS	1	$ 100,000	$ -	$ 100,000	20%	$ 120,000		Engineers Estimate
	Well Installation and Development	per well	40	$ 20,000	$ -	$ 800,000	30%	$ 1,040,000	Assumes 8-inch well with gravel pack, average of 60-feet deep, spaced 100 to 150-feet apart. Additional 10 wells for depth.	Engineers Estimate
	Submersible Pump and Pump Column	per well	40	$ 1,500	$ -	$ 60,000	20%	$ 72,000		Engineers Estimate
	Pump Installation and Wiring	per well	40	$ 3,750	$ -	$ 150,000	20%	$ 180,000		Engineers Estimate
	PVC Discharge Piping and Headers	LS	1	$ 20,000	$ -	$ 20,000	30%	$ 26,000		Engineers Estimate
100.04 Excavation and Segregation						**$ 9,588,000**		**$ 11,703,000**		
	Excavation, Stockpiling, Segregation of Soils	Ton	982,500	$ 7.50	$ 250,000	$ 7,619,000	20%	$ 9,143,000	Assumes 650,000 CY at 1.5 tons/CY plus $250,000 mobilization/demobilization fee plus removal of 5,000 CY of soil along southern edge to eliminate shoring.	Contractor Estimates of $5-$10/ton and previous project bids with excavation costs averaging $9.50/CY (or $6.30/ton)
	Sheetpile Construction into Grids	VSF	43,750	$ 45	$ -	$ 1,969,000	30%	$ 2,560,000	Sheetpile walls to divide area into three separate cells, LF of 950 with an average depth of 46 feet.	Contractor estimate and previous project bidsfor sheetpile construction $45/SF
100.04 Ex-Situ Thermal Treatment						**$ 500,000**		**$ 575,000**		
	Mobilization/Demobilization	LS	1	$ 500,000	$ -	$ 500,000	15%	$ 575,000	Mobilization/Demobilization to Site	Quote from Frank Kellog, 3/15/10 via phone call.
100.05 Backfilling and Compaction						**$ 4,913,000**		**$ 6,387,000**		
	Place and Compact Backfill	Ton	982,500	$ 5		$ 4,913,000	30%	$ 6,387,000	Assumes 650,000 CY plus 5,000 CY at 1.5 tons/CY	Contractor Estimates of $5-$10/ton and previous project bids - $8/CY or $5.35/ton
Task 1—Construction Costs Subtotal						**$ 28,212,000**		**$ 35,802,000**		
200.0 Operating Costs										
200.01 Operating Costs of Groundwater Treatment Plant for Dewatering Water						**$ 501,000**		**$ 626,000**		
	Carbon Adsorption (Initial Dewatering Period)	per pound	113,150	$ 1.25	$ -	$ 141,000	25%	$ 176,000	Assume initial dewatering period of 6 months to get area to steady (near dry) state and uses year 1 carbon volumes from Table 6.3 (620 lb/day) from CH2M Hill 2005 Engineering Evaluation	Table 6.3 from CH2MHill 2005 Engineering Evaluation, $1.25/lb.
	Carbon Adsorption (Post-Initial Dewatering Period)	per pound	186,150	$ 1.25	$ -	$ 233,000	25%	$ 291,000	Assume 3 additional years of maintaining depressed water table dewatering and uses Year 3 carbon volumes (170 lb/day) for Years 0.5 - 4, (values from CH2M Hill 2005 Engineering Evaluation)	Table 6.3 from CH2MHill 2005 Engineering Evaluation, $1.25/lb.
	Operation and Maintenance (Initial Dewatering Period)	LS per Year	0.5	$ 75,000	$ 5,640	$ 43,000	25%	$ 54,000	Based on 1 operator per year ($75,000 per year) plus maintenance at 4% of carbon cost for groundwater system.	
	Operation and Maintenance (Post-Initial Dewatering Period)	LS per Year	3	$ 25,000	$ 9,320	$ 84,000	25%	$ 105,000	Based on 1 operator per year ($25,000 per year) plus maintenance at 4% of carbon cost for groundwater system.	
200.02 Operating Costs of Thermal Treatment Plant for Soil						**$ 43,875,000**		**$ 50,456,000**		
	Treatment of Excavated Soil	CY	585,000	$ 75	$ -	$ 43,875,000	15%	$ 50,456,000	Assumes 650,000 CY with 10% of clean soil that does not need treatment. Cost is all inclusive from dirty stockpiled soil to clean stockpiled soil.	Quote from Frank Kellog, 5/13/10 via phone call and 3/9/10 e-mail
200.03 Operating Costs for Dewatering						**$ 339,000**		**$ 437,000**		
	Discharge Permit Fees	LS	1	$ 15,000	$ -	$ 15,000	20%	$ 18,000		Engineers Estimate
	Discharge Monitoring and Reporting	LS per Year	4	$ 6,000	$ -	$ 24,000	20%	$ 29,000		Engineers Estimate
	Operate and Maintain System (Initial Dewatering Period)	LS per month	6	$ 30,000	$ -	$ 180,000	30%	$ 234,000	Assumes initial dewatering period of 6 months to get area to steady (near dry) state. $1,000 per month per well	Engineers Estimate
	Electrical Power (Initial Dewatering Period)	LS per month	6	$ 2,000	$ -	$ 12,000	30%	$ 16,000	Assumes initial dewatering period of 6 months to get area to steady (near dry) state. Assumes $2,000 per month	Engineers Estimate
	Operate, Maintain, and Electrical Power (Post Initial Dewatering)	LS per month	36	$ 3,000	$ -	$ 108,000	30%	$ 140,000	Assumes excavation will take 3.5 years total. Includes costs for operating dewatering system after steady state has been reached. $3,000 per month	Engineers Estimate
Task 2—Operating Costs Subtotal						**$ 44,715,000**		**$ 51,519,000**		

