AGENCY REVIEW DRAFT

Technical Memorandum No. 5: Remedial Alternatives Development & Evaluation

Site Wide Feasibility Study

PSC Georgetown Facility

Seattle, Washington

Prepared for:

Philip Services Corporation
18000 72nd Avenue South, Suite 217
Kent, Washington 98032

April 2007

Project No. 8770

Geomatrix

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Prepared for:

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ACRONYMS AND ABBREVIATIONS

1,1,1-TCA	1,1,1-trichloroethane
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
ARARs	applicable or relevant and appropriate requirements
BEHP	bis(2-ethylhexyl) phthalate
BTEX	benzene, toluene, ethylbenzene, and xylenes
bgs	below ground surface
CAP	Corrective Action Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene
cm/sec	centimeters per second
CPOC	conditional point of compliance
COC	constituent of concern
CPOC	conditional point of compliance
CULs	cleanup levels
DARA	Deep Aquifer Remediation Rea
DCE	dichloroethene
DNAPL	dense nonaqueous phase liquid
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
facility, the	Philip Service Corporation Georgetown Facility, 734 South Lucile Street, Seattle, Washington
FS	feasibility study
GAC	granular activated compound
gpm	gallons per minute
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCIM	hydraulic control interim measure
HCIM Area	area within the hydraulic control interim measure barrier wall

ACRONYMS & ABBREVIATIONS
(Continued)

HDPE	high-density polyethylene
HSRA	HCIM Soil Remediation Area
ISB	in situ bioremediation
ISCO	in situ chemical oxidation
IPIM	inhalation pathway interim measure
lb	pounds
ITRC	Interstate Technology Regulatory Council
lb/day	pounds per day
LNAPL	light nonaqueous phase liquid
µg/L	micrograms per liter
mV	millivolts
mg/L	milligrams per liter
MCL	Maximum Cleanup Levels (Clean Water Act)
MDL	method detection limit
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
O_3/Ox	ozone oxidation
O&M	operation and maintenance
OSRA	Outside Soil Remediation Area
OSIRA	Shallow/Intermediate Remediation Area
Outside Area	the SWFS Area outside the boundaries of the HCIM Area
OWTRA	Outside Water Table Remediation Area
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
Permit	PSC Georgetown Facility, RCRA Part B Permit
PID	photo ionization detector
PLC	programmable logic controller

ACRONYMS & ABBREVIATIONS
(Continued)

PSC	Philip Services Corporation
PSCAA	Puget Sound Clean Air Agency
POTW	publicly-owned treatment works
PVC	polyvinyl chloride
redox	reduction/oxidation
RI	remedial investigation
RL	remediation level
SAD	Stone-Draw/Ashe & Drew
SPOC	standard point of compliance
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
SWFS	Site Wide Feasibility Study
SWFS Area	areas within the scope of the SWFS or area addressed by the SWFS
TASCO	the Amalgamated Sugar Company
TCA	trichloroethane
TCE	trichloroethene
TPH	total petroleum hydrocarbon
USGS	U.S. Geological Survey
UPRR	Union Pacific Railroad
UST	underground storage tank
UV/Ox	hydrogen peroxide and ultraviolet light
VC	vinyl chloride
VIAM	vapor intrusion assessment and mitigation
VOC	volatile organic compound
WAC	Washington Administrative Code

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AGENCY REVIEW DRAFT

TECHNICAL MEMORANDUM NO. 5: REMEDIAL ALTERNATIVES DEVELOPMENT & EVALUATION SITE WIDE FEASIBILITY STUDY

PSC Georgetown Facility
Seattle, Washington

1.0 PURPOSE AND SCOPE

This Technical Memorandum has been prepared to document work completed to date for the revised Site Wide Feasibility Study (SWFS) for the Philip Services Corporation (PSC) Georgetown facility.[1] This SWFS is intended to meet corrective action provisions of the PSC Georgetown facility RCRA Part B Permit and the requirements of the MTCA. The Permit, as issued under the authority of the Washington State Department of Ecology (Ecology), covers the regulated areas of the former PSC facility operations. PSC closed these areas (and all dangerous waste operations within these areas) in August 2003 under a closure plan approved by Ecology. At that time, all dangerous waste operations at the facility ceased.

During 2003 and 2004, PSC implemented an hydraulic control interim measure (HCIM). The HCIM involved construction of a subsurface barrier wall keyed into the aquitard underlying the facility and a groundwater pump-and-treat system designed to maintain an inward gradient to contain contaminated groundwater beneath the facility and adjacent properties. Implementation of the HCIM required PSC to purchase the TASCO property and adjoining railroad spur, and to acquire easements on two other properties adjacent to the facility (the Stone-Drew/Ashe & Jones

[1] Throughout this memorandum, the term "facility" is used to refer to the former Resource Conservation and Recovery Act (RCRA) dangerous waste operations located at 734 South Lucile Street, owned and operated by PSC. The term "corrective action facility" may also include certain properties adjacent to the former dangerous waste facility property that were acquired by PSC following closure of the dangerous waste operations in August 2003 [e.g., adjacent property to the northwest formerly owned by The Amalgamated Sugar Company (TASCO) that was impacted by historical releases from the PSC facility]. The facility RCRA Part B permit (Permit) requires PSC to perform corrective action beyond the boundaries of the permitted facility to address such releases. The Washington Model Toxics Control Act (MTCA) regulations, Chapter 173-340 WAC, also require PSC to perform cleanup actions to address releases from the facility at "any site or area where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise come to be located" (*see* WAC 173-340-200). For purposes of this Technical Memorandum, the term "Site" includes both the facility and other areas (e.g., TASCO) that have been affected by releases that occurred at the facility.

[SAD] property and the Aronson property). The HCIM has proven effective in providing hydraulic control of contaminated groundwater in these areas of the facility.

The Permit requires that the SWFS address all areas affected by releases from the facility. The area addressed by the SWFS (i.e., the SWFS Area) includes the properties currently owned by PSC (the facility and the adjacent TASCO property), portions of properties adjacent to the PSC properties (Union Pacific Railroad [UPRR], Aronson, and SAD properties), and the contiguous areas affected by releases from the facility extending downgradient (west) to Fourth Avenue South (Figure 1-1). The area affected by facility releases has been defined in the RI Report and subsequent Addenda (PSC, 2003, 2004a, 2004b, 2004c, 2004d). After the RI Report was completed, additional releases to soil and groundwater from non-PSC sources were identified downgradient from the facility, near Fourth Avenue South. The specific chemicals released in these downgradient areas include many of the facility COCs. These downgradient releases have resulted in an area of comingled releases that extend from approximately Fourth Avenue South to the Duwamish Waterway. Due to the presence of these downgradient source areas and the complexity of dealing with impacted groundwater from multiple sources, the scope of the SWFS has been limited, with Ecology concurrence, to the SWFS Area. Remedial action for the area downgradient from Fourth Avenue South will be addressed separately.

In response to comments received from Ecology on the initial draft SWFS report, PSC and Ecology have agreed to use a collaborative, phased process in preparing the revised draft SWFS report to ensure consensus among PSC, Ecology, and other interested parties on key issues that affect the SWFS. During this process, PSC has developed the five separate Technical Memoranda addressing the topics listed below to satisfy Permit and MTCA requirements for the complete SWFS:

1. Cleanup Levels, Constituents of Concern, Point of Compliance, Fate and Transport Modeling, and Corrective Action Schedule (Geomatrix, 2006a);
2. Remediation Areas (Geomatrix, 2006b);
3. Inhalation Pathway Interim Measure (Pioneer Technologies Corporation [Pioneer], 2006);
4. Technology Identification and Screening (Geomatrix, 2006c, 2007a);
5. Remedial Alternatives Development and Evaluation.

PSC prepared and submitted Technical Memoranda 1 through 4 in draft form to Ecology. Following Ecology review and comment, PSC revised the draft memoranda as appropriate for final approval by Ecology. It was agreed that work on the last Technical Memorandum, No. 5 (this memorandum), would begin after Ecology's final approval of Technical Memorandum No. 4. PSC will prepare the complete revised draft SWFS following Ecology's approval of Technical Memorandum No. 5 by combining the five memoranda listed above.[2]

This memorandum further develops remedial alternatives that could be implemented to address soil and groundwater impacts within the SWFS Area. These alternatives are based on remedial technologies identified in the technology screening presented in Technical Memorandum No. 4. Potentially applicable remedial alternatives are evaluated relative to criteria specified in the MTCA rules to select the preferred alternative. Finally, this memorandum presents a preliminary plan to implement the preferred alternative.

[2] These memoranda have been designed so that individual sections may be incorporated directly into the revised draft FSWP. It is anticipated that the text from the individual memoranda will appear in the report in a sequence different from the sequence of the memoranda as submitted to Ecology.

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2.0 REMEDIATION OBJECTIVES

As discussed in Technical Memorandum No. 2, the SWFS Area has been separated into two general areas for the purposes of the SWFS: (1) the HCIM Area and (2) the Outside Area. The HCIM and Outside Areas were further subdivided into individual soil and groundwater remediation areas based on several factors, including the nature and distribution of affected soil and groundwater, previously implemented interim measures, site ownership, and land use (Figures 2-1 and 2-2). Different remediation objectives must be considered for the HCIM Area and the Outside Area due to the significant differences in soil and groundwater conditions between the two areas, differences in property ownership and accessibility, and the issues affecting attainment of cleanup levels within a reasonable time frame. The general remediation objectives that apply to the entire SWFS Area, as well as remediation objectives specific to the HCIM and Outside Areas, are presented below.

2.1 GENERAL OBJECTIVES

The remediation objectives presented in the RI Report and approved by Ecology can be applied to the entire SWFS Area. These general remediation objectives are summarized as follows:

- Prevent direct human contact with surface or subsurface soil and inhalation of dust from surface soil affected with COCs at concentrations that exceed cleanup levels, or reduce the risks associated with these exposure pathways to acceptable levels.
- Reduce risks associated with inhalation of vapors from affected soil or groundwater to acceptable levels established in accordance with MTCA regulations.
- Protect human and ecological receptors by reducing COC concentrations in affected groundwater to cleanup levels based on protection of surface water.

2.2 HCIM AREA REMEDIATION OBJECTIVES

Several features specific to the HCIM Area will affect remediation and development of remediation alternatives. This area includes the source areas associated with the facility and also the highest observed constituent concentrations in soil and groundwater. COC concentrations in groundwater samples indicate that DNAPL is present in two locations within the HCIM Area, although DNAPL has not been observed in soil borings or monitoring wells. As discussed in Section 5.3 of Technical Memorandum No. 1, subsurface stratigraphy and vertical distribution of COC concentrations indicate that DNAPL ganglia are likely distributed throughout the soil profile and are associated with the numerous silt and fine-grained sand lenses within the HCIM Area. The portion of the HCIM area that was the former RCRA facility was investigated during the RI. This property was suspected to be heavily contaminated, as indicated from early investigation results. Based on these findings, the subsequent investigations focused primarily on assessing the areal extent of affected soil and groundwater, since it was assumed that heavy contamination by a wide variety of COCs existed throughout most of the facility. Additionally, installation of deep borings was generally avoided in the areas suspected to be most heavily impacted so as not to create new migration pathways. Thus, although there are minimal investigation and documentation of the potential presence of DNAPL, available data for constituents present in groundwater samples provides strong evidence that DNAPL is present within the HCIM Area.

The conceptual model for contaminant distribution beneath the facility is based on a thorough understanding of the site history (presented in the RI), the known releases from the USTs in the North Field area, the drum storage activities conducted on site in the late 1970s and early 1980s, and detected contaminant concentrations in groundwater samples collected from monitoring wells and direct-push probes. The location of the barrier wall on the TASCO, SAD, and Aronson properties was based partially on concentrations of VOCs in groundwater samples at concentrations indicating the potential presence of DNAPL. The northwest portion of the HCIM Area, which encompasses a portion of the TASCO and Aronson properties, clearly had VOC concentrations in groundwater samples above levels suggesting DNAPL at depths down to the intermediate silt. Similar concentrations were found in groundwater samples from along the SAD/PSC property line, although only in the water table and shallow depth intervals.

While much of the HCIM Area characterization data are older, recent investigation work along the SAD property line and on UPRR property indicates that the soils in areas where PSC drums were stored are anticipated to have high concentrations of facility COCs. Since drum storage and other waste management activities were conducted over much of the facility at various times, soil and groundwater are likely to be impacted throughout the portions of the former facility area inside the HCIM barrier wall.

Based on the constraints and considerations discussed above for the HCIM Area, PSC has developed the following remediation objectives for the HCIM Area, in addition to the general remediation objectives that apply to the entire SWFS Area:

- Prevent discharge of COCs from the HCIM Area at concentrations that exceed cleanup levels.

- For any actions not relying exclusively on containment, reduce contaminant concentrations in groundwater.

- Ensure that remedial actions implemented within the HCIM Area are compatible with the HCIM barrier wall.

- Support future redevelopment and reuse of the facility and the TASCO properties for industrial purposes.

To assess attainment of these objectives by the remedial alternatives presented in Section 4.0, the following factors have been considered:

- A substantial interim measure implemented for the HCIM Area (the installation of a subsurface barrier wall and a groundwater extraction and pretreatment system) has proven effective in controlling the discharge of impacted groundwater from the facility (Geomatrix, 2007b).

- It is desirable to reduce all COC concentrations to their cleanup levels if this can be done practicably. Some actions, however, may not be able to technically or cost-effectively reduce all COCs to cleanup levels. Reductions to remediation levels (concentrations higher than cleanup levels) are then desirable, and preferable to less significant reductions

- It is desirable to achieve the above remedial objectives before HCIM barrier wall failure; it is not, however, possible to reasonably predict when or if a failure may occur, as the primary failure mode would be due to a major earthquake significantly disturbing the facility.

2.3 OUTSIDE AREA REMEDIATION OBJECTIVES

Similar to the HCIM Area, the nature of the Outside Area affects remediation efforts and the development of practicable remedial alternatives. The area is densely developed and includes public and private landowners. The area is characterized by mixed land use, including industrial, commercial, and residential development. A portion of the UPRR Argo Rail Yard is included in the Outside Area. The area also includes busy public streets and many active subsurface utilities. The large number of independent property owners and tenants may significantly complicate obtaining access agreements to private properties to perform remediation or monitoring activities.

Releases from the PSC facility did not generally affect Outside Area soil, with the noted exceptions of the adjacent UPRR rail yard and portions of the PSC facility located outside the barrier wall. Groundwater within the Outside Area has been generally affected by releases from the facility. The highest COC concentrations in groundwater are typically found immediately downgradient of the HCIM barrier wall, with some lower concentration "hot spots" located farther downgradient.

Based on the constraints and considerations discussed above, PSC has developed the following remediation objectives for the Outside Area, in addition to the general remediation objectives established for the entire SWFS Area:

- Attain remediation levels at the CPOC within a reasonable time frame.
- Reduce constituent concentrations to achieve groundwater cleanup levels at the CPOC.
- Do not adversely affect existing and reasonably expected future land uses within the Outside Area.

Attainment of remediation levels at the CPOC is viewed as a priority for remediation of the Outside Area. The time frame for attainment of remediation levels at the CPOC should be shorter than the time frames considered reasonable for attaining cleanup levels at the CPOC.

The remedial alternatives will be developed to accomplish the following:

- Do not create nuisance conditions or conditions adverse to remediating downgradient source areas.
- Be compatible with the existing interim measures (both the HCIM and the IPIMs).

3.0 REMEDIAL ALTERNATIVES EVALUATION CRITERIA

This section presents the criteria used to evaluate the potential remedial alternatives identified for the SWFS Area and select the preferred alternative(s). The potential remedial alternatives were developed from the initial screening of potentially applicable remediation technologies in Technical Memorandum No. 4. These alternatives were designed to attain the remediation objectives presented in Section 2.0.

Each of the remedial alternatives presented in this Technical Memorandum were evaluated relative to the criteria specified in the MTCA rules to select the preferred alternative. The evaluation criteria used for this SWFS must address requirements of the MTCA regulations and the RCRA Part B permit. The evaluation criteria for this SWFS include:

- protectiveness and risk reduction,
- permanence,
- cost,
- long-term effectiveness,
- management of short-term risks,
- technical and administrative implementability,
- public concern, and
- reasonable time frame to meet cleanup levels.

The remedial alternatives considered in this Technical Memorandum were designed to attain the remediation objectives to the extent practicable. As described in Technical Memorandum No. 1, remediation levels included in this SWFS were established to ensure that COCs released from the facility would attenuate to meet groundwater cleanup levels prior to discharge to surface water. These remediation levels incorporate natural attenuation processes occurring between the point where the remediation levels would be attained and the discharge to the Duwamish Waterway. As noted previously, these remediation levels address only COCs released from the facility and do not address any non-PSC sources that may be present downgradient from the facility.

The SWFS evaluation criteria are defined and discussed in the following subsections. These criteria are used to evaluate the remedial alternatives presented in Sections 4 and 5 of this Technical Memorandum.

3.1 PROTECTIVENESS AND RISK REDUCTION

This criterion involves the degree to which a remedial alternative protects human health and the environment and reduces potential risks to human or ecological receptors. Evaluation of protectiveness and risk addresses long-term effects rather than short-term effects, which are evaluated under a different criterion. Alternatives that attain remediation levels and/or cleanup levels are considered as protective under this criterion, and alternatives that meet remediation or cleanup levels in a shorter time are considered to provide a higher level of risk reduction. Alternatives that rely on engineering controls or institutional controls to provide protectiveness and risk reduction are generally ranked lower for this criterion than alternatives that do not rely on these controls.

Factors considered for evaluating this criterion include:

- potential risks to human health and the environment during and following implementation of the alternative. Preremediation and pre-interim action risks will be used as a baseline to assess the reduction in risks that would result from implementing the remedial alternative;
- present and future land use for the SWFS Area;
- present and potential for future use of any water resources either associated with or affected by the site constituents within the SWFS Area;
- potential effectiveness and reliability of institutional controls associated with the alternative;
- the capability of the alternative to limit and monitor migration of COCs; and
- the toxicity of COCs.

3.2 PERMANENCE

Permanence is the degree to which a remediation alternative attains remediation objectives by permanently destroying COCs and the capability of the alternative to reduce contaminant toxicity, contaminant mobility, or the volume of affected media. Alternatives that actively degrade or destroy COCs would be ranked higher for this criterion than alternatives that utilize on-site or off-site containment. In accordance with MTCA requirements, the alternative providing the greatest degree of permanence is used as the baseline alternative against which other alternatives are compared. The other alternatives will be compared to the baseline alternative to identify the alternative that provides the greatest practicable degree of permanence. For the purposes of this SWFS, practicable shall be used as defined in WAC 173-340-200.

3.3 COST

Costs of remedial alternatives include implementation costs, O&M costs, monitoring costs, and management/reporting costs. Cost estimates were prepared for each remedial alternative considered in this SWFS. The costs include both initial implementation costs as well as future costs over the estimated remediation life, as discussed for each alternative in the following sections. Future costs are included in the total alternative cost using net present value (NPV) estimates. Cost estimates were prepared in general accordance with EPA guidance for preparing FS cost estimates under CERCLA (EPA, 2000).

The costs for implementing a remedial alternative include engineering, permitting, public relations, construction, purchase of facilities and equipment, building demolition or utility relocation, transportation and disposal, building restoration, access costs, and site restoration costs. Implementation costs typically occur at the beginning of the implementation program but may also include costs that occur later in the remediation program, such as costs for replacement or major repair of key remedial system components. Details regarding cost estimates for each of the alternatives are presented in Appendix A.

Costs for operations, maintenance (including minor repairs), monitoring, and reporting generally occur annually after construction has been completed. These costs include longer term, repeating expenses associated with multiyear remediation activities. Reporting costs are incurred to document monitoring and operations activities and provide regulatory information to Ecology. These ongoing, recurring, future costs usually include labor, power, utilities, sample analyses, subcontractors, agency oversight, and consumed materials. Future recurring costs are combined with initial implementation costs into a single NPV cost estimate for each remedial alternative. The NPV calculations consider an annual net discount rate (assumed to be 2.5 percent) that addresses the time value of money. The net discount rate is the interest rate that could be obtained from a prudent investment less a reasonable inflation rate. The net discount rate of 2.5% was selected in consultation with Ecology. This NPV cost estimate, including initial implementation costs and future recurring costs, is used to assess the cost criterion and compare the cost of the remedial alternatives. Details concerning operations, maintenance, monitoring, and reporting costs are included in Appendix A.

It is difficult to determine how long it may take to reach cleanup levels inside the HCIM Area. However, it is expected that substantial time would be needed to attain cleanup levels for all remedial alternatives considered. Therefore, a standard life of 100 years was assumed for NPV calculations. This length of time is considered sufficient to allow for long-term maintenance requirements for the HCIM barrier wall and to assess long-term monitoring costs. Additionally, costs projected beyond 100 years would not substantially increase NPV costs due to long-term compounding of the net discount rate). For the Outside area alternatives, it is projected that it would take 26 years to reach clean up levels using MNA; other Outside Area alternatives are expected to achieve cleanup levels at the CPOC in a shorter time. However, NPV costs for the Outside Area alternatives have also been based on a 100-year life, since monitoring must continue at the CPOC until cleanup levels are attained within the HCIM Area.

Once remediation levels are met inside the wall, and cleanup levels are attained in the Outside Area, long-term recurring costs would be based on O&M of the pump and treat system (HCIM Area) and compliance/performance monitoring on the outside of the wall (Outside Area recurring costs) at the CPOC. For the long-term cost of operating, maintaining, and monitoring of the HCIM Area, it has been have assumed that the wall would have structural damage due to a major earthquake, requiring substantial repair every 50 years. The estimated barrier wall repair costs are based on repair using a jet grouting approach to address cracks in the wall. Although it is not possible to predict when an earthquake would occur of a magnitude and location that would cause breaks in the barrier wall, it is known that there have been no slurry wall failures (for similar barrier wall) in at least the last 50 years in the United States and Europe. For this reason, the assumed wall failure frequency of once every 50 years is considered a conservative basis for barrier wall repair.

As part of costing, a sensitivity analysis was also completed to assess the effect of uncertainties associated with the implementation and with long-term operation. The anticipated costs are the best estimate and are used as the baseline costs for evaluating the alternatives. Low range and high range costs were also estimated for most HCIM Area alternatives by varying key cost factors with the greatest level of uncertainty. The uncertain cost elements were varied over an estimated range of uncertainty, generating the low and high estimates. Details for the sensitivity analysis are included in Appendix A.

3.4 LONG-TERM EFFECTIVENESS

For this criterion, the capability of a remedial alternative to reliably maintain its effectiveness over a long period of time is assessed. In addition, the production of residues is assessed; alternatives that do not generate hazardous substance residues would have a greater long-term effectiveness than alternatives that do produce such a residue. Permanent alternatives that result in destruction of COCs would provide better long-term effectiveness than alternatives relying on containment using engineering controls.

3.5 MANAGEMENT OF SHORT-TERM RISKS

Short-term risks associated with remedial alternatives include potential releases of material, water, particulates, or vapors containing COCs that could occur during implementation of the alternative. These types of losses could occur as a result of dust generation during excavation or handling of excavated materials, loss of affected soil or affected groundwater during treatment, or accidental releases during transport of affected media to a permanent disposal or treatment facility. Alternatives with potential risks that cannot be effectively managed would rank lower than those with minimal short-term risks or alternatives in which the short-term risks can be effectively managed.

3.6 TECHNICAL AND ADMINISTRATIVE IMPLEMENTABILITY

The technical and administrative implementability criterion refers to the capability to effectively implement a remedial alternative. Technical implementability involves technical and physical factors, such as the presence of existing buildings, that may affect implementation of an alternative or the need to have very specialized equipment for implementation. Administrative implementability involves factors such as permitting requirements or regulatory approvals needed for implementation. Administrative factors would most likely affect the implementation schedule, whereas technical factors could make an alternative ineffective or infeasible. Simple, proven remedial alternatives would rank high for technical implementability, while complex or unproven (developing) alternatives would rank low. Alternatives with minimal permitting requirements and that are readily accepted by regulatory agencies would rank high for administrative implementability.

Factors considered for evaluation of this criterion include:

- the size and complexity of the remedial alternative;
- the degree to which the remedial alternative can be integrated with existing operations and activities within affected areas;
- regulatory requirements, including permitting;
- present and future land use for the area above and adjacent to the project area, including any specific constraints land use may have on the alternative;
- present and potential for future use of any water resources either associated with or that may be affected by the site; and
- potential constraints to implementation of institutional controls associated with the alternative.

3.7 PUBLIC CONCERN

For this criterion, we evaluate the potential that implementing the alternative would generate concern among the general public, individuals at adjacent facilities, and the community. Remedial alternatives likely to be readily accepted by the public would rank higher than alternatives that may create issues that must be addressed. Potential public concerns include factors such as increased truck traffic, adverse traffic impacts, noise, dust, odors, release of vapors, use of hazardous materials, safety, and effects on property values. The heavy industrial, commercial, and residential land uses in an urban environment create significant potential for public concern related to site remediation. Previously voiced public concerns include (1) assigning responsibility for the contamination, (2) conducting cleanup quickly, and (3) opportunities for public involvement as the process proceeds.

3.8 REASONABLE RESTORATION TIME FRAME

The restoration time frame is the time required for an alternative to attain remediation objectives. In assessing this criterion, the practicability of attaining the shortest restoration time is assessed. Additional consideration is given to other facts that influence the urgency of remediation, including existing risks to human health and the environment, site use, potential future site use, availability of alternative water supplies, and reliance on institutional controls. These factors are assessed as a whole and used to determine the urgency of achieving the remedial objectives for a specific site. Alternatives that achieve remediation objectives in a shorter time would rank higher for this criterion than alternatives requiring a longer time. Alternatives that may not achieve remediation objectives for many years, if at all, would rank lower than those alternatives that attempt to restore the environment, even if there is uncertainty about the ability of the alternative to achieve remediation objectives. The practicality and necessity of implementing an alternative within a shorter time and the potential effectiveness and reliability of any institutional controls associated with the alternative are assessed for this criterion.

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4.0 DEVELOPMENT AND EVALUATION OF REMEDIAL ALTERNATIVES: HCIM AREA

The HCIM Area is entirely enclosed by a subsurface barrier wall, and most of the surface is covered by a cap consisting of microsilica concrete and asphalt. While most of the property within the HCIM Area is owned by PSC, the subsurface barrier wall extends onto two properties not owned by PSC. The HCIM Area encompasses the facility and includes the source area where the primary releases of COCs occurred. The HCIM has isolated this source area from the impacted groundwater plume extending downgradient from the HCIM Area. The HCIM Area is currently inactive except for limited storage of equipment in the only remaining building within the area (located on the former TASCO property). The area will eventually be redeveloped into industrial/commercial property consistent with land use in the immediate vicinity. The HCIM and existing cap will be incorporated into redevelopment.

Historic releases within the HCIM Area include chlorinated solvents, petroleum hydrocarbons, and other waste materials. The COCs within the HCIM Area include all COCs associated with the facility (VOCs, SVOCs, PCBs, and metals). As discussed in Technical Memorandum No. 2, the HCIM Area has been subdivided into two separate soil remediation areas, based on the nature and distribution of soil constituents within the HCIM Area. As shown in Figure 2-1, HCIM Soil Remediation Area 1 (HSRA-1) encompasses the portions of the facility within the barrier wall and HCIM Soil Remediation Area 2 (HSRA-2) includes the portions of the TASCO, SAD, and Aronson properties within the barrier wall. Soils present within HSRA-2 are not anticipated to be significantly impacted, except in the areas immediately adjacent to portions of the facility formerly used actively for site operations.

Groundwater impacts are known to be present throughout the entire HCIM Area, including all saturated zones above the aquitard on the facility, TASCO, and Aronson properties. With the exception of PCBs, the different COC classes generally coexist in groundwater distributed over most of the HCIM Area. Groundwater impacted by PCBs appears to be limited to the North Field, West Field, and the central portion of the facility. As shown on Figure 2-2, site investigation data indicate that DNAPL is likely present within two portions of the HCIM Area in the silt layers of the interbedded sand and silt aquifer down to the Silt Aquitard. Based on this distribution, a single HCIM Groundwater Remediation Area has been created, as shown on Figure 2-2.

The constituent concentrations and distribution, including the potential presence of DNAPL, will preclude full restoration of the HCIM Area and attainment of the SPOC for both soil and groundwater. COCs present within the barrier wall are persistent and represent potential risks via direct contact with soil, direct contact with groundwater, ingestion of either soil or groundwater, and inhalation of vapors released from impacted soil or groundwater. Remedial alternatives considered for the HCIM Area must address the nature and extent of impacted media in this area as well as the broad range of COCs and the potential exposure pathways. These alternatives must also be compatible with remedial actions that may be implemented in the Outside Area. For example, VOCs in the Outside Area have been shown to be naturally biodegrading under anaerobic conditions. The potential effect that any remedy considered for the HCIM Area could have on anaerobic conditions in the Outside Area must be considered for each alternative.

4.1 GROUNDWATER REMEDIATION LEVELS

Ecology has made comments in previous Technical Memoranda that the SWFS needs to evaluate a scenario or scenarios in which the subsurface barrier wall fails, resulting in a release of COCs to groundwater outside of the HCIM Area. To address Ecology's comments, PSC is evaluating the anticipated effectiveness of the various proposed cleanup Alternatives in reducing concentrations of COCs in the subsurface. As outlined in Section 4.1, six alternatives are being considered and evaluated for the HCIM Area. Appendix C presents a detailed review of existing literature on individual technologies and their performance in relation to COC reduction at various sites around the United States. Based on this review of technology performance, it becomes apparent that in situ remediation technologies are limited by the type of contaminant present, the distribution of the contaminant in the subsurface, the site geochemistry, and the site stratigraphy. The presence of DNAPL at the PSC facility presents challenges to all in situ technologies in completely destroying the COCs.

ISCO and/or steam stripping were included in Alternatives HA-4, HA-5, and HA-6 specifically to address DNAPL areas of the site. The efficiency of ISCO, however, at reducing COC concentrations at the PSC site would be limited by the geochemistry of the site and the site stratigraphy. The iron and manganese concentrations in the subsurface are very high, as is the total carbon load as a result of the wide variety of hydrocarbons and solvents in the subsurface. The chemical oxidant would react with all these constituents, and a great deal of the oxidant would be used up before the chlorinated VOCs were oxidized. This would likely result in the need to add oxidant at higher concentrations and more frequently than required at sites with simple geochemistry and a single contaminant type. In addition, most of the DNAPL is likely present within the interbedded silt and sand of the Intermediate Aquifer, and most will be sorbed to the silt. Homogeneous distribution of the chemical oxidant throughout the highly heterogeneous interbedded silt and sand would not be possible, which would result in pockets of COCs not being remediated. In addition, the oxidant would not be available to COCs within the silt layers, which could represent the majority of DNAPL. As a result, ISCO should be effective in the Shallow Aquifer but is not proposed in the Intermediate Aquifer. The same holds true for enhanced biodegradation.

Steam stripping is proposed in Alternatives HA-5 and HA-6 in the Intermediate Aquifer specifically to mobilize DNAPL in this interbedded zone; however, steam stripping is not a proven technology at the depths that would be employed at the PSC Georgetown Facility. Even at shallow depths, interbedded soils would result in variable effectiveness for steam stripping technology.

As a result there is not a single technology or group of technologies that could effectively treat the COCs in situ to the depths and conditions that occur in the HCIM Area. The anticipated effectiveness of any of the alternatives would be to reduce VOC concentrations considerably in the Shallow Aquifer, but have limited effect on the Intermediate Aquifer. Even though the shallow groundwater can be remediated, the diffusion and mixing of contaminated groundwater from the intermediate zone would result in recontamination of the shallow groundwater. VOC concentrations would be reduced in the Shallow Aquifer from present conditions, but would not meet cleanup levels in the foreseeable future.

Based on the anticipated effectiveness of the various alternatives in reducing concentrations, scenarios were modeled to develop RLs for various levels of barrier wall failure. The purpose of this evaluation was to assess the magnitude of releases that could occur to the downgradient aquifer and then to evaluate what magnitude of release could result in a risk to downgradient receptors, specifically the Duwamish Waterway. The calculated RLs for different barrier wall damage scenarios are presented in Tables 4-1a and 4-1b for the shallow and intermediate depth intervals, respectively. Appendix B documents the evaluation of the scenarios and the calculation of RLs.

Barrier walls installed with slurry technology have been used in Europe and the United States for at least 80 years. They are used primarily for geotechnical purposes in such applications as increasing stability of dams and hillsides and most commonly for dewatering purposes. Slurry walls are also used for ground improvements, including improving soil stability around key structures in areas prone to liquefaction. In dewatering applications, slurry walls are used around tunnels or subsurface building structures to minimize the amount of water withdrawal necessary to dewater the tunnel or basement of a building. In such an application, the slurry wall is subjected to very high lateral forces due to the differential water levels between the inside and outside of the walled area. There have been no documented failures of slurry walls (predominantly cement/clay walls in this application) even under these extreme stresses including in earthquake-prone areas.

Slurry walls have been used in contaminant containment systems only in the last 25 years, but they have been used have been used for at least 50 years for geotechnical applications. There has not been a single documented case of a slurry wall structural failure during this period, except during construction of the wall. Contaminant migration through slurry walls has been shown to occur through chemical diffusion through the wall and in some cases due to improper seals with the aquitard; however, no slurry wall has been reported as cracked or broken.

The barrier wall at the PSC Georgetown Facility was installed with slurry techniques and consists of a mixture of cement and attapulgite clay. These materials will not break down by natural conditions for at least many hundreds of years, and probably for thousands of years. However, in the Seattle area it has been assumed that a very large earthquake could result in liquefaction of soils that are supporting the barrier wall. In such a situation the barrier wall, which is a relatively rigid cement/clay wall and only 6 inches thick, could deform and crack and possibly even break. Tables 4-1a and 4-1b give RLs for various numbers of breaks in the barrier wall, ranging from a single 6-inch-wide break, to four breaks, to 12 breaks, and finally to the wall being shattered such that 25% of the wall area is permeable soil. The latter case is highly unlikely even with the largest known earthquakes.

Tables 4-1a and 4-1b show a range of scenarios for barrier wall failure. The tables indicate that for a highly conservative scenario where the wall is broken in at least 12 separate places and each break is 6 inches wide, remediation levels protective of the Duwamish Waterway would be met (and, in fact, these remediation levels are currently being met) in the HCIM Area. The worst case scenario modeled assumes the wall is completely destroyed. For this worst-case scenario, calculated remediation levels for TCE protective of the Duwamish Waterway, would not likely be met by any of the proposed alternatives. None of the alternatives would result in significant reduction of concentrations of TCE and other VOCs in the Intermediate Aquifer due to the presence of DNAPL within the highly interbedded sand and silts. Mixing of groundwater between the Intermediate and Shallow Aquifers would result in concentrations of TCE in the shallow and water table zones remaining above the remediation levels calculated for this worst case scenario. Since all alternatives fail to meet the worst case scenario for a wall failure, all alternatives must include long-term maintenance of the HCIM as an integral part of the final remedy.

4.2 HCIM Area Remedial Alternatives

Remedial alternatives for the HCIM Area have been developed from the retained remediation technologies described in Technical Memorandum No. 4 and modified by Ecology in correspondence dated 20 February 2007 (Ecology, 2007). Six remedial alternatives have been developed for detailed evaluation in this SWFS. These alternatives are designed to attain the remediation objectives described in Section 2. The remedial alternatives represent a combination of one or more of the retained remediation technologies.

The primary remediation objective for the HCIM Area is to prevent discharge of COCs from the HCIM Area to the Outside Area at concentrations that would exceed cleanup levels. A substantial interim measure, the HCIM, has proven effective in controlling the discharge of impacted groundwater from the facility. This IM has been incorporated into all remedial alternatives considered for the HCIM Area.