Alternative 2
Full Excavation and Ex-situ Treatment

Task #	Description	Units	Quantity	Unit Cost	Additional Costs	Estimated Total Cost	Contingency	Estimated Total Cost with Contingency	Notes	Cost Source
300.0 Restoration Costs										
300.01 Site Restoration						**$ 750,000**		**$ 1,125,000**		
	Cut-down Sheet Pile Wall	LS	1	$ 750,000	$ -	$ 750,000	50%	$ 1,125,000	Only cut down to below ground surface	Engineers Estimate
300.02 Well Decommissioning and Equipment Removal						**$ 832,000**		**$ 1,182,000**		
	Decommission Existing Wells	Per Well	100	$ 3,000	$ -	$ 300,000	30%	$ 390,000	Assume overdrilling for existing wells	Table 6.2 from CH2M Hill 2005 Engineering Evaluation
	Decommission New Dewatering Wells	Per Well	40	$ 800	$ -	$ 32,000	30%	$ 42,000	Assume grouting for new wells.	
	Decommission Treatment Plant	LS	1	$ 500,000		$ 500,000	50%	$ 750,000		Engineers Estimate
300.03 Permeable Cap						**$ 690,000**		**$ 828,000**		
	Install Permeable Soil Cap	CY	40000	$ 15	$ 90,000	$ 690,000	20%	$ 828,000	Assumes geotextile fabric (360,000 SF at $0.25/SF) and 3-feet of top soil.	Engineers Estimate
Task 3—Restoration Costs Subtotal						**$ 2,272,000**		**$ 3,135,000**		
400.0 Design, Permitting, and Site Preparation										
400.01 Design and Construction Oversight						**$ 4,232,000**		**$ 5,501,000**		
	Engineering Design/Project Administration	LS	1	$ 2,821,200	$ -	$ 2,821,000	30%	$ 3,667,000	10% of construction costs	
	Construction Oversight	LS	1	$ 1,410,600	$ -	$ 1,411,000	30%	$ 1,834,000	5% of construction costs	
400.02 Permitting						**$ 1,411,000**		**$ 1,834,000**		
	Permitting/Legal	LS	1	$ 1,410,600	$ -	$ 1,411,000	30%	$ 1,834,000	5% of construction costs	
400.03 Site Preparation						**$ 100,000**		**$ 150,000**		
	Demolition of On-Site Building and Utilities	LS	1	$ 100,000	$ -	$ 100,000	50%	$ 150,000		Engineers Estimate
Task 4—Design, Permitting, and Site Preparation Costs Subtotal						**$ 5,743,000**		**$ 7,485,000**		
	Subtotal					**$ 80,942,000**		**$ 97,941,000**		
	Tax (9.5%)					**$ 7,689,000**		**$ 9,304,000**		
	Total					**$ 88,631,000**		**$ 107,245,000**		

Abbreviations:

CY	Cubic yard
lb	pound
LS	Lump sum
QC	Quality Control
LF	Linear foot
VF	Vertical feet

Alternative 3a
Partial Excavation and In-situ Thermal Treatment

Task #	Description	Units	Quantity	Unit Cost	Additional Cost	Estimated Total Cost	Contingency	Estimated Total Cost with Contingency	Notes	Cost Source
100.0 Construction										
100.01	Secant Wall (includes reinforcement for shallow excavation)					**$ 10,381,000**		**$ 13,495,000**		
	Install Secant Wall Adjacent to Existing Sheetpile Wall	VSF	116,280	$ 82	$ 823,000	$ 10,381,000	30%	$ 13,495,000	Based on length of 1,938 feet long, average depth of 60 feet. Fixed additional costs are $232K for mob/demob, $528K for guide wall, $63K for QC.	Unit cost estimate for 117,800 VSF provided by Joe Lewis at Recon Services, 4/29/10. Cost pro-rated based on design CAD calculations.
100.02	Upgradient Cutoff Wall					**$ 211,000**		**$ 268,000**		
	Perimeter Barrier Wall Extension	VSF	10,100	$ 6	$ 100,000	$ 161,000	20%	$ 193,000	862 linear feet and an average of 11.7 feet deep based on CAD calculations. Wall is upgradient from Alt 1 to allow excavation at a 1.5:1 (H:V) slope. Cost is for a slurry wall installed via excavation and slurry mixing and installation.	Based on previous project bids from Recon ($5.55/SF) and Envirocon ($3.78/SF) plus $100,000 mobilization/demobilization and quote from Ed Hicks ($8/SF).
	Drainage System on Upgradient Side	LS	1	$ 50,000		$ 50,000	50%	$ 75,000	Assumes gravity drain	Engineer's Estimate
100.03	Dewatering					**$ 745,000**		**$ 956,000**		
	Mobilization/Demobilization	LS	1		$ -	$ 20,000	20%	$ 24,000		Engineer's Estimate
	Well Installation and Development	per well	30	$ 20,000	$ -	$ 600,000	30%	$ 780,000	Assumes 8-inch well with gravel pack, average of 60-feet deep, spaced 100 to 150-feet apart	Engineer's Estimate
	Submersible Pump and Pump Column	per well	30	$ 1,000	$ -	$ 30,000	20%	$ 36,000		Engineer's Estimate
	Pump Installation and Wiring	per well	30	$ 2,500	$ -	$ 75,000	20%	$ 90,000		Engineer's Estimate
	PVC Discharge Piping and Headers	LS	1	$ 20,000	$ -	$ 20,000	30%	$ 26,000		Engineer's Estimate
100.04	Excavation and Segregation					**$ 6,089,000**		**$ 7,435,000**		
	Sheetpile Construction into Grids	VSF	28,500	$ 45	$ -	$ 1,283,000	30%	$ 1,668,000	Sheetpile walls to divide area into three separate cells, 950 LF with an average depth of 30 feet.	Contractor estimate and previous project bidsfor sheetpile construction $45/SF
	Excavation, Stockpiling, Segregation of Soils and placement into MTTD from 0 to 30 feet bgs	Ton	607,500	$ 7.50	$ 250,000	$ 4,806,000	20%	$ 5,767,000	Assumes 400,000 CY at 1.5 tons/CY plus $250,000 mobilization/demobilization fee plus removal of 5000 CY of soil along southern edge to eliminate shoring.	Contractor Quotes $5-$10/ton and previous project/bid experience averagine $9.50/CY (or $6.30/ton)
100.05	Ex-situ Thermal Treatment					**$ 500,000**		**$ 575,000**		
	Mobilization/Demobilization	LS	1	$ 500,000	$ -	$ 500,000	15%	$ 575,000	Mobilization/Demobilization to Site	Quote from Frank Kellog, 3/15/10 via phone call.
100.06	In-situ Thermal Treatment					**$ 16,140,000**		**$ 20,938,000**	Assumes treatment from 0 to 50 ft. bgs (average). Does not have a "hot floor" specifically designed in to prevent downward contaminant migration. So a 30% contingency was added to the drill and install wells item. This means that jet grouting the leaky aquitard is not necessary.	
	Procurement and Mobilization	LS	1	$ 450,000	$ -	$ 450,000	20%	$ 540,000		TerraTherm March 2, 2010 cost estimate
	Power Drop and Transformer	LS	1	$ 92,000	$ -	$ 92,000	30%	$ 120,000		TerraTherm March 2, 2010 cost estimate
	Drill and Install Wells and Down Hole Equipment	LS	1	$ 6,021,556	$ -	$ 6,022,000	30%	$ 7,829,000	Assumes 747 TCH wells, 318 steam injection wells, 115 SVE wells, 94 steam extraction wells, 38 multiphase extraction wells, 175 temperature monitoring wells, 75 pressure monitoring wells. (pro-rated to account for smaller surface area, 7 acres v. 9 acres for Alt. 1)	TerraTherm March 2, 2010 cost estimate
	Electrical Construction	LS	1	$ 386,000	$ -	$ 386,000	30%	$ 502,000		TerraTherm March 2, 2010 cost estimate
	Mechanical Construction (incl. steam plant)	LS	1	$ 2,087,000	$ -	$ 2,087,000	30%	$ 2,713,000		TerraTherm March 2, 2010 cost estimate
	In-Situ Thermal Destruction Power Equipment	LS	1	$ 494,000	$ -	$ 494,000	30%	$ 642,000	Electrical Equipment	TerraTherm March 2, 2010 cost estimate
	Vapor Effluent Treatment System	LS	1	$ 6,304,187	$ -	$ 6,304,000	30%	$ 8,195,000	Includes liquid/vapor separation, thermal oxidization, vacuum extraction blowers and $1M allowance to tie into the water treatment plant. NAPL disposal costs are in Operating Costs.	TerraTherm March 2, 2010 cost estimate
	Commissioning	LS	1	$ 305,000	$ -	$ 305,000	30%	$ 397,000		
100.07	Groundwater Treatment Plant (Upgrade Existing)					**$ 2,000,000**		**$ 3,000,000**		
	Groundwater Treatment	LS	1	$ 2,000,000	$ -	$ 2,000,000	50%	$ 3,000,000	Assumes existing treatment system can handle flow. Need to install cooling tower, etc.	Engineer's Estimate based on CH2M Hill costs
100.08	Backfilling and Compaction					**$ 3,038,000**	50%	**$ 3,949,000**		
	Place and Compact Backfill	Ton	607,500	$ 5		$ 3,038,000	30%	$ 3,949,000	Assumes 400,000 + 5000 CY at 1.5 tons/CY	Contractor Estimates of $5-$10/ton and previous project bids - $8/CY or $5.35/ton
100.09	Low-permeability Cap at Base of Excavation					**$ 2,169,000**		**$ 2,494,000**		
	Materials and Placing Cap	LS	1	$ 2,169,000	$ -	$ 2,169,000	15%	$ 2,494,000	Geosynthetic Clay Liner or Insulated surface seal made of light aggregate concrete	TerraTherm 3/2/10 quote—$2.5M for 360,000 SF and Ed Hicks Quote in wrap-up e-mail $3M for 9 acres. @ 30 ft. bgs we have 245,000 SF per CAD calculations. Cost pro-rated.
Task 1—Construction Costs Subtotal						**$ 41,273,000**		**$ 53,110,000**		