Additional remedial objectives for the HCIM Area include:

- For any actions not relying exclusively on containment, reduce contaminant concentrations in groundwater. It is desirable to reduce all COC concentrations to their cleanup levels if this can be done practicably. Some actions, however, may not be able to technically or cost-effectively reduce all COCs to cleanup levels. Reductions to remediation levels (concentrations higher than cleanup levels) are then desirable, and preferable to less significant reductions.

- Achieve remedial objectives before HCIM barrier wall failure.

- Ensure that any remedial actions implemented within the HCIM Area are compatible with the HCIM barrier wall.

- Support future development and reuse of the facility and the TASCO properties for industrial purposes.

The remedial alternatives considered for the HCIM Area are described in the following subsections. Although not listed in the following alternative descriptions, the VIAM approach discussed in Technical Memorandum No. 3 is incorporated into each remedial alternative under consideration for the HCIM Area to mitigate potential impacts associated with the vapor intrusion pathway.

All of the remedial alternatives under consideration for the HCIM area also include performance groundwater monitoring. The performance groundwater monitoring system includes water level measurements to assess performance of the HCIM, and groundwater quality monitoring and laboratory testing for COCs. The HCIM performance monitoring and groundwater quality monitoring systems inside the HCIM area will be the same for all of the HCIM Area remedial alternatives, and will be included in discussion of Outside Area alternatives in Section 5. Cost estimates for the HCIM Area performance groundwater monitoring also will be included in cost estimates for the Outside Area in Section 5. Several HCIM Area remedial alternatives do include groundwater monitoring to assess implementation of the specific alternative. Monitoring required to assess implementation of individual HCIM Area remedial alternatives is discussed for each HA Alternative in this section.

All of the remedial alternatives under consideration for the HCIM area include the implementation of institutional controls to ensure that the alternatives are fully protective of human health. The negotiation of easements for properties included in remedial activities included an agreement on implementation of institutional controls on portions of the Aronson and SAD properties within the HCIM area.

There are a total of six alternatives for the HCIM area:

- Alternative HA-1: Active Hydraulic Containment - Relies on the existing HCIM system and natural attenuation to reduce COC concentrations to remediation levels.

- Alternative HA-2: Enhanced Anaerobic Bioremediation – includes all aspects of HA-1 but adds enhanced anaerobic bioremediation with injection and circulation of an electron donor to stimulate anaerobic degradation of COCs.

- Alternative HA-3: Enhanced Anaerobic Bioremediation/Dewatering/SVE – uses the same approach as HA-2, but includes a period of partial dewatering of the water table zone and vapor extraction to rapidly address VOCs in some of the shallow source areas.

- Alternative HA-4: ISCO/Dewatering/SVE – replaces enhanced anaerobic degradation in HA-3 with ISCO, which uses chemical oxidation to reduce COC concentrations.

- Alternative HA-5: Steam Stripping/Enhanced Anaerobic Bioremediation Dewatering/SVE – includes all elements of Alternative 3 and adds steam stripping to mobilize and collect VOC vapors. Steam stripping would be used to address both Intermediate and Shallow Aquifers.

- Alternative HA-6: Steam Stripping/Dewatering/SVE/Excavation – combines steam injection and partial dewatering and SVE in HA-5 with groundwater extraction to remove COCs, and adds excavation and disposal of hot spot soils to address PCBs and metals.

4.2.1 Alternative HA-1: Active Hydraulic Containment

Alternative HA-1 relies on containment and monitored natural attenuation to address soil and groundwater impacts within the HCIM Area. Alternative HA-1 includes the following elements:

- The existing barrier wall isolating and enclosing near-facility impacted soil and groundwater;
- The existing groundwater recovery and pretreatment system;
- Surface cap/cover;
- The existing groundwater monitoring wells and a revised monitoring program as described in Section 5; and
- Institutional controls.

This alternative incorporates the existing HCIM and includes capping and institutional controls to provide a comprehensive approach that addresses relevant COCs and potential exposure pathways. The components of Alternative HA-1 are shown on Figure 4-1.

The existing subsurface barrier wall would be maintained intact under this remedial alternative. The barrier wall completely encloses subsurface soils and groundwater within the HCIM Area down to the depth of the silt aquitard, and has been proven effective in limiting groundwater flow into the HCIM Area. Programs and systems for monitoring and inspecting the barrier wall to maintain its effectiveness have been established and proven effective. The existing barrier wall has a very low permeability (less than 10^{-8} cm/sec).

The existing groundwater recovery and pretreatment system, which consists of two extraction wells, an air stripper, and associated pumps and controls, has also been incorporated into this remedial alternative. Treated groundwater is discharged to a POTW under a permit issued by King County. The system has continuously and reliably maintained an inward hydraulic gradient and has met regulatory standards for treated groundwater quality and air emissions during over 3 years of operation. Programs and systems have been established for operation, maintenance, inspection, and monitoring of the groundwater recovery and pretreatment system. Under this remedial alternative, an inward hydraulic gradient would be maintained across the barrier wall.

However, it should be noted that the inward hydraulic gradient is not necessary to achieve containment. Based on a reasonably conservative failure scenario, it has been shown (Appendix B) that the contained groundwater presently meets cleanup levels based on surface water quality. With the barrier wall intact, passive containment (non-pumping scenario) would limit migration of facility COCs and support attainment of cleanup levels outside the barrier wall. Shutting off the groundwater recovery and treatment system would need to be evaluated and approved by Ecology before it could be considered.

Based on fate and transport modeling presented in Technical Memorandum No. 1 (Geomatrix, 2006a), the expected loss of COCs through the wall would be negligible if the permeability of the barrier wall is in the high range (i.e., 1×10^{-7} cm/sec), because inward advective flow of groundwater would overwhelm outward diffusion. For low barrier wall permeability (i.e., 1×10^{-10} cm/sec) advective flow would be negligible and loss of COCs through the wall may occur by diffusion, and would represent the worst-case loss of Facility COCs under this alternative. The diffusion rate was estimated for chlorinated VOCs, which are of primary concern for potential risks. The estimated worst-case rate of diffusion through the barrier wall for this alternative is 0.0009 lb/day; details for these calculations are included in Appendix B of Technical Memorandum No. 1. This diffusive flux of chlorinated VOCs through the barrier wall is considered negligible.

Alternative HA-1 would supplement the existing microsilica concrete and asphalt caps that currently cover much of the HCIM Area with new caps placed over currently uncapped areas (see Figure 4-1). The new cap would consist of a minimum thickness of 3 inches of asphalt to provide a continuous, low-permeability cover. The purpose of the cap would be to serve as a barrier to prevent direct contact with impacted soil and prevent erosion and runoff of impacted soil. While the surface cover is not intended as a complete barrier to surface water infiltration and recharge, the cover would promote runoff and limit infiltration of surface water within the HCIM Area. The cap would be regularly inspected and maintained to ensure it effectively provides an engineered barrier and limits infiltration.

Groundwater monitoring data indicate that ongoing natural biodegradation of chlorinated solvents within the HCIM Area will reduce chlorinated COC concentrations within the water table, shallow, and intermediate depth intervals. As discussed in Technical Memorandum No. 1, data collected in Spring 2006 show a generally decreasing trend over time for TCE in some monitoring wells, as well as an increasing trend of TCE biodegradation products (VC and cis-1,2-DCE) in the same wells. Groundwater data collected through the end of 2006 show decreasing trends for both TCE and the degradation products. Groundwater samples collected from the intermediate depth interval during the RI indicate that *Dehalococcoides* microorganisms are present in HCIM Area groundwater. These organisms are capable of degrading VC to ethene (He et al., 2003). These data indicate that reductive dechlorination is active in the HCIM Area; it is expected that concentrations of VC and cis-1,2-DCE will decrease in the future as the mass of TCE decreases and degradation of VC and cis-1,2-DCE progresses to ethane and CO_2. Published values for anaerobic biodegradation rates range from 0.76 to 14 years for TCE, 0.22 to 5.0 years for cis-1,2-DCE, and 0.26 to 5.8 years for VC (Wiedemeier et al., 1999). Prior to the barrier wall being installed, anaerobic biodegradation was occurring within the HCIM area primarily as a result of the mass of carbon-based COCs creating reducing conditions in the source and plume areas. Groundwater entering the site from upgradient was redox neutral, but conditions varied between reducing and oxygenated conditions. Since the wall has been installed, the HCIM area is functioning as an in situ bioreactor with very little fresh oxygenated water able to enter the system and high concentrations of hydrocarbons and solvents in the source areas rapidly using up any oxygen remaining. This situation should result in excellent conditions for natural anaerobic degradation of the VOCs and some of the SVOCs.

Based on the detected concentrations of these constituents in HCIM Area groundwater, cleanup levels could potentially be reached between 3 and 70 years if DNAPL were not present in the HCIM Area. However, the DNAPL that is suspected to be present in the HCIM Area will act as a continuing source of groundwater contamination and will likely preclude the attainment of cleanup levels for chlorinated VOCs for the foreseeable future.

According to the modeling performed as part of this technical memorandum (Appendix B) remediation levels have already been reached at the CPOC for all barrier wall breakage scenarios except a worst-case scenario in which the barrier wall is totally shattered, which is an extremely unlikely scenario. The fact that remediation levels are currently being met means that remediation objectives are also being met. However, because there are currently no monitoring wells in the areas of suspected DNAPL, the existing COC data for the HCIM Area may not be representative of the areas with the highest concentrations of COCs. Based on groundwater monitoring, remediation levels are currently being met, at a minimum, throughout much of the HCIM Area.

Groundwater monitoring data also indicate that nonchlorinated organic constituents are undergoing natural biodegradation within the HCIM Area. As shown in Figures 4-2 and 4-3, a trend of decreasing BTEX concentrations has been observed in some water table monitoring wells within the HCIM Area. Table 4-2 summarizes natural attenuation indicator parameters detected in HCIM Area and background (upgradient) monitoring wells. Available data after the construction of the barrier wall is limited. However, concentrations of dissolved oxygen (an electron receptor utilized for biodegradation of non-chlorinated organics) in the water table depth interval are generally lower within the HCIM Area than in background monitoring wells (see Table 4-2). In addition, concentrations of metabolic byproducts (ethane and methane) are elevated in the water table and shallow depth intervals within the HCIM Area in comparison to background (upgradient) monitoring wells. Dissolved oxygen concentrations measured within the HCIM Area indicate that the water table, shallow, and intermediate groundwater depth intervals are anaerobic. Biodegradation of nonchlorinated organics within these intervals is likely occurring due to anaerobic oxidation.

Groundwater monitoring is a key component of Alternative HA-1. The basic performance groundwater monitoring system, consisting of groundwater level measurements to assess performance of the HCIM and groundwater quality monitoring, is the same for all HA Alternatives. Because groundwater monitoring for the HCIM Area would be implemented simultaneously and in conjunction with monitoring associated with the selected remedial alternative for the Outside Area, the discussion and cost estimates for groundwater performance monitoring for all HA Alternatives are included with groundwater monitoring systems described for Outside Area Alternatives in Section 5.

No additional groundwater monitoring beyond the performance monitoring included in all of the Outside Area Alternatives would be included in Alternative HA-1. Several HCIM Area remedial alternatives do include additional groundwater monitoring, beyond the performance monitoring described in Section 5, to assess implementation of the specific alternative. Table 4-3 summarizes key features of additional groundwater monitoring specific to each HA Alternative included to assess implementation of that specific alternative.

As discussed previously, remediation levels within the HCIM Area are currently being met, based on a hypothetical break in the barrier wall in as many as 12 locations due to a severe earthquake. It is difficult to estimate the time that would be required for COC concentrations within HCIM Area groundwater either to reach remediation levels assuming no wall is present or to meet cleanup levels because the mass of contaminants in the subsurface is unknown (due to the suspected presence of DNAPLs). However, it is unlikely that either the conservative remediation levels or cleanup levels will be reached at all depths in the foreseeable future. Estimated remediation times for individual COCs within the HCIM Area are summarized in Tables 4-4a and 4-4b for Alternatives HA-1 through HA-6, based on a review of sites with similar contaminant concentrations where natural attenuation was utilized (see Appendix C for details).

The final component of Alternative HA-1 is a set of institutional controls that would ensure the alternative is fully protective of human health. The institutional controls included in this alternative are:

- Prohibit use of groundwater beneath the HCIM Area for any purpose;
- Require use of appropriate personal protective equipment and compliance with the HAZWOPER requirements specified in 29 CFR 1910.120 for all subsurface work conducted within the HCIM Area;
- Require notification of future property owners that recovered soil or groundwater from the HCIM Area may be required to be managed in accordance with the requirements of the Washington Dangerous Waste Rules (WAC 173-303);
- Require installation and operation of appropriate engineering controls to limit the entry and accumulation of soil gas within any building present or constructed over any portion of the HCIM Area;
- Require inspection and maintenance of the cap covering the HCIM Area, and require any potential future site construction or development to maintain the continuity and effectiveness of the cap; and
- Require operation, maintenance, inspection, monitoring, and expeditious repair (if necessary) of the existing HCIM components (barrier wall recovery wells,

groundwater extraction and pretreatment system, instruments and controls, and monitoring wells) in accordance with the existing operation, monitoring, and maintenance plan.

These institutional controls would be enforceable conditions incorporated into the deed for the properties either partially or totally contained within the HCIM Area. In addition, PSC would provide financial assurance for the continued monitoring, maintenance, and repair of the HCIM barrier wall, groundwater recovery and pretreatment system, and cap. These institutional controls would remain in place until soil and groundwater cleanup levels were attained within the HCIM Area.

As discussed above, Alternative HA-1 has for the most part already been implemented, and the 3 years of operation of this alternative has resulted in significantly improved groundwater quality downgradient from the HCIM area. The only items needed to fully implement this alternative are to complete the asphalt capping in a few locations and implement the institutional controls. These last items could be completed within 6 months of the final Cleanup Action Plan approval (see Figure 4-4).

The advantages of implementing Alternative HA-1 are summarized below:

- HA-1 is readily implementable. The only elements remaining to be implemented are capping a few small areas of the HCIM area and placing the institutional controls. For the most part this alternative was implemented with the installation of the HCIM.

- Remediation levels consistent with all but the worst-case scenario for damage to the barrier wall are already being met by this technology.

- This alternative would result in destruction of VOCs and reduction in COC mass.

- The containment system has been shown to be very effective in eliminating releases from the HCIM area to the downgradient area, with concentrations of COCs rapidly improving in the downgradient groundwater.

- Implementing this alternative would allow the site to be redeveloped immediately, thereby placing the property back into productive use and generating jobs and tax revenue for the community. Other alternatives all have longer implementation time frames, which would delay redevelopment of the site.

The disadvantages of Alternative HA-1 are:

- The alternative relies heavily on the success of the containment system to protect downgradient receptors for a long period of time.

- The alternative is unlikely to result in cleanup levels being attained inside the wall within a reasonable time frame.
- Remediation levels within most of the site are already being met, but source areas within the HCIM Area may contain VOC concentrations above remediation levels.
- This alternative would address metals, PCBs, and SVOCs within the HCIM area through containment, but would not achieve cleanup levels within the HCIM Area.

4.2.2 Alternative HA-2: Enhanced Anaerobic Bioremediation

Remedial Alternative HA-2 incorporates all of the components of Alternative HA-1 and includes anaerobic biostimulation to enhance and accelerate biodegradation of chlorinated VOCs (Figure 4-5). Alternative HA-2 includes the following elements:

- The existing barrier wall isolating and enclosing near-facility impacted soil and groundwater;
- The existing groundwater recovery and pretreatment system;
- Surface cap/cover;
- Electron donor injection into affected HCIM Area groundwater;
- Installation of additional performance monitoring wells and an enhanced anaerobic bioremediation monitoring program;
- The existing groundwater monitoring wells and a revised monitoring program, as discussed in Section 5; and
- Institutional controls.

Enhanced anaerobic bioremediation would be conducted in an effort to reduce the mass of DNAPL suspected to be present in two general areas within the HCIM Area and to reduce the time required to achieve groundwater cleanup levels. As discussed in Section 2.2, COC concentrations in groundwater at two locations within the HCIM Area are consistent with a trail of DNAPL ganglia present from the water table interval to the Silt Aquitard. An ISB system would be installed to enhance and accelerate anaerobic biological degradation of chlorinated VOCs that is occurring within the HCIM Area. As noted in the final RI Report, monitoring conducted within the HCIM Area has positively identified ethene, ethane, and *Dehalococcoides* bacteria in groundwater, confirming that factors necessary for biodegradation of chlorinated VOCs are present. The ISB program would increase the organic carbon content in the treatment zone pore space by adding carbohydrate and distributing it throughout the target area. The excess organic carbon could be used as an electron donor by existing subsurface bacteria to accelerate ongoing biodegradation of TCE, cis-1,2-DCE, and VC to ethene. Existing literature (see Appendix C) indicates that enhanced biodegradation has been effective at reducing VOC concentrations, even in source areas where the DNAPL is present as ganglia as is the case within the HCIM area. As with all technologies evaluated as part of this FS, reducing the concentration of COCs within the Intermediate Aquifer (interbedded silts and sands) to CULs within a reasonable time frame is not considered likely short of excavating the entire site. However, concerns about COCs at depths greater than 50 feet are minimal, since this portion of the aquifer has low permeability and VOCs are unlikely to migrate downgradient to the Duwamish Waterway. In essence, groundwater meets remediation levels for the intermediate zone even without the wall present. In addition, vapor intrusion is not a pathway for COCs at this depth. For this reason, the enhanced bioremediation will target the shallow and water table zones down to a depth of approximately 50 feet. In the Shallow Aquifer (shallow and water table zone), cleanup levels are not being met, although remediation levels appear to have been met for most wall failure scenarios. Monitoring data are not available for source areas within the HCIM Area, and therefore it is possible that remediation levels are not being achieved in those areas. Implementation of Alternative HA-2 would target those source areas.