Alternative 3a
Partial Excavation and In-situ Thermal Treatment

Task #	Description	Units	Quantity	Unit Cost	Additional Cost	Estimated Total Cost	Contingency	Estimated Total Cost with Contingency	Notes	Cost Source
200.0 Operations										
200.01 Operating Costs of Thermal Heating and Treatment Systems (6.8 years)						**$ 32,016,000**		**$ 40,022,000**		
	Energy Costs to Heat Steam InjectionWells	MM BTU	2.10E+05	$ 22.00	$ -	$ 4,615,000	25%	$ 5,769,000	Quantity is based on propane quantity for Alt. 1 and the steam injected ratio of Alt. 1 to Alt. 3a (based on steam injected, steam extracted and operating time).	Based on Puget Sound Energy Large Demand Service Rates (http://www.pse.com/SiteCollectionDocuments/rates/summ_elec_prices_2010_01_01.pdf)
	Energy Costs to Heat Thermal Conduction Wells	kWh	1.03E+08	$ 0.06231	$ -	$ 6,439,000	25%	$ 8,049,000		Based on Puget Sound Energy Large Demand Service Rates (http://www.pse.com/SiteCollectionDocuments/rates/summ_elec_prices_2010_01_01.pdf)
	Groundwater Treatment by Carbon Adsorption	pound	8.27E+05	$ 1.25	$ -	$ 1,034,000	25%	$ 1,293,000	Usage rate is based on CH2M Hill estimates, Table 6.3 (2005 Engineering Evaluation). Year 1—620 lb/day, Year 2—540 lb/day, Year 3—460 lb/day, Year 4 & 5—170 lb/day, Year 5 applied to Years 5-6.8.	Table 6.3 from CH2M Hill 2005 Engineering Evaluation, $1.25/lb.
	Vapor Treatment using Thermal Oxidizer (propane costs)	MM BTU	7.97E+04	$ 22.00	$ -	$ 1,753,000	25%	$ 2,191,000	1 gallon Propane = 91,600 BTU	TerraTherm March 2, 2010 cost estimate is ~$2/gallon.
	Maintenance Hardware	LS	1	$ 1,629,000	$ -	$ 1,629,000	25%	$ 2,036,000		TerraTherm March 2, 2010 cost estimate
	Labor, Travel, per diem for Operation and Maintenance of ISTR and Vapor Treatment Systems	LS	1	$ 12,944,000	$ -	$ 12,944,000	25%	$ 16,180,000		TerraTherm March 2, 2010 cost estimate
	Operation and Maintenance of Groundwater Treatment Systems	LS per year	6.8	$ 175,000	$ -	$ 1,190,000	25%	$ 1,488,000	Based on 1 operator per year ($75,000 per year) plus maintenance $100,000/year	
	Process Monitoring, Sampling, and Analysis	LS	1	$ 942,000	$ -	$ 942,000	25%	$ 1,178,000		TerraTherm March 2, 2010 cost estimate
	Reporting	LS	1	$ 214,000	$ -	$ 214,000	25%	$ 268,000		TerraTherm March 2, 2010 cost estimate
	Rental Equipment	LS	1	$ 1,256,000	$ -	$ 1,256,000	25%	$ 1,570,000		TerraTherm March 2, 2010 cost estimate
200.02 Operating costs of Treatment Plant (cool-down period—2 years)						**$ 1,000,000**		**$ 1,251,000**		
	Groundwater Treatment by Carbon Adsorption	pound	1.24E+05	$ 1.25	$ -	$ 155,000	25%	$ 194,000	Usage rate is based on CH2M Hill estimates, Table 6.3 (2005 Engineering Evaluation). Year 5 - 170 lb/day - applied to Years 6.8 - 8.8.	Table 6.3 from CH2MHill 2005 Engineering Evaluation, $1.25/lb.
	Maintenance Hardware	LS per Year	2	$ 119,779	$ -	$ 240,000	25%	$ 300,000	Assumes 50% of annual rate during heating period and pro-rated for 2 years.	TerraTherm March 2, 2010 cost estimate
	Operation and Maintenance of Groundwater Treatment Systems	per year	2	$ 125,000	$ -	$ 250,000	25%	$ 313,000	Based on 1 operator per year ($75,000 per year) plus maintenance $50,000/year	
	Process Monitoring, Sampling, and Analysis	LS per Year	2	$ 69,265	$ -	$ 139,000	25%	$ 174,000	Assumes 50% of annual rate during heating period and pro-rated for 2 years.	TerraTherm March 2, 2010 cost estimate
	Reporting	LS per Year	2	$ 15,735	$ -	$ 31,000	25%	$ 39,000	Assumes 50% of annual rate during heating period and pro-rated for 2 years.	TerraTherm March 2, 2010 cost estimate
	Rental Equipment	LS per Year	2	$ 92,353	$ -	$ 185,000	25%	$ 231,000	Assumes 50% of annual rate during heating period and pro-rated for 2 years.	TerraTherm March 2, 2010 cost estimate
200.03 Creosote Disposal						**$ 600,000**		**$ 780,000**		
	Disposal	gallons	300,000	$ 2	$ -	$ 600,000	30%	$ 780,000	Assumes 1.2M gallons of creosote is present at the whole site and 50% of that is present in the upper 30-feet. Approximately 50% of the remaining 600K gallons will be removed as free product.	TerraTherm 3/2/10 Quote
200.04 Operating Costs of Thermal Treatment Plant for Soil						**$ 27,000,000**		**$ 31,050,000**		
	Treatment of Excavated Soil	CY	360,000	$ 75	$ -	$ 27,000,000	15%	$ 31,050,000	Assumes 400,000 CY with 10% of clean soil that does not need treatment.. Cost is all inclusive from dirty stockpiled soil to clean stockpiled soil.	Quote from Frank Kellog, 5/13/10 via phone call and 3/9/10 e-mail
200.05 Operating Costs for Dewatering						**$ 409,000**		**$ 520,000**		
	Discharge Permit Fees	LS	1	$ 15,000	$ -	$ 15,000	20%	$ 18,000		Engineer's Estimate
	Discharge Monitoring and Reporting	LS per Year	3	$ 6,000	$ -	$ 18,000	20%	$ 22,000		Engineer's Estimate
	Operate and Maintain System (Initial Dewatering Period)	LS per month	6	$ 22,500	$ -	$ 135,000	30%	$ 176,000	Assumes initial dewatering period of 6 months to get area to steady (near dry) state. $750 per month per well	Engineer's Estimate
	Electrical Power (Initial Dewatering Period)	LS per month	6	$ 1,000	$ -	$ 6,000	30%	$ 8,000	Assumes initial dewatering period of 6 months to get area to steady (near dry) state. Assumes $1,000 per month	Engineer's Estimate
	Operate, Maintain, and Electrical Power (Post Initial Dewatering)	LS per month	24	$ 2,000	$ -	$ 48,000	30%	$ 62,000	Assumes excavation will take 2.5 years total. Includes costs for operating dewatering system after steady state has been reached. $2,000 per month	Engineer's Estimate
	Carbon Adsorption (Initial Dewatering Period)	per pound	56,575	$ 1.25	$ -	$ 71,000	25%	$ 89,000	Usage rate is based on 50% of Alt. 2 (Full excavation) due to reduced depth of excavation and shorter time frame.	Table 6.3 from CH2M Hill 2005 Engineering Evaluation, $1.25/lb.
	Carbon Adsorption (Post-Initial Dewatering Period)	per pound	93,075	$ 1.25	$ -	$ 116,000	25%	$ 145,000	Usage rate is based on 50% of Alt. 2 (Full excavation) due to reduced depth of excavation and shorter time frame.	Table 6.3 from CH2M Hill 2005 Engineering Evaluation, $1.25/lb.
Task 2—Operating Costs Subtotal						**$ 61,025,000**		**$ 73,623,000**		

Alternative 3a
Partial Excavation and In-situ Thermal Treatment

Task #	Description	Units	Quantity	Unit Cost	Additional Cost	Estimated Total Cost	Contingency	Estimated Total Cost with Contingency	Notes	Cost Source
300.0 Restoration										
300.01 Site Restoration						**$ 750,000**		**$ 1,125,000**		
	Cut-down Sheet Pile Wall	LS	1	$ 750,000	$ -	$ 750,000	50%	$ 1,125,000	Only cut down to below ground surface	Engineers Estimate
300.02 Well Decommissioning and Equipment Removal						**$ 3,390,000**		**$ 4,507,000**		
	Decommission Existing Wells	Per Well	100	$ 3,000	$ -	$ 300,000	30%	$ 390,000	Assume overdrilling for existing wells	Table 6.2 from CH2M Hill 2005 Engineering Evaluation
	Decommission New Thermal Treatment Wells	Per Well	1,215	$ 800	$ -	$ 972,000	30%	$ 1,264,000	1562 wells per TerraTherm, pro-rated due to smaller surface area (7 acres v. 9 acres). Assume grouting for new wells.	
	Decommission New Dewatering Wells	Per Well	30	$ 800	$ -	$ 24,000	30%	$ 31,000	Assume grouting for new wells.	
	Decommission Treatment Plant	LS	1	$ 500,000		$ 500,000	50%	$ 750,000		Engineers Estimate
	Demobilization Thermal Equipment	LS	1	$ 1,594,000	$ -	$ 1,594,000	30%	$ 2,072,000		TerraTherm March 2, 2010 cost estimate
300.03 Permeable Cap						**$ 690,000**		**$ 828,000**		
	Install Permeable Soil Cap	CY	40000	$ 15	$ 90,000	$ 690,000	20%	$ 828,000	Assumes geotextile fabric (360,000 SF at $0.25/SF) and 3-feet of top soil.	Engineers Estimate
Task 3—Restoration Costs Subtotal						**$ 4,830,000**		**$ 6,460,000**		
400.0 Design, Permitting, and Site Preparation										
400.01 Design and Construction Oversight						**$ 6,191,000**		**$ 8,048,000**		
	Engineering Design/Project Administration	LS	1	$ 4,127,300	$ -	$ 4,127,000	30%	$ 5,365,000	10% of construction costs	
	Construction Oversight	LS	1	$ 2,063,650	$ -	$ 2,064,000	30%	$ 2,683,000	5% of construction costs	
400.02 Permitting						**$ 2,064,000**		**$ 2,683,000**		
	Permitting/Legal	LS	1	$ 2,063,650	$ -	$ 2,064,000	30%	$ 2,683,000	5% of construction costs	
400.03 Site Preparation						**$ 100,000**		**$ 150,000**		
	Demolition of On-Site Building and Utilities	LS	1	$ 100,000	$ -	$ 100,000	50%	$ 150,000		Engineers Estimate
Task 4—Design, Permitting, and Site Preparation Costs Subtotal						**$ 8,355,000**		**$ 10,881,000**		
	Subtotal					**$ 115,483,000**		**$ 144,074,000**		
	Tax (9.5%)					**$ 10,971,000**		**$ 13,687,000**		
	Total					**$ 126,454,000**		**$ 157,761,000**		

Abbreviations:

bgs	below ground surface
BTU	British thermal unit
CY	Cubic yard
kWh	Kilowatt-Hour
lb	pound
LF	Linear foot
LS	Lump sum
MM BTU	Million British thermal units
NAPL	Non-aqueous phase liquid
QC	Quality Control
SF	Square foot
SVE	Soil vapor extraction
TCH	Thermal conduction heating
VF	Vertical feet