Several proven electron donor materials are readily available for ISB, including molasses, sodium lactate, and emulsified vegetable oil. The specific electron donor that would be used for each groundwater zone would be selected through pilot testing conducted during the preparation of the corrective action plan. For the purpose of estimating the cost of this alternative for this SWFS, it was assumed that only the Shallow Aquifer (water table and shallow zones) would be treated, and that molasses would be used as the electron donor. Groundwater flow within the HCIM Area is significantly influenced by the barrier wall, and it is anticipated that groundwater flow gradients are extremely limited. In addition, it is anticipated that multiple electron donor injections would be necessary. Therefore, it was assumed that recirculation wells would be necessary to distribute the electron donor in the targeted treatment areas.

The conceptual design for Alternative HA-2 includes the installation of a recirculation well system within the HCIM Area to uniformly distribute the substrate within the water table and shallow depth intervals. A total of 10 extraction wells and 22 injection wells would be installed, as shown on Figure 4-5. Electron donor would be injected into a targeted treatment zone consisting of one extraction well and the four nearest injection wells. Injection within a targeted treatment zone would be accomplished by withdrawing water from the central extraction well, mixing an electron donor with the extracted groundwater, and reinjecting the mixture through the four surrounding injection wells spaced about 50 feet apart. Groundwater recirculation would continue until the electron donor is detected in the extracted groundwater. Two nested wells would be located at each injection well and extraction well location. Each well would be constructed with 40 feet of screen. The shallow injection/extraction wells would be installed to a depth of approximately 50 feet bgs to treat the water table and shallow groundwater intervals.

Repeat injections would be conducted periodically to maintain a high level of biological activity and effective reductive dechlorination of chlorinated VOCs and breakdown products. For estimating costs, it was assumed that two injections would be performed each year over a 4-year period, for a total of eight injection events. The required carbohydrate injection would be determined from pilot testing; however, PSC estimates that approximately 325 gallons of carbohydrate would need to be injected in each recirculation cell (consisting of one extraction well and four injection wells) during each injection event. For cost estimating purposes, it is anticipated that each recirculation cell would be operated for 24-48 hours during each injection event.

Pilot testing of Alternative HA-2 would be needed to confirm the effectiveness of this technology, determine the radius of influence of the injection/extraction wells, and design the ISB system. The pilot testing would likely be performed by installing one nested recirculation cell (i.e., one set of nested extraction wells and four nested sets of injection wells) and monitoring wells, completing an injection event in each targeted treatment interval, and conducting performance monitoring. Costs for pilot testing have been included in the implementation cost estimate.

A performance monitoring well network is an integral part of Alternative HA-2 to evaluate the effectiveness and performance of the ISB system. As shown on Figure 4-6, two new nested monitoring wells would be installed at two locations to monitor the distribution of the electron donor substrate. Degradation of the groundwater COCs and the carbohydrate would be monitored within the injection/extraction wells and monitoring wells. For cost estimating purposes, it was assumed that quarterly monitoring of the wells would be conducting during the 4-year injection program, followed by two years of semiannual sampling (see Table 4-3). In addition, Alternative HA-2 also includes the groundwater monitoring program common to all HA Alternatives, as described in Section 5.

Although enhanced anaerobic bioremediation would reduce the mass of DNAPL within the treatment areas, it is unlikely to remove all DNAPL ganglia present, and it would have limited effect on DNAPL within the Intermediate Aquifer. Subsurface heterogeneities, preferential flow paths, and poor mixing in the subsurface may result in inefficient treatment. It is difficult to estimate the time that would be required for COC concentrations in groundwater within the HCIM Area to reach cleanup levels because the contaminant mass in the subsurface is unknown. Based on a review of sites with similar contaminant concentrations where enhanced anaerobic bioremediation was implemented, PSC estimates that it may take up to about 6 years to achieve remediation levels in the source areas. Since the Intermediate Aquifer would not be treated by this approach, cleanup levels within the Intermediate Aquifer would not likely be met within the foreseeable future. Tables 4-4a and 4-4b summarize the probability that anaerobic bioremediation and monitored natural attenuation would achieve remediation and cleanup levels for individual COCs within the HCIM Area within a specified time frame. For estimating costs, a total monitoring period of 6 years has been assumed for monitoring the enhanced bioremediation program inside the barrier wall; long-term monitoring costs outside the barrier wall are included in the costs for the Outside Area alternatives.

Implementation of this alternative will take approximately 5 to 6 years following approval of the CAP (Figure 4-4). Year one would involve permitting, design, and pilot testing of the enhanced biodegradation application rates/well system, followed by up to 4 years of injection treatments.

Administrative controls would be incorporated into the alternative to ensure that human health and the environment are adequately protected by Alternative HA-2. These administrative controls would be the same as described for Alternative HA-1 in Section 4.2.1.

The advantages of HA-2 are:

- The alternative can be readily implemented and employs a proven technology for chlorinated VOCs.
- This alternative would result in both VOC destruction and reduction in mass.
- The alternative would enhance the existing anaerobic conditions as opposed to other alternatives, which would risk disrupting this system.
- The alternative would result in meeting remediation levels within the HCIM Area, including in the source areas in a relatively short time frame, thereby protecting the Duwamish Waterway in the unlikely case of barrier wall failure.

The disadvantages of HA-2 are:

- HA-2 would not result in meeting CULs within the foreseeable future.
- This alternative would not result in significant reduction in concentrations for metals, PCBs or SVOCs, remediation levels for these constituents have already been attained within the HCIM Area;
- Implementation of this alternative could take up to 5 years, during which time, it would not be possible to fully redevelop the property.
- The alternative would rely on the containment of the HCIM to protect the downgradient vapor intrusion receptors.
- Enhanced bioremediation has been shown to be effective for source areas, assuming that the carbon source can come in contact with all the source material; however, silt lenses within the deeper portion of the shallow zone may impede success at this site.

4.2.3 Alternative HA-3: Enhanced Anaerobic Bioremediation and Soil Vapor Extraction

Remedial Alternative HA-3 incorporates all of the components of Alternative HA-2. This alternative also includes implementation of an SVE system coupled with partial site dewatering to treat elevated concentrations of VOCs in the vadose zone and address shallow residual DNAPL. This Alternative assumes that some DNAPL or high concentrations of VOCs may be present within the shallow and water table zones in the source areas and that this DNAPL could impede the ability to achieve both remediation levels and cleanup levels in the shallow and water table zones. The conceptual site model assumes that DNAPL is probably most likely present deeper in the subsurface with the majority of the remaining DNAPL in the Intermediate Aquifer at depths greater than 40 ft bgs. At those depths, failure of the barrier wall would result in a release, but the permeability at that depth would limit migration to the Duwamish Waterway. Releases at shallower depths could travel farther before MNA reduces concentrations below CULs. To address this potential, this alternative adds SVE to reduce concentrations of VOCs in shallow soils, particularly in the source areas, faster than by either Alternative HA-1 or HA-2.

The following elements are included in Alternative HA-3:

- The existing barrier wall isolating and enclosing near-facility impacted soil and groundwater;
- An upgraded groundwater recovery and pretreatment system, with greater capacity than the existing system;

- Surface cap/cover;
- Partial site dewatering and SVE;
- Electron donor injection into affected HCIM Area groundwater;
- Installation of additional performance monitoring wells and an enhanced bioremediation monitoring program;
- The existing groundwater monitoring wells and a revised monitoring program, as discussed in Section 5; and
- Institutional controls.

The components of Alternative HA-3 would be implemented in a phased approach. The first phase of remediation activities would include construction of new caps over currently uncapped areas and implementation of SVE. Based on soil sampling results presented in the RI, SVE would be implemented in three areas on the PSC facility and adjacent portions of the SAD property, as shown in Figure 4-6. Each SVE area would consist of two vapor extraction wells and one new groundwater extraction well. As discussed in Technical Memorandum No. 1, SVE was previously conducted within the HCIM Area in the former North Field, immediately north of the former TASCO building. Approximately 19,000 pounds of VOCs were removed from the subsurface in this area over several years before the system was shut down due to diminishing returns. It is likely that SVE would remove additional VOC mass from this area after dewatering lowers the water table.

Groundwater extraction would be conducted in the three SVE treatment areas to lower the water table approximately 10 to 15 feet and vertically extend the effective zone of the vapor extraction wells. Groundwater modeling indicates that in order to lower the water table an additional 10 to 15 feet in the HCIM area, groundwater extraction would need to be maintained at a total pumping rate of between 30 and 50 gpm. The conceptual design of the groundwater extraction system includes one new extraction well installed in each SVE treatment area (three wells total), plus the two existing extraction wells, for a total of five wells. The locations of the extraction wells are shown on Figure 4-6. In addition, the existing HCIM groundwater recovery system would be modified to increase the treatment capacity to accommodate the additional dewatering groundwater. Each new extraction well would be constructed of 6-inch inside diameter, Schedule 80 PVC blank casing and stainless steel wirewrap (0.03-inch slot) well screen. The wells would be installed to a depth of approximately 40 feet bgs, with 30 feet of screen installed from the bottom of the boring. Dedicated, submersible, groundwater extraction pumps would be installed in the new extraction wells approximately 5 feet above the bottom of the wells. A pumping rate of 10 to 20 gpm would be maintained in each well.

The existing treatment system for the HCIM groundwater extraction system does not have sufficient capacity to treat the additional groundwater (approximately 30 to 50 gpm) that would be extracted under Alternative HA-3. In addition, the extracted groundwater may contain elevated concentrations of metals. Therefore, the extracted groundwater would be treated by a separate low-profile air-stripper to remove VOCs, followed by chemical dosing/precipitation to remove metals prior to discharge to the King County POTW. The King County discharge permit would be modified for the period of the dewatering to allow this higher discharge volume. For estimating purposes, it was assumed that dewatering to this depth and soil vapor extraction would be completed within four years; however, actual vapor extraction could be different, as appropriate to effectively remove contaminant mass.

A total of six vapor extraction wells would be installed to a depth of approximately 25 feet bgs and would be constructed with 4-inch diameter Schedule 40 PVC with 20 feet of 0.10-inch slotted well screen. The annulus around the well screen and casing would be filled with filter sand to approximately 1 foot above the screen and sealed with approximately 1 foot of hydrated bentonite pellets above the filter sand. The remaining annulus around the well casing would then be filled to grade with concrete. Each SVE well would be connected to a flow-control manifold to allow flow from each SVE well to be independently adjusted as necessary to control the zone influenced by the SVE system. Except for a small area that would be covered with asphalt, the entire HCIM Area is currently capped with a combination of microsilica concrete and asphalt (Figure 4-6). Because the duration of the SVE is expected to be relatively short, all system piping would be routed above ground to minimize disturbance to the existing cap system.

A regenerative blower with a capacity of 400 cfm would be used to induce a vacuum on the vapor extraction wells and direct the recovered vapor stream to the emission control system. A vacuum of approximately 25-inches of water would be induced on each SVE well. Based on operational data obtained from the previous SVE system at the site, it is anticipated that the radius of influence of each vapor extraction well would be approximately 50 to 75 feet at this applied vacuum and the vapor flow rate from each well would be approximately 50 cubic feet per minute.

Emission controls for the extracted vapor stream would be selected based on initial system testing following installation of the SVE wells. During the initial test period, the extracted vapor stream would be treated with GAC prior to discharge to the atmosphere. For estimating the operational costs of Alternative HA-3, it was assumed VOC concentrations in the extracted vapor stream would require treatment with a rented catalytic oxidizer unit for 1 year. The extracted vapor stream would then be treated with granular activated carbon units for the life of the system. For cost estimating purposes, it was assumed that the system would operate for a period of 4 years. The actual operational period of the system would likely be determined based on VOC concentrations in the extracted vapor streams and whether the system has reached a point of diminishing returns.

Operation of the SVE system will be monitored by collection of vapor samples from the extracted vapor stream and individual SVE wells, as well as periodic measurements of VOC concentrations in the extracted vapor stream with a PID. In addition, collection of vapor samples downstream of the emission controls system would likely be required as a condition of the air permit for the system. For cost estimating purposes, it was assumed that:

- Vapor samples would be collected from the emission control influent and effluent streams monthly;
- Vapor samples would be collected from individual SVE wells semiannually;
- PID measurements would be taken monthly, and
- SVE would be completed in 1 year.

A Notice of Construction would be prepared and submitted to the PSCAA prior to construction of the SVE system.

At the completion of the SVE operation, anaerobic bioremediation would be conducted within the two suspected DNAPL areas, as outlined under Alternative HA-2 and depicted in Figure 4-5. Groundwater levels within the HCIM Area would be allowed to recover to pre-SVE conditions prior to initiation of anaerobic bioremediation activities.

Implementation of this Alternative, as shown on Figure 4-4, would take up to 10 years after approval of the CAP. The SVE and treatment systems would both need to be permitted and constructed. Once dewatering was initiated it would take approximately another 6 to 12 months to achieve desired water levels. SVE could be initiated concurrently with the dewatering, but maximum SVE recovery would not occur until dewatering were complete to the target depth of 25 feet bgs. At this time we anticipate that SVE would be conducted for at least 1 year after groundwater levels have been lowered and take up to 3 years to complete, depending on the concentrations of VOCs in the subsurface. Anaerobic enhancement was assumed to be initiated in the source areas upon completion of the SVE operation; however, it may be feasible to commence bioremediation before SVE completion. Enhanced in situ anaerobic biodegradation has been assumed to take four years for pilot testing and for periodic electron donor injections; monitoring of enhanced bioremediation has been assumed to continue for 2 years after completing the final substrate injection. Total implementation time is anticipated to be 5 to 9 years (Figure 4-4).

Administrative controls would be incorporated into the alternative to ensure that human health and the environment are adequately protected by Alternative HA-3. These administrative controls would be the same as described for Alternative HA-1 in Section 4.2.1.

The advantages of implementing HA-3 are:

- This alternative would use an aggressive technology, SVE, to address remnant VOC contamination in the shallow soil and upper water table zone, which should reduce restoration time frames for this portion of the stratigraphy.
- With the more aggressive approach, VOCs would be destroyed, concentrations would be reduced, and CULs could potentially be achieved for VOCs within the water table zone, at least temporarily.
- All technologies associated with this alternative are proven technologies for the VOCs.

The disadvantages of Alternative HA-3 are:

- Implementation of additional pump and treat and SVE would require extensive work on the site for about 10 years (four years for dewatering/SVE followed by 6 years for substrate injection and bioremediation monitoring). This would result in a delay of redevelopment and reuse of the site for about 10 years;
- The need to pump at higher rates to temporarily dewater the upper portion of the aquifer would require redesigning and reconstructing the groundwater treatment system and obtaining new PSCAA and King County Discharge permits. King County may not be willing to accept the high volumes of water anticipated. If King County would not take this volume of water, the alternatives would be to reduce the amount of dewatering that would occur, which would reduce the effectiveness of

SVE, or to apply for an injection permit for reinjection of water into the downgradient plume. The injection permit would require at least 1 year to obtain.

- This alternative would not result in any significant reduction in concentrations of SVOCs, metals, or PCBs, although remediation levels would be met for these COCs.
- Site characterization of the water table zone on the former facility area is not adequate to confirm that the SVE would address all source areas.
- Groundwater pumping inside the HCIM area would result in upward gradients from the Deep Aquifer. This would likely result in contaminated groundwater from the intermediate zone to be carried upward into the shallow and water table zones, recontaminating these zones. As a result, it is unlikely that CULs would be met in the foreseeable future. If this were the case, the alternative would still rely on containment to protect receptors downgradient from vapor intrusion.

4.2.4 Alternative HA-4: In Situ Chemical Oxidation and SVE

Remedial Alternative HA-4 incorporates all of the components of Alternative HA-3, except enhanced anaerobic bioremediation. Instead, ISCO would be conducted in an effort to reduce the mass of DNAPL suspected to be present in two areas within the HCIM Area. Alternative HA-4 would include the following elements:

- The existing barrier wall isolating and enclosing near-facility impacted soil and groundwater;
- An upgraded groundwater recovery and pretreatment system, with greater capacity than the existing system;
- Surface cap/cover;
- Partial site dewatering and SVE;
- ISCO in HCIM Area groundwater;
- Installation of additional monitoring wells and an ISCO performance monitoring program;
- The existing groundwater monitoring wells and a revised monitoring program, as discussed in Section 5; and
- Institutional controls.

The components of Alternative HA-4 would be implemented in phases. The first phase of remediation activities would include construction of new caps over currently uncapped areas and implementation of SVE, coupled with partial site dewatering. The SVE extraction and pretreatment system, as well as dewatering extraction wells, would be implemented as described for Alternative HA-3 in Section 4.2.3. ISCO would be implemented following decommissioning of the SVE/dewatering system and the return of HCIM Area groundwater elevations to pre-SVE levels.

ISCO involves the application of a chemical oxidant, such as potassium permanganate, sodium persulfate, or hydrogen peroxide, to react with organic contaminants. The specific oxidant that would be used for each groundwater interval within the HCIM Area would be selected through pilot testing conducted during preparation of the CAP. As discussed for Alternatives HA-2 and HA-3, the treatment would not likely be effective in the Intermediate Aquifer and would focus only on the Shallow Aquifer (above approximately 50 feet depth); therefore for the purposes of cost estimating for this SWFS, it was assumed that potassium permanganate ($KMnO_4$) would be used to treat the Shallow Aquifer (water table and shallow zones). $KMnO_4$ is more stable in the subsurface than hydrogen peroxide or Fenton's reagent, and is less reactive with reduced metals than sodium persulfate.

It is anticipated that groundwater recirculation would be necessary to effectively distribute the oxidant in the targeted treatment zones (the suspected DNAPL areas). A recirculation well system and monitoring well network would be utilized for Alternative HA-4 that is similar to the conceptual design for the ISB system of Alternative HA-2 (10 extraction wells and 22 injection wells). The location and layout of the recirculation well system is shown on Figure 4-7. ISCO treatment of each targeted zone would be accomplished by withdrawing water from a central extraction well, mixing an oxidant with the extracted groundwater, and reinjecting it through four surrounding injection wells spaced 50 feet apart. Oxidant injection and groundwater recirculation would continue until unreacted oxidant is detected in the extracted groundwater. Injection wells and extraction wells would be constructed with 40 feet of screen. The shallow injection/extraction wells would be installed to a depth of approximately 50 feet bgs to treat the water table and shallow groundwater intervals.