Alternative 3b
Partial Excavation with Soil Stabilization

Task #	Description	Units	Quantity	Unit Cost	Labor	Estimated Total Cost	Contingency	Estimated Total Cost with Contingency	Notes	Cost Source
100.0 Construction										
100.01	Secant Wall (includes reinforcement for shallow excavation)					**$ 10,381,000**		**$ 13,495,000**		
	Install Secant Wall Adjacent to Existing Sheetpile Wall	VSF	116,280	$ 82	$ 823,000	$ 10,381,000	30%	$ 13,495,000	Based on length of 1,938 feet long, average depth of 60 feet. Fixed additional costs are $232K for mob/demob, $528K for guide wall, $63K for QC.	Unit cost estimate for 117,800 VSF provided by Joe Lewis at Recon Services, 4/29/10. Cost pro-rated based on design CAD calculations.
100.02	Upgradient Cutoff Wall					**$ 211,000**		**$ 268,000**		
	Perimeter Barrier Wall Extension	VSF	10,100	$ 6	$ 100,000	$ 161,000	20%	$ 193,000	862 linear feet and an average of 11.7 feet deep based on CAD calculations. Wall is upgradient from Alt 1 to allow excavation at a 1.5:1 (H:V) slope. Cost is for a slurry wall installed via excavation and slurry mixing and installation.	Based on previous project bids from Recon ($5.55/SF) and Envirocon ($3.78/SF) plus $100,000 mobilization/demobilization and quote from Ed Hicks ($8/SF).
	Drainage System on Upgradient Side	LS	1	$ 50,000		$ 50,000	50%	$ 75,000	Assumes gravity drain	Engineer's Estimate.
100.03	Dewatering					**$ 745,000**		**$ 956,000**		
	Mobilization/Demobilization	LS	1		$ -	$ 20,000	20%	$ 24,000		Engineer's Estimate.
	Well Installation and Development	per well	30	$ 20,000	$ -	$ 600,000	30%	$ 780,000	Assumes 8-inch well with gravel pack, average of 60-feet deep, spaced 100 to 150-feet apart	Engineer's Estimate.
	Submersible Pump and Pump Column	per well	30	$ 1,000	$ -	$ 30,000	20%	$ 36,000		Engineer's Estimate.
	Pump Installation and Wiring	per well	30	$ 2,500	$ -	$ 75,000	20%	$ 90,000		Engineer's Estimate.
	PVC Discharge Piping and Headers	LS	1	$ 20,000	$ -	$ 20,000	30%	$ 26,000		Engineer's Estimate.
100.04	Excavation and Segregation					**$ 6,089,000**		**$ 7,435,000**		
	Sheetpile Construction into Grids	VSF	28,500	$ 45	$ -	$ 1,283,000	30%	$ 1,668,000	Sheetpile walls to divide area into three separate cells, 950 LF with an average depth of 30 feet.	Contractor estimate and previous project bidsfor sheetpile construction $45/SF
	Excavation, Stockpiling, Segregation of Soils and placement into MTTD from 0 to 30 feet bgs	Ton	607,500	$ 7.50	$ 250,000	$ 4,806,000	20%	$ 5,767,000	Assumes 400,000 CY at 1.5 tons/CY plus $250,000 mobilization/demobilization fee plus removal of 5000 CY of soil along southern edge to eliminate shoring.	Contractor Quotes $5-$10/ton and previous project/bid experience averagine $9.50/CY (or $6.30/ton)
100.05	Ex-situ Thermal Treatment					**$ 500,000**		**$ 575,000**		
	Mobilization/Demobilization	LS	1	$ 500,000	$ -	$ 500,000	15%	$ 575,000	Mobilization/Demobilization to Site	Quote from Frank Kellog, 3/15/10 via phone call.
100.06	Soil Stabilization					**$ 31,250,000**		**$ 39,063,000**		
	Stabilize Soil Below 30 feet bgs	CY	250,000	$ 125	$ -	$ 31,250,000	25%	$ 39,063,000	Assumes 250,000 CY that will be stabilized	Per phone conversation with Ed Hicks and his follow up e-mail. $100/CY for Portland Cement, $125/CY for Portland Cement with activated carbon
100.07	Backfilling and Compaction					**$ 3,038,000**	50%	**$ 3,949,000**		
	Place and Compact Backfill	Ton	607,500	$ 5		$ 3,038,000	30%	$ 3,949,000	Assumes 400,000 + 5000 CY at 1.5 tons/CY	Contractor Estimates of $5-$10/ton and previous project bids - $8/CY or $5.35/ton
Task 1—Construction Costs Subtotal						**$ 52,214,000**		**$ 65,741,000**		
200.0 Operations										
200.01	Operating Costs of Thermal Treatment Plant for Soil					**$ 27,000,000**		**$ 31,050,000**		
	Treatment of Excavated Soil	CY	360,000	$ 75	$ -	$ 27,000,000	15%	$ 31,050,000	Assumes 400,000 CY with 10% of clean soil that does not need treatment.. Cost is all inclusive from dirty stockpiled soil to clean stockpiled soil.	Quote from Frank Kellog, 5/13/10 via phone call and 3/9/10 e-mail
200.02	Operating Costs of Treatment Plant (Treat Dewatered Water)					**$ 282,000**	0%	**$ 353,000**		
	Carbon Adsorption (Initial Dewatering Period)	per pound	56,575	$ 1.25	$ -	$ 71,000	25%	$ 89,000	Usage rate is based on 50% of Alt. 2 (Full excavation) due to reduced depth of excavation and shorter time frame.	Table 6.3 from CH2MHill 2005 Engineering Evaluation, $1.25/lb.
	Carbon Adsorption (Post-Initial Dewatering Period)	per pound	93,075	$ 1.25	$ -	$ 116,000	25%	$ 145,000	Usage rate is based on 50% of Alt. 2 (Full excavation) due to reduced depth of excavation and shorter time frame.	Table 6.3 from CH2MHill 2005 Engineering Evaluation, $1.25/lb.
	Operation and Maintenance (Initial Dewatering Period)	LS per Year	0.5	$ 75,000	$ 2,840	$ 40,000	25%	$ 50,000	Based on 1 operator per year ($75,000 per year) plus maintenance at 4% of carbon cost for groundwater system.	
	Operation and Maintenance (Post-Initial Dewatering Period)	LS per Year	2	$ 25,000	$ 4,640	$ 55,000	25%	$ 69,000	Based on 1 operator per year ($25,000 per year) plus maintenance at 4% of carbon cost for groundwater system.	
200.03	Operating Costs for Dewatering					**$ 222,000**		**$ 286,000**		
	Discharge Permit Fees	LS	1	$ 15,000	$ -	$ 15,000	20%	$ 18,000		Engineer's Estimate
	Discharge Monitoring and Reporting	LS per Year	3	$ 6,000	$ -	$ 18,000	20%	$ 22,000		Engineer's Estimate
	Operate and Maintain System (Initial Dewatering Period)	LS per month	6	$ 22,500	$ -	$ 135,000	30%	$ 176,000	Assumes initial dewatering period of 6 months to get area to steady (near dry) state. $750 per month per well	Engineer's Estimate
	Electrical Power (Initial Dewatering Period)	LS per month	6	$ 1,000	$ -	$ 6,000	30%	$ 8,000	Assumes initial dewatering period of 6 months to get area to steady (near dry) state. Assumes $1,000 per month	Engineer's Estimate
	Operate, Maintain, and Electrical Power (Post Initial Dewatering)	LS per month	24	$ 2,000	$ -	$ 48,000	30%	$ 62,000	Assumes excavation will take 2.5 years total. Includes costs for operating dewatering system after steady state has been reached. $2,000 per month	Engineer's Estimate
Task 2—Operating Costs Subtotal						**$ 27,504,000**		**$ 31,689,000**		