Repeat injections would be conducted periodically to maintain an oxidant concentration in the treatment zones capable of oxidizing chlorinated VOCs and their breakdown products. For estimating costs, it was assumed that two injections would be performed each year over a 4-year period, for a total of eight injection events. The oxidant and required mass of oxidant to be injected would be determined from pilot testing. Based on the reducing conditions and elevated iron concentrations observed in HCIM Area groundwater, the soil oxidant demand of the treatment area was assumed to be 6 pounds of $KMnO_4$ per cubic yard of treated aquifer (Haselow, 2003). For the purpose of estimating the costs of Alternative HA-4, it was assumed that 2,625 pounds of $KMnO_4$ would be injected as a 2 percent solution in each recirculation cell during each injection event. A total of 26,250 pounds of $KMnO_4$ would be injected during each event, and 210,000 pounds of $KMnO_4$ total would be injected over all eight injection events. It is anticipated that each recirculation cell (consisting of one extraction well and four injection wells) would be operated for 24-48 hours during each injection event.

Pilot testing of Alternative HA-4 would be needed to select the most effective oxidant for the HCIM Area, confirm the effectiveness of this technology, confirm the injection mass, and determine the radius of influence of the extraction/injection wells. The pilot testing would be performed by installing one nested recirculation cell (i.e., one set of nested extraction wells and four sets of injection wells) and monitoring wells, conducting bench-scale treatability studies, completing an injection event, and conducting performance monitoring. Pilot testing could be completed within 6 to 9 months.

High levels of other oxidizable substances in the treated zone, such as soil organic material and reduced-state metals (e.g., ferrous iron), can significantly reduce the treatment efficiency and effectiveness of ISCO by consuming the oxidant. Typically, the majority of oxidant injected during ISCO treatment of impacted groundwater is consumed overcoming this soil oxidant demand. During the installation of the extraction and injection wells for the pilot study, soil samples would be collected from each targeted treatment zone for use in bench-scale treatability studies to evaluate the soil oxidant demand in the HCIM Area. These treatability studies would also be used to select the most effective oxidant for the HCIM area. Following the completion of the bench-scale tests, a pilot test would be conducted by completing an injection event using the nested recirculation cell and conducting performance monitoring. Costs for pilot testing and the bench-scale treatability studies have been included in the implementation cost estimate.

A monitoring well network is an integral part of Alternative HA-4. As shown on Figure 4-7, four additional monitoring wells (two nested sets) would be installed to evaluate the effectiveness and performance of the ISCO system. Nested sets of monitoring wells would be installed at two locations to monitor the oxidant distribution in the water table and shallow groundwater intervals. Degradation of the groundwater COCs and consumption of the oxidant would be monitored within the injection, extraction, and monitoring wells. Upon dissolution, permanganate causes the solution to turn purple, which provides an indicator for the presence of unconsumed permanganate oxidant. The concentration of unreacted oxidant in the injection, extraction, and monitoring wells would be evaluated with a colorimeter (such as a Hach Manganese LR, Pocket Colorimeter, or similar). For cost estimating purposes, it was assumed that quarterly monitoring of the wells would be conducting during the 4-year injection program, followed by 2 years of semiannual sampling, and annual sampling thereafter. Alternative HA-4 also includes the groundwater monitoring program discussed in Section 5.0.

Administrative controls would be incorporated into the alternative to ensure that human health and the environment are adequately protected by Alternative HA-2. These administrative controls would be the same as described above for Alternative HA-1.

Although ISCO would reduce the mass of DNAPL suspected to be present within the shallow zone of the HCIM Area, it is unlikely to remove all DNAPL ganglia that may be present. Subsurface heterogeneities, preferential flow paths, and poor mixing in the subsurface may result in inefficient treatment. It is difficult to estimate the time that would be required for COC concentrations within HCIM Area groundwater to reach cleanup levels, because the mass of contaminants in the subsurface is unknown. Currently the HCIM Area meets remediation levels for the most realistic but highly conservative wall failure scenarios; however, COCs may be present above remediation levels within source areas where monitoring wells are not present. Due to the fact that cleanup of the DNAPL within the interbedded silt and sand of the Intermediate Aquifer is not practical, cleanup levels (refer to Appendix C for details) are not expected to be met within a reasonable time frame. For estimating remediation costs of this alternative, it was assumed that ISCO would be implemented after completing dewatering/SVE, and that oxidant injections would occur over a four year period. Monitoring inside the barrier wall was assumed to continue for two years after the final oxidant injection to confirm treatment effectiveness. Long-term monitoring costs at the CPOC are included in the Outside Area alternatives.

Implementation time for this alternative would be similar to HA-3, on the order of 5 to 9 years (Figure 4-4).

The advantages of implementing Alternative HA-4 are:

- Chemical oxidation is a proven technology for addressing VOCs, particularly in source areas. VOCs would be destroyed by this alternative and mass would be reduced.

- The alternative should result in a reduced restoration time frame to meet remediation levels in the Shallow Aquifer although current data suggest that these remediation levels are already being met.

The disadvantages of this alternative are:

- This alternative would not result in any significant reduction in concentrations of SVOCs, metals, or PCBs, although remediation levels would be met for these COCs.

- Implementing this alternative would take a minimum of 5 years and require pilot testing and considerable additional permitting. As a result, the site could not be redeveloped for at least 5 years;

- The geochemistry within the Shallow Aquifer in the HCIM area is complex, and iron and manganese concentrations are very high. These metals as well as other COCs would consume a considerable amount of chemical oxidant. As a result it is unknown how complete the oxidation of VOCs would be or how much oxidant would be required to destroy the VOCs, resulting in a larger uncertainty in final costs (a larger potential range of costs).

- Remediation levels have already been attained in the HCIM Area, but it is doubtful that cleanup levels would be met by this alternative in any of the aquifer zones due to recontamination that would occur from the Intermediate to the Shallow zones; and

- This alternative is not appropriate for the intermediate zone due to the highly interbedded silt and sand.

4.2.5 Alternative HA-5: Steam Injection, Enhanced Anaerobic Bioremediation, Dewatering, and SVE

Alternative HA-5 includes all of the elements of HA-3. In addition, steam injection would be conducted in an effort to reduce the mass of DNAPL suspected to be present in two areas within the HCIM Area in both the Intermediate and Shallow Aquifers. Enhanced anaerobic bioremediation would be implemented following steam injection to address remaining concentrations of chlorinated COCs; due to temperature limitations, enhanced bioremediation could not be implemented until subsurface temperatures decrease to about 80 F. Partial site dewatering and SVE would be conducted to treat elevated concentrations of VOCs in the vadose zone and address shallow residual DNAPL. This alternative, unlike the preceding alternatives, would target the total depth of chemical impacts within the HCIM Area with an aggressive technology, steam stripping, with the intention of trying to reduce restoration time frames for meeting cleanup levels in the HCIM Area.

Alternative HA-5 would include the following elements:

- The existing barrier wall isolating and enclosing near-facility impacted soil and groundwater;
- An upgraded groundwater recovery and pretreatment system, with greater capacity than the existing system;
- Surface cap/cover;
- Partial site dewatering and SVE;
- Steam injection in affected HCIM Area groundwater;
- Electron donor injection into remaining areas of affected HCIM Area groundwater;
- Installation of additional performance monitoring wells and an enhanced anaerobic bioremediation monitoring program;
- The existing groundwater monitoring wells and a revised monitoring program, as discussed in Section 5; and
- Institutional controls.

The components of Alternative HA-5 would be implemented in a phased approach as illustrated in Figure 4-8. Phase 1 of remediation activities would include the construction of new caps over currently uncapped areas and implementation of SVE, as discussed for Alternative HA-3 in Section 4.2.3. Phase 2 of Alternative HA-5, which includes steam injection, would be implemented following the decommissioning of the SVE/dewatering system and the return of HCIM Area groundwater elevations to pre-SVE levels; it was assumed that groundwater recovery would require one year. Implementation costs for each phase were included as future costs (see Appendix A).

Steam injection would be conducted to mobilize the suspected DNAPL and aid in its removal from two locations within the HCIM Area. Steam injection mobilizes and removes DNAPL from the subsurface through several mechanisms (Davis, 1998). As steam is initially injected into the affected aquifer, it cools and condenses as it moves out into the formation. As more steam is injected, this cold water front is pushed through the formation toward an extraction well, flushing mobile contaminants from the pore spaces. As the formation heats up, hot water moves through the treatment zone, which reduces the viscosity of the contaminants and increases the capture of contaminants by the extraction well. When the formation has been heated sufficiently to allow steam to reach the contamination, additional contaminant mass is removed through volatilization and SVE. Unlike the above alternatives, steam injection is a technology that mobilizes COCs and, as such, cannot be implemented in the Shallow Aquifer above. Targeting the Shallow Aquifer alone would risk mobilizing the DNAPL from that zone downward, as opposed to the DNAPL being captured and removed. For this reason, steam injection is being considered for both the Shallow and Intermediate Aquifers. According to the available literature (Appendix C), steam stripping was successful in reducing VOC concentrations by as much as 98% in one study of shallow groundwater treatment in granular soils. Other studies indicate a much lower level of success in deeper and/or more variable soil types.

The conceptual design of the steam injection system, which is shown on Figure 4-8, includes installation of 18 steam injection wells, 18 dual-phase extraction wells, and two additional SVE wells for a total of eight SVE wells under Alternative HA-5. Four of the SVE wells installed during the Phase 1 of Alternative HA-5 would also be utilized. Each treatment zone would consist of one centrally located extraction well, and four injection wells spaced 45 feet apart. Steam would be injected through the four extraction wells, and a centrally located dual-phase extraction well would recover mobilized DNAPL constituents, impacted groundwater, condensed steam, and vapor. SVE wells would operate over the treatment area to capture any vapors that escape the treatment zone. Two nested wells would be located at each steam injection well and dual-phase extraction well location. Each well would be constructed with 40 feet of screen. The shallow injection/dual-phase extraction wells would be installed to a depth of approximately 50 feet bgs to treat the water table and shallow groundwater intervals. The second well at each nested steam injection or dual-phase extraction well location would be installed to a depth of approximately 90 feet bgs to treat the intermediate groundwater interval. Dedicated, submersible, groundwater extraction pumps would be installed in each dual-phase extraction well approximately 5 feet above the bottom of the well. A pumping rate of 5 gpm would be maintained in each well. Based on the steam requirements for similar applications, it is estimated that approximately 720 tons/year of carbon dioxide (a greenhouse gas) would be produced during steam injection. Assuming a 5-year injection time, a total of about 3,600 tons of greenhouse gases would be released under this alternative.

The two additional SVE wells would be installed to a depth of 8 to 10 feet bgs and would be constructed with 5 feet of screen, for a total of eight SVE wells. The variable-speed, regenerative blower with a capacity of 1,000-cfm would be utilized to induce a vacuum of approximately 25 inches of water on each SVE and dual-phase extraction well. An Ecology underground injection permit may be required for steam injection and an air permit would be required for the SVE system. For cost estimating purposes, it was assumed that the dewatering and SVE phase would require four years to complete,

The extracted groundwater, steam, and contaminated vapors would be treated in a treatment system consisting of a heat exchanger/condenser, vapor liquid separator, catalytic oxidizer, and air stripper. The water vapor in the extracted vapor stream would be condensed and treated with the extracted groundwater by an air stripper prior to discharge to a POTW under a permit issued by King County. Chemical dosing and precipitation may also be necessary to remove elevated concentrations of metals that may be present in the extracted groundwater. A catalytic oxidizer would be used to treat VOCs in the extracted vapor stream prior to discharge to the atmosphere.

Steam injection could not be implemented in proximity to the HCIM barrier wall due to the potential for adverse impacts to the wall material. Therefore, a 50-foot buffer zone would be maintained between the areas to be treated by steam injection and the barrier wall, as shown in Figure 4-8. In addition, monitoring wells with temperature sensors would be installed to monitor temperature gradients throughout the treatment area and near the barrier wall. Two additional nested wells, one at each treatment depth, would be installed at each of three locations for a total of 10 monitoring wells (five nested pairs). The locations of the wells are shown on Figure 4-7.

For cost estimating purposes, it was assumed that the steam injection system would be installed and would operate for a period of 5 years. The cost estimate for steam injection is based on literature values by cost per cubic yard, and not a conceptual design of system components since the design, installation, and operating costs of this technology are difficult to evaluate due to the complexity of the system and proprietary nature of the technology. Therefore, a single cost element has been included for steam injection; for NPV calculation, this cost was placed in year 3 of the 5-year steam injection period (see Appendix A). Based on initial system performance testing, steam injection may be conducted in cycles. Under this operational scenario, SVE and dual-phase extraction would continue between steam injection cycles to depressurize the steam zone and create a thermodynamically unstable system. Cycling of steam injection in this manner has been shown to reduce the amount of steam required, and may potentially reduce the time to reach cleanup levels (Davis, 1998). The actual operational period of the system would likely be determined based on VOC concentrations in the extracted vapor and groundwater streams and whether the system had reached a point of diminishing returns. Groundwater monitoring within the HCIM Area would be conducted during the 5-year steam injection period.

Subsurface heterogeneities and preferential flow paths are expected to cause uneven heating in the treatment zone, resulting in inefficient treatment. In addition, significant portions of the suspected DNAPL areas may not be treatable by steam injection due to the proximity of the barrier wall and the presence of the TASCO building. Therefore, enhanced anaerobic bioremediation would be conducted following completion of steam injection (including cool-down) to further reduce the potential mass of DNAPL and dissolved phase constituents in the HCIM Area. Enhanced anaerobic bioremediation would be implemented as outlined for Alternative HA-2 in Section 4.2.2.

For scheduling purposes (see Figure 4-4) it was assumed that the subsurface would cool to pretreatment temperatures within 2 years; however, preliminary calculations indicate that it could take as long as 20 years to cool sufficiently to support growth of organisms known to be capable of supporting reductive dechlorination of chlorinated VOCs. It was assumed that enhanced bioremediation injections would be conducted for 4 years with an additional 2 years (6 years total) of monitoring within the HCIM Area for enhanced bioremediation. Long-term monitoring at the CPOC has been included in the Outside Area alternatives. Similar to the other alternatives it is likely that cleanup levels would not be met within a reasonable time frame by this technology due to the heterogeneities within the aquifers. Recontamination due to diffusion from the silt lenses and the aquitard are expected to cause recontamination of the Intermediate and Shallow Aquifers.

The implementation period for this alternative could be much longer than for the other alternatives. Designing and implementing the steam injection technology would likely take one to two years plus at least another year for pilot testing. Actual implementation time is anticipated to take about 5 years, as about 1 year would be needed to heat the subsurface to the necessary temperature. Following treatment by steam injection, the site would need several years for ground temperatures to cool prior to implementing enhanced biodegradation, with a 4-year period projected for substrate injection. As a result, total implementation time for this alternative would be about 16 years at minimum and could extend to more than 25 years if the subsurface cools slowly. For cost estimating purposes we have assumed 20 years. It would not be possible to return the site to productive use during the remediation period.

Administrative controls would be incorporated into the alternative to ensure that human health and the environment are adequately protected by Alternative HA-5. These administrative controls would be the same as described for Alternative HA-1 in Section 4.2.1.

The advantages of implementing HA-5 are:

- The technology of steam stripping in this alternative could result in mobilization and capture of more DNAPL than other alternatives.
- The alternative would result in mass removal from all three groundwater zones above the Silt Aquitard.
- This alternative could remove mass for SVOCs as well as VOCs.
- This alternative would meet remediation levels in all zones, but cleanup levels would not likely be met.

The disadvantages of Alternative HA-5 are:

- The technology of steam stripping would mobilize contaminants; however, the ability to capture those contaminants is much less certain. This technology was implemented in an extensive pilot test at the Puget Sound Resources CERCLA site and was a complete failure as DNAPL was mobilized without full capture.
- The technology of steam stripping has been shown to be effective on granular soils and at depths of less than 30 feet. However this is not a proven technology for VOCs to the depths required for this project.
- The implementation of this alternative would take at least 16 years. The steam stripping would require extensive pilot testing followed by permitting. As a result, the site would not be redeveloped for at least 16 years.
- The technology is unproven for such a complex site, and as a result the ability to meet cleanup levels are also unproven.
- Since the alternative relies on mobilization of DNAPL, implementation presents a risk of COC migration through the Silt Aquitard.
- The amount of energy required to implement steam stripping over such a large saturated zone would be immense.

- The technology of steam stripping could not be conducted near the barrier wall owing to concerns of damage to that feature and may therefore not be effective.

4.2.6 Alternative HA-6: Steam Injection, Groundwater Extraction, SVE with Dewatering, and Excavation

This alternative combines steam injection and SVE/dewatering with groundwater extraction for mass reduction. In addition, vadose zone soil containing COC concentrations above cleanup levels for PCBs and metals would be excavated for off-site disposal. Alternative HA-6 would include the following elements:

- The existing barrier wall isolating and enclosing near-facility impacted soil and groundwater;
- An upgraded groundwater recovery and pretreatment system with greater capacity than the existing system;
- Surface cap/cover;
- Partial site dewatering and SVE;
- Steam injection in affected HCIM Area groundwater;
- Groundwater recovery for mass reduction;
- Excavation and off-site disposal of highly impacted soil;
- Reconstruction of the cap following excavation;
- The existing groundwater monitoring wells and a revised monitoring program as discussed in Section 5; and
- Institutional controls.

Alternative HA-6 would be implemented in phases. Phase 1 would include capping of uncapped areas and implementation of SVE with dewatering, as described for Alternative HA-3 in Section 4.2.3. Following decommissioning of the SVE system, steam injection would be conducted in Phase 2 to reduce the mass of DNAPL suspected to be present within the HCIM Area, as detailed for Alternative 5 in Section 4.2.5. Phase 2 of Alternative HA-6 would include continued groundwater recovery in the two suspected DNAPL areas following cessation of steam injection to further reduce the mass of chlorinated VOCs present in HCIM Area groundwater and excavation of impacted soil. In addition to VOC recovery, the recovery system may reduce metals concentrations present within the suspected DNAPL areas. As discussed in Technical

Memorandum No. 1, arsenic has been detected in water table and intermediate monitoring wells 1-S-1 and 1-I (located within the suspected DNAPL area in the North Field) at concentrations greater than 20 and 50 times the cleanup level, respectively. In addition, copper, nickel, and barium (1-S-1 only) have been detected in these wells above their respective cleanup levels.