Alternative 3b
Partial Excavation with Soil Stabilization

Task #	Description	Units	Quantity	Unit Cost	Labor	Estimated Total Cost	Contingency	Estimated Total Cost with Contingency	Notes	Cost Source
300.0 Restoration										
300.01 Site Restoration						**$ 750,000**		**$ 1,125,000**		
	Cut-down Sheet Pile Wall	LS	1	$ 750,000	$ -	$ 750,000	50%	$ 1,125,000	Only cut down to below ground surface	Engineers Estimate
300.02 Well Decommissioning and Equipment Removal						**$ 524,000**		**$ 781,000**		
	Decommission Existing Wells	Per Well	100	$ 3,000	$ -	$ 300,000	30%	$ 390,000	Assume overdrilling for existing wells	Table 6.2 from CH2M Hill 2005 Engineering Evaluation
	Decommission New Dewatering Wells	Per Well	30	$ 800	$ -	$ 24,000	30%	$ 31,000	Assume grouting for new wells.	
	Decommission Treatment Plant	LS	1	$ 500,000		$ 500,000	50%	$ 750,000		Engineers Estimate
300.03 Permeable Cap						**$ 690,000**		**$ 828,000**		
	Install Permeable Soil Cap	CY	40000	$ 15	$ 90,000	$ 690,000	20%	$ 828,000	Assumes geotextile fabric (360,000 SF at $0.25/SF) and 3-feet of top soil.	Engineers Estimate
Task 3—Restoration Costs Subtotal						**$ 2,114,000**		**$ 2,929,000**		
400.0 Design, Permitting, and Site Preparation										
400.01 Design and Construction Oversight						**$ 7,832,000**		**$ 10,181,000**		
	Engineering Design/Project Administration	LS	1	$ 5,221,400	$ -	$ 5,221,000	30%	$ 6,787,000	10% of construction costs	
	Construction Oversight	LS	1	$ 2,610,700	$ -	$ 2,611,000	30%	$ 3,394,000	5% of construction costs	
400.02 Permitting						**$ 2,611,000**		**$ 3,394,000**		
	Permitting/Legal	LS	1	$ 2,610,700	$ -	$ 2,611,000	30%	$ 3,394,000	5% of construction costs	
400.03 Preparation						**$ 100,000**		**$ 150,000**		
	Demolition of On-Site Building and Utilities	LS	1	$ 100,000	$ -	$ 100,000	50%	$ 150,000		Engineers Estimate
Task 4 Subtotal						**$ 10,543,000**		**$ 13,725,000**		
	Subtotal					**$ 92,375,000**		**$ 114,084,000**		
	Tax (9.5%)					**$ 8,776,000**		**$ 10,838,000**		
	Total					**$ 101,151,000**		**$ 124,922,000**		

Abbreviations:

bgs below ground surface
CY Cubic yard
lb pound
LF Linear foot
LS Lump sum
QC Quality Control
SF Square foot
VF Vertical feet