The groundwater extraction wells for the steam injection system would be utilized for groundwater recovery, and each extraction well would be pumped at a rate of 2 gpm. The extracted groundwater would be treated by the steam injection groundwater treatment system and then reinjected into the shallow and intermediate groundwater depth intervals to flush additional contaminants toward the extraction wells and prevent dewatering of the HCIM Area. The conceptual design of the steam injection, groundwater extraction, and reinjection system is shown on Figure 4-9. Based on the steam requirements for similar applications, it is estimated that approximately 720 tons/year of carbon dioxide (a greenhouse gas) would be produced during steam injection. Assuming a 5-year injection time, a total of about 3,600 tons of greenhouse gases would be released under this alternative.

Concentrations of chlorinated VOCs and metals in the water table, shallow, and intermediate groundwater intervals would be monitored during groundwater extraction in existing HCIM Area monitoring wells and in wells installed to monitor steam injection temperature gradients. The operational period of the groundwater extraction system would depend on several factors, including:

- The mass of DNAPL currently present within the HCIM Area;
- The effectiveness of the steam injection program;
- The mobility and concentrations of the contaminants remaining after cessation of steam injection; and
- The capture efficiency of the groundwater extraction wells.

For cost estimating purposes, it was assumed that the dewatering/SVE operations and steam injection operations would be as described above for Alternative HA-5. The groundwater extraction/reinjection system was assumed to operate for a total 15 years; it was assumed that pumping would be maintained during SVE and steam injection operations. Semiannual groundwater samples would be collected for VOC and metals analysis inside the barrier wall during this period to monitor the effectiveness of the remediation systems. It was assumed that monitoring inside the barrier wall would cease when groundwater recovery is stopped. Long-term monitoring at the CPOC is included in the Outside Area alternatives.

The third phase of Alternative HA-6 would include excavation and off-site disposal of soil containing elevated inorganic and PCB concentrations within HSRA-1. It is projected that the excavation would be done after completing steam injection, probably about 10 years after commencing implement of this alternative. Soil currently containing VOCs and SVOCs would not be excavated because these areas would be addressed by SVE, as discussed above. Based on soil sampling results presented in the RI, excavation and off-site disposal would be implemented in two areas, as shown in Figure 4-9. The excavation areas would include PCB- and metals-impacted soil near the northeastern UPPR property boundary and a small area with elevated concentrations of metals around former sampling location HAC-17. The structural integrity of the HCIM barrier wall and the TASCO building would be protected during excavation activities by maintaining a minimum 5-foot buffer around the barrier wall and building foundation. In addition, excavation sidewall slopes of 1.5:1 (horizontal to vertical) would be maintained away from the barrier wall and building foundation.

Excavations would be completed to the top of the groundwater (approximately 8 to 10 feet bgs). It is anticipated that approximately 2,000 bank cubic yards of soil would be removed for off-site disposal. The excavated soil would likely be classified as dangerous waste and would have to be transported by licensed haulers to appropriately permitted disposal facilities.

Confirmation soil samples would be collected from the sidewalls of the excavations at a frequency of one per 50 linear feet of excavation sidewall. A minimum of one confirmation sample would be collected from each excavation sidewall. Confirmation samples would not be collected from the base of the excavations, because the excavations would be completed to the water table. Following completion of soil removal, the excavations would be backfilled with clean fill and compacted. The disturbed areas would be repaved with a minimum of 3 inches of asphalt to replace the existing cap over the excavation areas.

Implementation of this alternative would be faster than HA-5, but longer than HA-4 (Figure 4-4) with a project implementation time of about 17 years. This assumes that the final groundwater pump and treat portion of the alternative could be conducted during the time that the subsurface is hot. It is anticipated that redevelopment could be implemented within about 18 years after commencing implementation of the alternative.

Administrative controls would be incorporated into the alternative to ensure that human health and the environment would be adequately protected by Alternative HA-6. These administrative controls would be the same as described above for Alternative HA-1.

The advantages of implementing HA-6 are:

- The technology of steam stripping in this alternative could result in mobilization and capture of more DNAPL than other alternatives.
- The alternative would result in mass removal from all three groundwater zones above the Silt Aquitard.
- This alternative could remove mass for SVOCs as well as VOCs.
- This alternative would meet remediation levels in all zones, but cleanup levels would not likely be met.

The disadvantages of Alternative HA-6 are:

- The technology of steam stripping would mobilize contaminants; however, the ability to capture those contaminants is much less certain. This technology was implemented in an extensive pilot test at the Puget Sound Resources CERCLA site and was a complete failure due to mobilization of DNAPL and failure to recover it.
- The technology of steam stripping has been shown to be effective on granular soils and at depths of less than 30 feet; however, this is not a proven technology for VOCs to the depths required for this project.
- Implementation of this alternative could take at least 17 years. The steam stripping would require extensive pilot testing followed by permitting. As a result, the site would not be redeveloped for at least 18 years;
- The technology is unproven for such a complex site, and as a result the ability to meet CULs is also unproven.
- Since the alternative relies on mobilization of DNAPL, implementation presents a risk of COC migration through the Silt Aquitard.
- The amount of energy required to implement steam stripping over such a large saturated zone would be immense.
- The technology of steam stripping could not be conducted near the barrier wall due to concerns of damage to that feature and therefore may not be effective.

4.3 EVALUATION OF HCIM AREA REMEDIAL ALTERNATIVES

The objectives for the six remedial alternatives considered for the HCIM Area are to prevent direct contact with site COCs, limit constituent migration from the HCIM Area to acceptable levels, be compatible with the HCIM barrier wall, and support future redevelopment and reuse of the facility and the TASCO properties. All alternatives would attain these objectives.

This section compares and evaluates the remedial alternatives based on the MTCA criteria discussed in Section 3. In the subsections below, the alternatives are evaluated relative to their ability to meet each of the criteria. For each criterion, the alternatives are evaluated on a scale of 1 to 5. A rating of 5 means the alternative is expected to most completely meet the criterion. For example, none of the alternatives would result in meeting the cleanup criteria for all COCs, so none of the alternatives would receive a 5 rating for permanence and risk reduction.

A rating of 1 indicates that the alternative is expected to perform poorly for that criterion, relative to the other criteria. A rating of 1 does not necessarily mean that the alternative would not adequately meet the criterion; it only means that other alternatives would be more effective in meeting that specific criterion.

All of the remedial alternatives under consideration attain the remediation objectives outlined in Section 2. Direct contact with affected soil is addressed by placement of a cap over affected soil and implementing institutional controls to limit subsurface work and require appropriate health and safety measures. The cap also minimizes potential dust generation in addition to preventing runoff of affected soils. Institutional controls have been included in all of the alternatives to require vapor intrusion barriers for any buildings constructed within the HCIM Area that would be occupied on a regular basis. The barrier wall provides protection of human and ecological receptors by providing a physical containment barrier that significantly reduces the release of groundwater-borne constituents from the HCIM Area. Any constituents that may pass through the barrier wall would be addressed by the remedial alternatives for the Outside Area. Therefore, the remedial alternatives considered for the HCIM Area would comprehensively attain the remediation objectives established in this SWFS.

In the following subsections, each of the remedial alternatives is compared to the evaluation criteria described in Section 3. These comparisons summarize the primary factors that address each criterion. The evaluation has been summarized for all evaluation criteria in Table 4-5.

4.3.1 Protectiveness and Risk Reduction Evaluation

The relative ranking of the alternatives for this criterion is shown on Table 4-5. In general terms, the protectiveness and risk reduction criterion involves the degree to which remedial alternatives protect human health and the environment and provide a reduction in risks posed by the contamination. All of the alternatives under consideration are expected to significantly reduce risks and be protective of human health and the environment. However, the alternatives differ in the amount of contaminant mass reduction that could be achieved in soil and groundwater and, therefore, would be expected to also differ in overall protectiveness and risk reduction. The technology assessment (Appendix C) and the remediation level modeling (Appendix B) indicate that none of the alternatives would meet ultimate cleanup levels and, therefore none of the alternatives were given a maximum rating of 5 on this criterion. Based on meeting remediation levels, all of the alternatives currently meet remediation levels and, therefore, are essentially equal in protectiveness. All of the alternatives would rely on essentially the same institutional controls to prevent direct exposure to impacted groundwater and would therefore be equally protective in this respect, and all alternatives rely on the HCIM containment. Alternative HA-6 was given a 4 rating since this alternative removes PCBs and metals in the near surface soil, and as a result reduces reliance on the surface cover for minimizing on-site human exposure to COCs.

Alternative HA-1 includes active hydraulic containment, capping, monitored natural attenuation, and institutional controls to address contaminant concentrations in HCIM Area soil and groundwater. Although monitored natural attenuation appears to have reduced concentrations of VOCs and select SVOCs in groundwater below remediation levels, this alternative would not address PCBs and inorganics in groundwater. Alternative HA-1 would address COC in HCIM Area groundwater through reductive dechlorination in the highly reducing environment within the barrier wall containment, but does not use an active approach to reduce COC concentrations. HA-1 relies on capping and institutional controls to prevent direct contact with impacted soil. Although this technology does not use an active approach to reduce the COCs, the calculation of remediation levels (Appendix B) indicates that this technology is currently meeting remediation levels for the most likely scenario of wall failure. This alternative would not result in attainment of cleanup levels for the foreseeable future, nor would it address PCBs, SVOCs, or metals. As a result, Alternative HA-1 can only be rated in the mid range of this criterion, and was rated 3 for protectiveness and risk reduction.

Alternatives HA-2, HA-3, HA-4, HA-5, and HA-6 incorporate technologies that would attempt to reduce the mass of DNAPL suspected to be present within the HCIM Area and reduce VOC concentrations in groundwater (enhanced anaerobic bioremediation, ISCO, and steam injection). Alternatives HA-3, HA-4, HA-5, and HA-6 include SVE and partial site dewatering to reduce the VOC concentrations in vadose zone soil and the water table interval in the source areas. However, based on the analysis of these technologies' ability (Appendix C) to reduce COC concentrations, it is apparent that the heterogeneities of the stratigraphy and the depth of COC impacts would limit the ability of these technologies to reduce concentrations of COCs significantly below those achieved by HA-1. These technologies would reduce the cleanup time frame for the Shallow Aquifer; however, they would have limited effect in the Intermediate Aquifer due to the highly interbedded sand and silts. It is expected that much of the VOC mass is sorbed to and within the silt layers and would not be amenable to cleanup even with the most aggressive methods. Since groundwater in the Intermediate Aquifer will remain at relatively high concentrations, diffusion and mixing between the Intermediate and Shallow Groundwater Zones will still occur, resulting in some recontamination of the Shallow Aquifer after treatment. Under all scenarios, containment will still be required to protect downstream receptors. As a result, alternatives HA-2, HA-3, HA-4, and HA-5 have the same protectiveness and amount of risk reduction as HA-1. As with HA-1, these alternatives would not address metals, SVOCs, or PCBs in groundwater or vadose zone soil. These four Alternatives are rated 3 for this criterion since they all meet remediation levels, are all protective, but none would result in cleanup levels being met in the foreseeable future.

Alternative HA-6 includes limited excavation and off-site disposal to address metals and PCB hotspots, and therefore partially addresses these COCs in soil. Since some metals and PCBs are removed, this alternative received a higher rating (4) than the other five alternatives, although it still would not result in attainment of cleanup levels for the foreseeable future.

4.3.2 Permanence

The permanence criterion, as defined in Section 3, involves the degree to which the remedial alternative would reduce the toxicity and mobility of affected media through permanent destruction of hazardous substances. None of the six alternatives would result in attainment of cleanup levels within the foreseeable future. All of the alternatives would result in reduction in total mass of COCs, but there may not be a significant reduction of COC concentrations with any of the alternatives due to the inability of all alternatives to be effective at cleaning up the COCs and DNAPL within the interbedded silts and sand of the Intermediate Aquifer. If COC concentrations remain similar after treatment under the various options, toxicity and mobility would not necessarily be reduced; however, for the purposes of this analysis we have assumed that differences in the amount of reduction in mass could eventually result in a reduction of toxicity and mobility. As a result, the analysis of this criterion compares the amount of mass reduction between alternatives.

Alternative HA-1 was rated the lowest (1) of the alternatives because it would use a passive approach to COC reduction, which would not address DNAPL within a reasonable time frame. Groundwater recovered under Alternative HA-1 would be pretreated using an air stripper. The pretreatment groundwater would be discharged to a POTW for biological treatment, where the COCs would be either biologically degraded or stripped to the atmosphere. Volatile COCs stripped from the groundwater would be either adsorbed or destroyed by the permanganate/activated carbon adsorber. Adsorbed VOCs would be destroyed. Additional destruction of volatile COCs would occur due to ongoing in situ biodegradation, which is active within the HCIM Area. Based on groundwater monitoring within the HCIM Area, remediation levels appear to have been met by natural attenuation. In addition, the HCIM Area is a closed system with little fresh groundwater moving into the area to add oxygen, and strong reducing conditions are present thereby continuing the natural anaerobic degradation of COCs.

Alternative HA-2 is rated higher (2) than HA-1 because it would remove additional COC mass within a shorter time frame through the implementation of an aggressive enhanced anaerobic bioremediation approach. HA-1 relies on the natural reducing conditions to reduce COC concentrations, but the natural conditions might not result in much reduction within the DNAPL areas. HA-2 would use a recirculating system of wells to effectively treat the source areas, including DNAPL areas in the Shallow Aquifer, and should achieve more mass removal than HA-1.

Alternatives HA-3 and HA-4 include the implementation of SVE coupled with partial site dewatering to remove VOCs from vadose zone soil and address shallow residual DNAPL. HA-3 uses enhanced anaerobic biodegradation to reduce COC concentrations, whereas HA-4 uses ISCO to treat COCs. Literature suggests that both technologies should be successful in reducing mass of VOCs and to some extent SVOCs. In addition, the more aggressive groundwater extraction component of these alternatives (for partial site dewatering) may also reduce inorganic COC concentrations in shallow groundwater. Both alternatives would result in the destruction of groundwater COCs and DNAPL suspected to be present within the HCIM Area within the

Shallow Aquifer. The more aggressive level of remediation imparted by the addition of dewatering and SVE to these alternatives should result in more mass removal than HA-2 and they have been rated a 3 for Permanence.

Alternative HA-5 is rated higher (4) than Alternatives HA-3 and HA-4 because it includes the implementation of two separate technologies (steam injection and biostimulation) to reduce/remove DNAPL mass and dissolved phase organics, and this alternative also would target both the Intermediate Aquifer and the Shallow Aquifer. The effectiveness of HA-5 within the Intermediate Aquifer would likely be limited, however, due to the interbedded nature of the Intermediate Aquifer and the fact that DNAPL is sorbed to and within the silt layers.

Alternatives HA-6 is also rated 4. This alternative incorporates the removal of PCBs and inorganics in subsurface soil through excavation and off-site disposal. Subsurface soil containing elevated PCB and metals concentrations would be excavated from two locations within HSRA-1. It is anticipated that approximately 2,000 cubic yards of soil would be excavated and disposed of at an off-site facility, resulting in the permanent removal of COCs. The removal of a small amount of soil does not warrant a higher rating than HA-5 as the two alternatives are essentially equal in total COC mass removal, particularly the more mobile COCs. HA-6 would not address all PCBs or metals on site, just the two hot spots, and these COCs would not be destroyed but simply moved to another location.

4.3.3 Costs

NPV cost estimates were prepared for the HCIM Area remedial alternatives, as presented in Table 4-6 and described in Appendix A. The NPV costs combine initial costs for implementation of an alternative with recurring costs for future operation, maintenance, and monitoring. NPV cost estimates allow the alternatives to be compared on an equal basis. As shown on the projected implementation schedule (Figure 4-4), some implementation costs would occur in the future, after initial remediation or planning tasks are completed. As outlined in Appendix A, the NPV discount rate used was 2.5 % based on discussions with Ecology. This is a very conservative discount rate based on the current U.S. Treasury Bill interest rate of approximately 5% and an inflation rate of 2.5%.

Implementation costs include estimated costs for obtaining access to conduct the remediation; for engineering and planning; for purchasing equipment, materials, and chemicals; for permitting; and for construction. Recurring costs include estimates for operation and maintenance labor, Ecology oversight, materials and chemicals used in remediation, periodic replacement of remediation equipment, long-term property access, power and waste disposal, water quality monitoring, and project management. As discussed in Section 3-3, The NPV costs are based on the implementation and operation period for each of the six alternatives. Since none of the alternatives would reach cleanup levels in the foreseeable future, containment would remain a component of each alternative.

The NPV costs were compared by alternative and the alternatives were simply ranked on their costs compared to the other alternatives. As a result, Alternative HA-1 is the least expensive to implement and was ranked highest (5) as shown on Table 4-5. The NPV costs for Alternatives HA-2 is ranked next (4). Alternatives HA-3 and HA-4 could be similar in costs based on our analysis; however, the potential range in costs for HA-4 (ISCO) is much greater due to the unknowns of how much chemical oxidant would be required to overcome local geochemistry issues. As a result HA-3 was rated 3, whereas HA-4 was rated lower at 2.

The two alternatives that employ steam stripping, HA-5 and HA-6, have implementation costs that are clearly much higher than the other four alternatives (by a factor of about 3 to 5), and therefore, both these alternatives were ranked lowest (1) on Table 4-5. Since the NPV costs for Alternatives HA-5 and -6 are approximately \$30,000,000 greater than the next higher cost (\$15,278,000 for Alternative HA-4) and provide minimal additional benefits, their costs are considered disproportionate.

The results of the cost sensitivity analysis are also shown on Table 4-6. Minimal variance was shown for Alternative HA-2, while a variance of about \$29,000,000 was noted for Alternative HA-6. Although substantial variance was noted for Alternatives HA-5 and HA-6, the low and high for these alternatives were at least twice the next highest cost alternative, indicating disproportionate costs.

4.3.4 Long-Term Effectiveness

Long-term effectiveness includes the degree of certainty and reliability of the alternative to maintain its effectiveness over the long term. This criterion also considers whether treatment residue would remain from the alternative that would require management. The benefits realized by an alternative are compared to the negative consequences associated with the alternative in assessing long-term effectiveness. All six alternatives under consideration would incorporate the same institutional controls; therefore, the institutional controls for each alternative would have essentially the same effectiveness and reliability.

All six alternatives under consideration would rely on the HCIM barrier wall to control off-site migration of groundwater COCs until cleanup levels are achieved. All six alternatives are equal in meeting remediation levels protective of the Duwamish Waterway under the most realistic scenario for damages to the wall. All six alternatives would also rely on the cap system to prevent direct contact with impacted soil. The need for containment as an integral part of all alternatives indicates that none of the alternatives can achieve a rating of 5 for this criterion.

Alternative HA-1 relies on natural attenuation to address long-term effectiveness, whereas all other alternatives use an active approach to reduce COC mass. In theory, the active approaches should be more effective in the long term. Theoretically the alternatives that reduce more mass should ultimately reduce COC concentrations and reduce long-term risks to the environment. For this reason Alternative HA-1 is rated lowest with a rating of 1 for this criterion. Alternatives HA-2 through HA-6 would result in greater destruction of soil and groundwater COCs than Alternative HA-1, although none would meet cleanup levels in the foreseeable future. Since Alternatives HA-2 through HA-6 would reduce more COC mass, they have been rated higher on Table 4-5 than HA-1, which is given the lowest rating (1).

Although Alternatives HA-5 and HA-6 would result in the greatest amount of soil COC destruction because they both address the Intermediate Aquifer with steam injection, neither alternative would achieve cleanup levels. In addition, these two alternatives have an extremely long implementation period of as much as 20 years. Since they do remove more COCs, particularly in the Intermediate Aquifer, they have been rated higher than other Alternatives, but receive only a 3 rating.

Alternatives HA-2, HA-3, and HA-4 were rated equally with a 2 rating. Technically these alternatives remove more mass than Alternative HA-1, but less mass than either Alternative HA-5 or HA-6. Likewise, they would achieve results more rapidly than Alternative HA-1 but slower than Alternatives HA-5 and HA-6.

4.3.5 Management of Short-Term Risks

Short-term risk refers to the risk to human health and the environment during implementation of an alternative. Although it is possible to design remedial actions to mitigate or minimize potential risks, it is not possible to eliminate risks through design or actions. In assessing this criterion, it has been assumed that alternatives have been designed to incorporate appropriate and proven methods to mitigate short-term risks. However, regardless of the approach taken, remedial actions that remove soil or require construction of any type have higher short-term risks than those that do not. Although measures to mitigate these risks are not discussed in this section, appropriate measures have been included in the cost analysis as part of this feasibility study to minimize short-term risks in all alternatives.

Alternative HA-1 is rated 5, which is the highest of the alternatives under consideration, because it would not require additional subsurface activities (e.g., excavation, installation of wells, etc.), is the fastest to implement, and has the lowest short-term exposure potential. As shown on Table 4-5, Alternative HA-2 received the next highest rating (4), because it includes minimal subsurface activities (installation of additional extraction, injection, and monitoring wells) and implementation would be completed within about 5 years. There would be some increase in short-term risks due to the potential for exposure to impacted soil and groundwater during drilling activities. Alternative HA-3 would include the operation of an SVE system, and therefore there would be additional risk for short-term exposure during construction and operation of this technology. In addition, the implementation period could take close to 10 years (see Figure 4-3), and any implementation this long could result in injuries or accidents to remediation workers. HA-2 has been given a 4 rating and Alternative HA-3 has been given a 3 rating.

Alternatives HA-4 received a relatively low rating of 2, because this alternative includes significant health and safety concerns due to use of highly reactive chemicals (chemical oxidizers) and it has a long period of implementation (10 years), which increases risk of injury and accident. Alternatives HA-5 and HA-6 both received the lowest rating of 1 due to the use of pressurized steam for remedial activities. Both alternatives would require implementation of carefully designed engineering controls to address associated health and safety concerns. The total implementation period for both these alternatives could approach 20 years, which increases the risk of injury and accident during remediation activities. Alternative HA-6 also includes additional short-term exposure risks associated with the excavation and handling of subsurface soil.

4.3.6 Technical and Administrative Implementability

This criterion involves both technical and administrative issues related to construction and operation of the remedial alternatives. Factors considered in assessing the alternatives against this criterion include administrative/regulatory requirements, impact on existing land uses, the means for implementing and enforcing institutional controls, and requirements for extensive construction or ongoing operation and maintenance.

As shown in Table 4-5, Alternative HA-1 was rated highest of all the alternatives under consideration because it would rely on the existing HCIM barrier wall and cap system, which has proven effective in controlling off-site migration of impacted groundwater and preventing direct contact with subsurface soil. Essentially Alternative HA-1 has been mostly implemented and therefore receives a 5 rating.

Alternative HA-2 is rated 4 since HA-2 would require obtaining injection permits and installing additional wells. HA-2 would also require injection and recirculation of electron donor and nutrients over a 4-year period. This has the potential to create technical issues, such as fouling and plugging of wells, requiring considerable effort to address.

HA-3 is rated 3 as the addition of SVE and dewatering would require more permitting (for example the King County discharge permit will need to be modified, and the treatment system redesigned) and considerable technical implementation concerns. Implementation of SVE under Alternative HA-3 would require the preparation and submittal of a Notice to Construct to the PSCAA prior to construction of the SVE system. Both Alternatives HA-2 and HA-3 would require an underground injection permit to be obtained from Ecology to allow injection of electron donor to groundwater. Implementation of Alternative HA-2 would take as long as 10 years, and PSC would need to deal with technical problems, such as maintaining a pump and treatment system at very high flow rates for the period of dewatering, iron fouling of wells, SVE operation mechanics, and the same issues with injection wells as Alternative HA-2. As a result, Alternative HA-3 is rated lower (3) than either HA-1 or HA-2.

Alternative HA-4 was rated 2 and lower than HA-3 because of the administrative and technical challenges associated with ISCO remediation. Chemical oxidant is a hazardous material, and injection of ISCO would require obtaining an injection permit, which will be more difficult to obtain than that for electron donor injection. In addition, there would be technical difficulties associated with obtaining effective contact between the oxidant and the contaminant in the subsurface during ISCO remediation. Subsurface heterogeneities, preferential flow paths, and poor mixing in the subsurface may result in inefficient treatment. Although effective distribution of an electron donor substrate for enhanced anaerobic bioremediation (Alternatives HA-2 and HA-3) is also difficult, slow releasing electron donors are available (such as emulsified vegetable oil) that would provide a long-term source of electron donor substrate to the impacted groundwater intervals. Oxidants such as permanganate and Fenton's Reagant react quickly with contaminants and other oxidizable substances in the treated zone, such as soil organic matter and reduced-state metals. It can be difficult to maintain a concentration of unreacted oxidant in the subsurface capable of treating the targeted chlorinated VOCs. Based on the iron fouling observed in the existing groundwater recovery system for the HCIM barrier wall system, a significant amount of oxidant may be required to overcome the natural soil oxidant demand in the HCIM Area. In addition, fouling and plugging problems in the injection and recirculation wells are expected to be much higher for ISCO than for enhanced biodegradation.

Alternatives HA-5 and HA-6 received the lowest rating (1) due to the complexity of the steam injection systems included in both alternatives. These alternatives also received low ratings due to the technical difficulties associated with the delivery and effective distribution of steam at depths of up to 90 feet bgs and the protection of the HCIM barrier wall from potential adverse effects from the injected steam.

4.3.7 Public Concerns

Potential community concerns with implementation of each remedial alternative are assessed for this criterion, including general concerns of the public and specific concerns of neighboring landowners. It is expected that the primary public concerns associated with the HCIM Area alternatives would be from neighboring landowners, because the site and neighboring sites are used for industrial purposes. The primary public concerns are expected to be related to VOC releases to ambient air, odor, and noise. Public concerns related to restoration time frames could also be voiced, although this concern is more an issue for the Outside Area. Finally, the period of implementation of the various alternatives ranges from as little as 6 months to as much as 17 years. The longer periods of implementation could result in public concerns about disturbances, odor, noise, traffic, and the longer period of time for negative perceptions of the neighborhood. Finally, the property is currently virtually idle, generating little revenue to the City of Seattle. The longer the implementation time frame, the longer the time before the property can be redeveloped and put into productive use.

Alternative HA-2 received the highest rating, 5, for this criterion, because it has a relatively low potential for release of VOCs to ambient air and is unlikely to create objectionable levels of odor and noise. In addition, this alternative includes active efforts to reduce COC concentrations in HCIM Area groundwater (enhanced anaerobic bioremediation) and has a shorter period of time to implement than Alternatives HA-3 through HA-6; Alternative HA-2 would thus result in earlier redevelopment of the site.

Alternative HA-1 is the easiest to implement and could be completed and redeveloped without any concerns from the local public; however, the public could perceive that HA-1 is too passive an alternative and that cleanup is not being adequately addressed. As a result of the potential public concern of passive cleanup, Alternative HA-1 is rated 4 and lower than HA-2.

Alternatives HA-3 and HA-4 are both rated lower than HA-2, because the blower used for the SVE system could cause unacceptable noise levels if proper engineering controls were not implemented. In addition, SVE may also include the perceived risk of contaminant discharge to ambient air. In situ chemical oxidation (Alternative HA-4) could cause public concern due to the injection of chemical oxidants into site groundwater, although this potential concern did not affect its rating. Injection of electron-donor substrates (Alternatives HA-2, HA-3, and HA-5) would be unlikely to cause public concern due to the innocuous nature of the electron donors and the public's familiarity with the substrates (e.g., molasses, emulsified vegetable oil, etc.). As a result, both HA-3 and HA-4 were rated the same as HA-1: 4.

Both Alternative HA-5 and HA-6 were rated 1 for public concern due to concerns of noise and possibly odor from the steam injection process and the extremely long time frame to complete implementation of these alternatives. Both alternatives would result in a delay of as much as 20 years before the site could be fully redeveloped, since the implementation would be a phased approach of the various technologies within these two alternatives. The noise and activity related to the excavation and transportation of potentially dangerous wastes over public roadways associated with Alternative HA-6 would also have direct implications for the public, and Alternative HA-6 therefore receives the minimum rating of 1.

4.3.8 Reasonable Restoration Time Frame

Restoration time frame involves the urgency of achieving remediation objectives and the practicability of attaining a shorter restoration time frame, with consideration given to a number of factors such as site risks, site use and potential use, availability of alternative water supply, effectiveness and reliability of institutional controls, and toxicity of hazardous substances at the site.

Although Alternatives HA-1 through HA-6 include active remedial actions to reduce COC concentrations in vadose zone groundwater, none of the six is anticipated to meet cleanup levels throughout the shallow and intermediate groundwater zones. All six alternatives under consideration for the HCIM Area include long-term containment of impacted soil and groundwater. None of the six meets soil cleanup levels, although Alternative HA-6 would remove the soils most impacted with PCBs and metals. Therefore, the alternatives were not rated relative to the time frame required to achieve soil and groundwater cleanup levels. Rather, the alternatives were evaluated based on the time required by each alternative to reach groundwater remediation levels and potentially to meet cleanup levels in the very long term.

It was assumed that the continued monitoring, maintenance, and repair (if necessary) of the HCIM barrier wall system would be required until VOC concentrations in the water table interval are reduced to below cleanup levels. In addition, Ecology has expressed concern about the potential exposure of downgradient receptors to VOC vapors associated with the water table in the event of a catastrophic failure of the barrier wall (e.g., worst-case earthquake failure scenario). However, since none of the alternatives can meet this objective, preference was given to alternatives that (1) reduce VOC concentrations to below remediation levels within the shortest time frame and (2) to those that ultimately could meet cleanup levels the fastest, albeit not in the foreseeable future. Finally, since none of the alternatives would meet cleanup levels in a reasonable time frame, the time required to place the HCIM Area into productive use was also considered.

Alternatives HA-5 and HA-6 both target the Intermediate Aquifer in an attempt to mobilize and reduce DNAPL concentrations. As a result they would both reduce more total mass than the other Alternatives, and they should therefore eventually should lead to a shorter time frame, albeit still lengthy, to ultimately meet cleanup levels. For this reason, Alternatives HA-5 and HA-6 have been given a rating of 4 on Table 4-5. It should be noted that the active remediation time for these two alternatives is the longest of the alternatives considered, as shown in Figure 4-4. As noted above, it would be necessary to allow soil and groundwater to cool to near original temperatures to implement the enhanced bioremediation component of Alternative HA-5; while it was optimistically assumed to occur within 2 years in development of the implementation schedule, cooling time could be as long as 10 to 15 years.

Alternatives HA-2, HA-3, and HA-4 all have been given a moderate rating (3). All three of these alternatives would readily meet the remediation levels developed for a most realistic barrier wall scenario and ultimately have similar potentials in reducing total mass. Alternatives HA-3 and HA-4 would employ a more aggressive approach to remediate the water table zone (dewatering and SVE) than Alternative HA-2; however, they would not result in a faster cleanup time frame than HA-2, and HA-2 has the advantage of a faster implementation period. Faster implementation would result in the property being placed back into productive use sooner.

Alternative HA-1 has been given the lowest rating (2) of the six alternatives, since this approach would have slower reduction of COC mass within the DNAPL/source areas than other more aggressive alternatives. Although this alternative currently is meeting remediation levels within the HCIM area, the existing data may not adequately represent the entire area. However, this alternative would allow the site to be placed back into productive use the soonest.

4.4 SELECTION OF HCIM AREA PREFERRED REMEDIAL ALTERNATIVE

Selection of a preferred alternative under MTCA requires that preference be given to alternatives that use permanent solutions to the maximum extent practicable, provide for a reasonable restoration time frame, and consider public concerns. According to MTCA (WAC 173-340-200), a permanent solution or permanent cleanup action means an action in which cleanup standards can be met without further action being required at the site involved, other than the approved disposal of any residue from the treatment of hazardous substances.

The MTCA rules also specify that a baseline alternative be defined as the remedial alternative that permanently destroys site COCs to the maximum extent practicable and achieves the shortest restoration time frame. The baseline alternative is to be used as a basis for comparing other remedial alternatives and selecting the preferred alternative. For the HCIM Area, six remedial alternatives have been established as potentially applicable to the site, as discussed in Technical Memorandum No. 4 (as modified by Ecology in correspondence dated 20 February 2007). None of the alternatives is expected to be capable of restoring the site to prerelease conditions within a reasonable time frame. Alternative HA-6 was selected as the baseline alternative for the HCIM Area, because it would result in the greatest removal and/or destruction of site COCs and therefore has the greatest degree of permanence. All HCIM alternatives are evaluated relative to Alternative HA-6 below.

4.4.1 Comparison of HCIM Area Alternatives

As shown in Table 4-5, Alternative HA-2 received the highest total rating, although it was rated the highest only for public concern; however, it was rated high (4) for cost, management of short-term risks, and technical and administrative implementability. Based on the rating scores in Table 4-5, Alternative HA-2 would be preferred over Alternative HA-1, which was rated second, because HA-1, which would rely on natural anaerobic degradation and the HCIM Area barrier wall and cap system, scored low on permanence and restoration time frame. HA-2 received the highest rating for the public concern criterion, as it would be easy to implement, achieve results quickly, and be perceived by the public as an aggressive cleanup action. Alternative HA-1 is extremely quick to implement, since most aspects of this alternative are already complete, but HA-1may be considered by the public to be a passive cleanup approach. Alternative HA-2 is likely to create the least amount of public concern, because it has the lowest potential for release of VOCs to ambient air and is the least likely to create objectionable levels of odor and noise.

Although none of the alternatives under consideration would likely result in the attainment of groundwater cleanup levels within the foreseeable future, Alternative HA-2 was rated lower than HA-3 and HA-4 for the permanence criterion, as those alternatives incorporate SVE to remove additional near-surface source COCs. It is also rated lower than Alternatives HA-5 and HA-6 for permanence, as both those alternatives reduce mass in the Intermediate Aquifer.

Alternative HA-3 was rated third and was lower than HA-2 and HA-1, because it would be more costly to implement. Alternative HA-3 may have a greater potential to cause public concerns, because the SVE system blower could create unacceptable noise levels (if proper engineering controls were not implemented) and due to potential public perception of risk of contaminant discharges to ambient air. The SVE system and additional dewatering needed for Alternative HA-3 would also require more permitting than HA-1or HA-2, and implementation would take longer.

Alternative HA-4 is rated fourth and lower than HA-2 based on cost, management of short-term risks, technical and administrative implementability, and public concern. Alternative HA-4, which uses ISCO technology to treat VOCs, would result in more destruction of mass than HA-2, thereby scoring higher for permanence, but would not result in a greater degree of protectiveness or risk reduction. As was shown in Appendix C, none of the alternatives would result in attainment of cleanup levels within the HCIM Area. However, based on modeling to develop remediation levels (Appendix B), all the HCIM alternatives are likely to meet the remediation levels. Therefore, Alternative HA-4's advantage in mass reduction is outweighed by the higher rating of HA-2 and HA-1 for the other criteria.

Alternatives HA-5 and HA-6, the baseline alternative, are rated lowest overall. These two alternatives have very high cost compared to Alternatives HA-1 through HA-4; the NPV cost for these two alternatives is approximately 4.5 times the cost of the next highest cost alternative. Alternatives HA-5 and HA-6 also score low (score of 1) for management of short-term risks and for technical and administrative implementability, due to the complexity of steam injection and the fact that the implementation time frame would stretch out to nearly 20 years, delaying the time when the facility property could be returned to productive use.