Generational Remedy Alternative Cost Summary

	Alternative 1: In-Situ Thermal Treatment		Alternative 2: Full Excavation and Ex-situ Treatment		Alternative 3a: Partial Excavation and In-situ Thermal Treatment		Alternative 3b: Partial Excavation and Soil Stabilization		Generational Remedy - Average	
	Without Contingency	With Contingency	Without Contingency	With Contingency	Without Contingency	With Contingency	Without Contingency	With Contingency	Without Contingency	With Contingency
Task 1—Construction Costs Subtotal	$ 34,046,000	$ 44,121,000	$ 28,212,000	$ 35,802,000	$ 41,273,000	$ 53,110,000	$ 52,214,000	$ 65,741,000	$ 38,936,000	$ 49,694,000
Task 2—Operating Costs Subtotal	$ 40,300,000	$ 50,437,000	$ 44,715,000	$ 51,519,000	$ 61,025,000	$ 73,623,000	$ 27,504,000	$ 31,689,000	$ 43,386,000	$ 51,817,000
Task 3—Restoration Costs Subtotal	$ 6,690,000	$ 8,978,000	$ 2,272,000	$ 3,135,000	$ 4,830,000	$ 6,460,000	$ 2,114,000	$ 2,929,000	$ 3,977,000	$ 5,376,000
Task 4—Design, Permitting, and Site Preparation Costs Subtotal	$ 6,909,000	$ 9,003,000	$ 5,743,000	$ 7,485,000	$ 8,355,000	$ 10,881,000	$ 10,543,000	$ 13,725,000	$ 7,888,000	$ 10,274,000
Subtotal	$ 87,945,000	$ 112,539,000	$ 80,942,000	$ 97,941,000	$ 115,483,000	$ 144,074,000	$ 92,375,000	$ 114,084,000	$ 94,186,000	$ 117,160,000
Tax (9.5%)	$ 8,355,000	$ 10,691,000	$ 7,689,000	$ 9,304,000	$ 10,971,000	$ 13,687,000	$ 8,776,000	$ 10,838,000	$ 8,948,000	$ 11,130,000
Total	$ 96,300,000	$ 123,230,000	$ 88,631,000	$ 107,245,000	$ 126,454,000	$ 157,761,000	$ 101,151,000	$ 124,922,000	$ 103,134,000	$ 128,290,000

Generational Remedy Life Cycle Costs

Generational Remedy[1,2,3,4]	Total Cost over 200 Years (2010 Dollars)[5]	Total Cost over 400 Years (2010 Dollars)[5]	NPV using USEPA Guidance (2.7%)[6]	Years 0–10	Years 11–50	Years 51–100	Years 101–150	Years 151–200	Years 201–250	Years 251–300	Years 301–350	Years 351–400
Alternative 1: In-Situ Thermal Treatment	$123,230,000	$123,230,000	$102,773,000	$ 94,792,308	$ 28,437,692	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Alternative 2: Full Excavation and Ex-situ Treatment	$107,245,000	$107,245,000	$99,077,000	$ 107,245,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Alternative 3a: Partial Excavation and In-situ Thermal Treatment	$157,761,000	$157,761,000	$131,572,000	$ 121,354,615	$ 36,406,385	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Alternative 3b: Partial Excavation and Soil Stabilization	$124,922,000	$124,922,000	$115,408,000	$ 124,922,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Average of Alternatives 1, 2, 3a, and 3b	$128,290,000	$128,290,000	$112,556,000	$ 128,290,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
USEPA Containment Remedy[3,7,8]												
Capital Costs	$30,000,000	$30,000,000	$27,715,000	$ 30,000,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Replacement Costs	$78,600,000	$165,700,000	$10,174,000	$ -	$ 15,400,000	$ 23,900,000	$ 23,900,000	$ 15,400,000	$ 23,900,000	$ 23,900,000	$ 15,400,000	$ 23,900,000
Operation and Maintenance Costs	$171,400,000	$342,800,000	$31,740,000	$ 8,570,000	$ 34,280,000	$ 42,850,000	$ 42,850,000	$ 42,850,000	$ 42,850,000	$ 42,850,000	$ 42,850,000	$ 42,850,000
Total Costs	**$280,000,000**	**$538,500,000**	**$69,629,000**	**$ 38,570,000**	**$ 49,680,000**	**$ 66,750,000**	**$ 66,750,000**	**$ 58,250,000**	**$ 66,750,000**	**$ 66,750,000**	**$ 58,250,000**	**$ 66,750,000**

Notes:

Costs include contingencies.

1 Generational Remedy Alternatives 1 and 3a costs are distributed evenly over Years 1–13. Alternatives 2 and 3b costs are distributed evenly over Years 1–5. The Average of all 4 Alternatives is distributed evenly over Years 1–9.
2 For the Generational Remedy Alternatives, the Capital/Replacement Costs and Operation and Maintenance (O&M) Costs are considered a lump sum due to the short life span of the remedy.
3 Costs for the Containment Remedy include tax at 8.8%. Costs for the Generational Remedy include tax at 9.5%.
4 Generational Remedy Alternatives assumes no on-going monitoring or operations and maintenance.
5 Total costs do not include inflation over time.
6 USEPA Guidance document using real discount rates (2.7%) for projects for more than 30 years from Appendix C of OMB Circular A-94.
7 Costs for the USEPA Containment Remedy are from the report text (Section 3.4) and assume a 5-year construction period.
8 USEPA Containment Remedy Long Term Costs include $857K per year for O&M (O&M costs include extraction and monitoring well replacement costs), $8.5M every 30 years for replacement of the groundwater treatment system and $6.9M every 50 years for replacement of the Sheetpile Wall and assumes the sheetpile wall is already 10 years old.

Abbreviations:

NPV Net Present Value
USEPA U. S. Environmental Protection Agency