Alternative HA-6, the baseline alternative, is rated lowest overall but highest for Protectiveness and Risk Reduction, Permanence, and Restoration time frame, even though the alternative would not fully restore the facility for unrestricted use. However, Alternative 6 is far costlier than Alternatives 1–4 and is also rated lowest for short-term risk, technical and administrative implementability, and public concern. The higher rating for protectiveness and risk reduction is based on excavating and off-site disposal of metals- and PCB-contaminated soils, but cleanup levels for these COCs as well as for VOCs would still not be met by this alternative. The baseline alternative would still require the barrier wall and cover containment system to maintain protection of human health and the environment for the foreseeable future, and in that sense offers no greater protectiveness than HA-1 and HA-2. The disproportionate costs of the baseline alternative far outweigh any perceived benefit in protectiveness and risk reduction provided by such an aggressive remedy versus the other alternatives.

4.4.2 Preferred HCIM Area Remedial Alternative

Based on the numerical comparison presented above, the preferred remedial alternative for the HCIM Area would be Alternative HA-2; however, HA-1, which was rated 1 point lower than HA-2, would also provide an equal amount of protectiveness and risk reduction, could be implemented faster, for a lower cost, and would result in redevelopment of the property more quickly. Since HA-1 meets the remediation objectives at a lower cost and allows the property to be redeveloped and put into productive use at least 3 years faster than HA-2, HA-1 is the Preferred Alternative. HA-1 provides active hydraulic containment and natural attenuation to address the source area. This remediation approach is readily implementable; most of the containment and monitoring components are currently in place. A few areas are not presently capped and, therefore, placement of asphalt in these locations would be required to limit infiltration and provide for complete protection from direct contact with COCs. Long-term operation and maintenance would include routine inspection and maintenance of the barrier wall and cap, as well as maintenance of the groundwater recovery and treatment system. The primary potential for failure of the physical components of the Preferred Alternative would be catastrophic seismic events in the area or construction disturbance of the cap or barrier wall. Failure of the cap or barrier wall by either of these scenarios could be corrected by repairing the damaged areas using proven, readily available technologies.

Appendix B develops remediation levels protective of the Duwamish Waterway based on various scenarios for a failure of the barrier wall. A conservative yet realistic case for failure of the barrier wall would result from a large subduction zone earthquake in the Seattle area, and such an earthquake could result in large scale liquefaction of soils in the vicinity of the wall. Under such a scenario, we have assumed the wall would deform and break in several locations. In developing remediation levels for the HCIM Area, we assumed various numbers of breaks through both the downgradient and upgradient portions of the wall, with each break 6 inches thick. The Preferred Alternative, HA-1, would be expected to meet remediation levels for a scenario under which 12 breaks occur in the wall, each 6 inches wide, a very unlikely scenario. Currently Alternative HA-1 meets remediation levels for this highly conservative scenario, although data are not available for groundwater in the source areas of the HCIM Area. Even assuming that some locations have groundwater concentrations within the HCIM Area that are not currently below remediation levels, the strongly reducing conditions within the HCIM Area are anticipated to rapidly reduce concentrations to remediation levels within 10 years.

All the other alternatives also appear to meet these same remediation levels, but none of the alternatives would meet remediation levels for a scenario where the wall is totally shattered (resulting in a permeability increase of 25%), nor would any of the alternatives, including the baseline alternative, meet cleanup levels in the foreseeable future. As a result all alternatives would require maintaining the containment system.

The Preferred Alternative for the HCIM Area, HA-1, would fully attain remediation objectives:

- The Preferred Alternative would prevent direct contact with soils and inhalation of dust within the HCIM Area by providing a cap over affected soils and by implementing institutional controls that would require appropriate health and safety precautions for future subsurface construction.

- The Preferred Alternative would reduce risks due to inhalation of vapors by incorporating institutional controls requiring vapor intrusion provisions for future buildings that may be occupied.
- The Preferred Alternative would protect human and ecological receptors in the Duwamish Waterway by effectively containing affected groundwater and limiting the further release of COCs.

In addition, the Preferred Alternative would provide:

- An approach that has already been substantially implemented and could be fully constructed and implemented, within 6 months to 1 year following approval of a CAP, with minimal delays for engineering, permitting, and construction. This is 3 to 4 years faster than Alternative HA-2 and up to 16 years faster than implementing the baseline alternative;
- Long-term physical containment of near-facility impacted soil and groundwater through engineered barriers constructed of durable, natural materials;
- An isolated environment established in the contained area to promote and maintain active anaerobic biological degradation of organic site constituents;
- A monitoring well network that would allow ongoing monitoring and assessment of the effectiveness of the remedial measures;
- A reliable, low-maintenance remediation approach using proven, robust technologies;
- An approach that would create minimal short-term risks and have minimal potential for causing public concern about exposure to site constituents during construction; and
- An approach that would allow the property to be redeveloped and placed into productive use in 1 year or less.

The Preferred Alternative (HA-1) for the HCIM Area would be compatible with the remedial alternatives being considered for the Outside Area, and would fully comply with MTCA, the Dangerous Waste Regulations (WAC 173-303), and the RCRA regulations. The Preferred Alternative for the HCIM Area would comply with the requirements of the Permit and achieve the environmental indicator standards for controlling potential exposure to both soil and groundwater for affected media located at and near the facility. The Preferred Alternative would provide effective containment for affected soil and groundwater in accordance with the MTCA regulations. Only minor amounts of dangerous wastes would be generated from implementation of the alternative, primarily resulting from well sampling.

The HCIM Area Preferred Alternative would effectively contain and control near-facility affected soils and groundwater; institutional controls included in the alternative address the inhalation pathway for soil and groundwater and potential direct exposure pathways. Therefore, the Preferred Alternative for the HCIM Area would control potential exposures related to affected soil, groundwater, and soil gas, achieving the environmental indicator goals for the facility. Affected media located outside the HCIM Area are addressed by the Outside Area alternatives, discussed in Section 5.

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5.0 DEVELOPMENT AND EVALUATION OF REMEDIAL ALTERNATIVES: OUTSIDE AREA

Remedial alternatives for the Outside Area must comprehensively address the affected media, COCs specific to the affected media, and potential exposure pathways for this area. Affected media include groundwater, soil, and soil gas. Groundwater exposure pathways to be addressed by remedial alternatives for the Outside Area include direct contact, ingestion (direct and incidental), and volatilization to soil gas or directly to indoor air. Potential exposure pathways for impacted soil include direct contact, incidental ingestion, volatilization to soil gas, and migration to groundwater. The exposure pathway of potential importance for impacted soil gas is migration of the soil gas to indoor air.

Impacted soil within the Outside Area is limited to the area near the facility. As discussed in Technical Memorandum No. 2, the Outside Area has been subdivided into three soil remediation areas based on the nature and extent of soil constituents in the Outside Area (as shown on Figure 2-1). OSRA-1 encompasses the area along the facility property line with UPRR. Soil within OSRA-1 has been affected by several organic COCs, including VOCs (both chlorinated and nonchlorinated), SVOCs, TPH, metals, and PCBs. Outside Soil Remediation Area 2 (OSRA-2) is located on PSC property southeast of the HCIM barrier wall and extends onto the utility easement along South Lucile Street. This area has been impacted by VOCs, metals, and PCBs. OSRA-3 extends from the facility onto the SAD property to South Lucile Street and Denver Avenue South. Soil within OSRA-3 has been affected by VOCs, SVOCs, TPH, metals, and PCBs.

Currently, the extent of impacted groundwater to be addressed by the Outside Area remedial alternatives is represented by the extent of the indicator COCs identified in Technical Memorandum No. 1 (TCE, VC, and 1,4-dioxane). These indicator COCs are present in the Outside Area within the water table, shallow, and intermediate groundwater sample intervals at concentrations exceeding final SWFS cleanup levels. In the intermediate groundwater sample interval, VC is the major contaminant along a 400-foot section just downgradient of the barrier wall, along Denver Avenue South. VC concentrations in samples from this area are as high as 1,000 µg/L. VC and TCE were found in groundwater samples from the shallow interval over about 120 linear feet along the intersection of Denver Ave South and South Lucile Street, where concentrations for TCE ranged from 0.4 to 1.7 µg/L, and concentrations for VC ranged from 3.4 to 15 µg/L. Many chlorinated COCs in addition to the indicator COCs are present in samples from the water table groundwater interval just downgradient of the barrier wall, from the northwest corner of the barrier wall to the intersection of South Lucile Street and Airport Way South. These include 1,1,1-TCA, 1,1-DCA, 1,1-DCE, PCE, TCE, and VC. Concentrations for these constituents range from just above cleanup levels to 100 μg/L, depending on the location along this 800-foot corridor. In addition to these chlorinated VOCs, metals, SVOCs, and BTEX were detected in groundwater samples. The groundwater monitoring has shown that metals, SVOCs, and BTEX have not migrated as far downgradient as the chlorinated VOCs, and modeling of these other COCs has shown that these constituents will not migrate to the Duwamish Waterway. Migration of metals is related to the oxidation/reduction potential within the aquifer, with metals, particularly arsenic, iron, and manganese, migrating farther under reducing conditions. The organic COCs create stronger reducing conditions, which results in metals moving downgradient. As VOC concentrations are reduced, the reducing conditions should lessen and metals will be attenuated. Appendix D discusses the metals attenuation in more detail. This attenuation of metals is apparent in the area near Fourth Avenue South.

The remaining indicator COC, 1,4-dioxane, is of importance due to its high solubility and mobility and due to its persistence in the environment. While 1,4-dioxane would not be addressed by most commonly used remediation technologies, monitoring data indicate that it will be attenuated to concentrations below cleanup levels prior to reaching the Duwamish Waterway. Nevertheless, Ecology requested that alternatives be added to the Outside Area to address 1,4-dioxane.

For the COCs in groundwater, there are only three potential exposure pathways: (1) groundwater discharge to surface water, providing exposure to ecological receptors or to human receptors by ingestion of fish; (2) vapor migration to buildings (the inhalation pathway); and (3) short-term exposures of construction workers performing subsurface work, due to vapor migration from affected groundwater. The inhalation pathway currently is being addressed by the IPIMs, as described in Technical Memorandum No. 3.

As discussed in Technical Memorandum No. 2, groundwater remediation areas were defined for the Outside Area based on the nature and extent of groundwater COCs within the Outside Area (Figures 5-1 and 5-2). The water table groundwater interval was subdivided into three remediation areas, designated OWTRA-1 through OWTRA, as shown on Figure 5-1. The shallow and intermediate groundwater intervals were also subdivided intro three remediation areas, designated OSIRA-1 through OSIRA-3, as shown on Figure 5-2. The final Outside Area groundwater remediation area is the DARA.

The Outside Area (except for the DARA) was isolated from the contamination source areas when the HCIM barrier wall was completed in January 2004. The DARA is separated from the upper saturated zone by the Silt Aquitard. Construction of this barrier wall not only separated the source area from Shallow Aquifer groundwater within the Outside Area, it also substantially changed groundwater flow patterns; the area immediately downgradient from the barrier wall is still adapting to the changes made by the wall. Due to the size of the enclosed area (approximately 2 acres of surface with a barrier wall about 300 feet wide [parallel to the groundwater flow], 600 feet long [perpendicular to groundwater flow], and tied into the uppermost confining unit), the groundwater flow pattern in the Shallow Aquifer immediately downgradient from the barrier wall will likely be adjusting for several years, and the Intermediate Aquifer will probably be adjusting for much longer. Groundwater flow rates in the "shadow" of the barrier wall are expected to be much lower than flow rates outside the shadow of the wall, which are estimated to be approximately 20 feet per year in the intermediate groundwater interval and 190 feet per year in the water table and shallow intervals.

Although the barrier wall around the HCIM Area isolates the ongoing source for COCs in the Outside Area, there is a potential for flux of COCs through the barrier wall at very low concentrations. Therefore, the Outside Area remedial alternatives must address a continuous source of low-concentration COCs from the HCIM Area. This is consistent with mass flux calculations through the wall that will be described in the appropriate section (presently anticipated to be Section 3) of the revised draft SWFS report. This potential release of low concentrations of COCs through the barrier wall must be addressed when evaluating remedial alternatives for the Outside Area and when assessing attainment of cleanup levels.

As noted in Technical Memorandum No. 1, substantial data have been collected documenting that natural attenuation, including very active biodegradation, is occurring within the Outside Area. Appendix B of Technical Memorandum No. 1 describes the approach used to calculate the observed biodegradation rates. Attenuation has been documented for both chlorinated and nonchlorinated VOCs. Due to the history of the facility and the fairly high groundwater flow velocity (approximately 190 feet per year in the water table and shallow intervals), it is assumed that the impacted Outside Area groundwater plume beyond the "shadow" recently created by the barrier wall is under steady-state conditions, reflecting convective transport by groundwater migration, retardation by the saturated zone matrix, and degradation by natural processes. It has also been confirmed that off-site, non-PSC releases have occurred at locations outside the scope of the FS in the area west of Fourth Avenue South. It is expected that the same conditions contributing to natural attenuation of the impacted groundwater within the Outside Area will cause natural attenuation of releases from these other downgradient sources. The remediation strategies developed for the Outside Area should incorporate these natural attenuation processes to the extent practicable and should also be designed so that they do not interfere with natural attenuation for the downgradient source areas.

Fate and transport modeling was done to assess natural degradation and groundwater flow processes that are active in the Outside Area. Modeling was done using BIOCHLOR, a screening level model that incorporates biodegradation and retardation with advective transport of groundwater constituents. This model has been accepted by EPA for preliminary assessment of the fate and transport of chlorinated VOCs in groundwater. The current, measured groundwater gradients were used for this modeling. Aquifer parameters (hydraulic conductivity and porosity) were taken from the RI Report (PSC, 2003). Default parameters specified by Ecology in the MTCA regulations were used for the soil organic carbon fraction and the partitioning coefficients. Degradation rates used for modeling enhanced bioremediation were taken from published literature (Aronson, 1997, 1999; ATSDR, 1998, 1999, 2004a, 2004b; Wiedemeier et al., 1999). Initial concentrations used for these model runs were the measured maximum concentration in the areas located immediately downgradient from the barrier wall. Details concerning the modeling are presented in Appendix B of Technical Memorandum No. 1. The results from the modeling were used in designing and evaluating the Outside Area remedial alternatives, as discussed in this section.

5.1 OUTSIDE AREA REMEDIATION CONSIDERATIONS

Outside Area remedial alternatives presented in this SWFS have been developed from the remediation technologies described in Technical Memorandum No. 4 that were retained after the screening process and as discussed with Ecology. These alternatives have been designed to attain the remediation objectives described in Section 3 of Technical Memorandum No. 4 and Section 2 of this Memorandum. General considerations applicable to the Outside Area remedial alternatives, including establishment of remediation objections specific to the Outside Area, are discussed below.

5.1.1 Outside Area Remediation Objectives

As discussed in Technical Memorandum No. 1, the proposed CPOC for ultimate attainment of cleanup levels in groundwater for the water table, shallow, and intermediate depth intervals is immediately downgradient of the barrier wall (see Figure 5-3). The long-term remediation goal for the Outside Area remedial alternatives will be to attain groundwater cleanup levels at this CPOC. During remediation of the Outside Area, monitoring would be conducted along or immediately downgradient of the CPOC to assess attainment of remediation levels and cleanup levels. The remediation levels were established for select compounds as described in Technical Memorandum No. 1. These remediation levels allow for natural attenuation between the CPOC and the Duwamish Waterway. Groundwater monitoring data that have been collected in the vicinity of this CPOC indicate that existing concentrations of COCs are below remediation levels.

Remediation objectives specific to the Outside Area include the following:

- Attain remediation levels at the CPOC within a reasonable time. Attainment of remediation levels is a priority objective and is expected to be attainable within a shorter time frame than attainment of cleanup levels.
- Ultimately reduce COC concentrations within the Outside Area to achieve groundwater cleanup levels at and downgradient of the CPOC.
- Do not adversely affect existing land use within the Outside Area.

The remedial alternatives will be developed to also accomplish the following:

- Do not create nuisance conditions or conditions adverse to treating downgradient source areas.
- Be compatible with the existing interim measures (both the HCIM and the IPIMs).

5.1.2 Deep Aquifer Remediation Area Considerations

The nature and extent of affected groundwater in the DARA was discussed extensively in Technical Memorandum No. 1. Additional monitoring data have been collected within the DARA since completion of Revised Technical Memorandum No. 1 in June 2006 (Geomatrix, 2006a). Conclusions regarding the nature and extent of affected groundwater within the DARA, based on Technical Memorandum No. 1 and more recent data, are summarized below:

- Concentrations of chlorinated VOCs (except for VC in samples from Well CG-116-127) are below final SWFS cleanup levels for the Deep Aquifer and have been below cleanup levels since mid-2004.
- VC concentrations in samples from Well CG-116-127 are approximately twice the final SWFS cleanup level of 0.031 µg/L.

- Concentrations of TPH-D in samples from all DARA wells have been below final SWFS cleanup levels in monitoring results since early 2002.

- Concentrations of chrysene in the one DARA well in which it was detected have been below the final SWFS cleanup level since early 2005.

- Concentrations of BEHP exceeded final SWFS cleanup levels in samples from one well (CG-104-D). The most recent concentrations were about 14 times the cleanup level. The detected concentrations in the Deep Aquifer samples range from 0.74 to 45 µg/L, while detected concentrations in samples from the overlying saturated zone (water table, shallow, and intermediate depths) range from 0.06 to 27.7 µg/L. Monitoring data indicate that the highest concentrations of BEHP are present in the Deep Aquifer and that BEHP has been detected in the Deep Aquifer upgradient of the facility, suggesting that the observed concentrations are not likely related to facility releases.

- Detected concentrations of copper, hexavalent chromium, and vanadium decrease across the facility (i.e., upgradient concentrations are greater than downgradient concentrations), suggesting that these constituents are not related to facility releases. The cleanup levels for these COCs are based on protection of surface water (i.e., the surface water protection level is lower than the drinking water protection level).

- Silver is present in the DARA at a concentration approximately twice the final SWFS cleanup level, which is based on protection of surface water (i.e., the surface water protection level is lower than the drinking water protection level). Silver is not a COC in the water table at shallow and intermediate depth intervals.

- Selenium is a COC for the Deep Aquifer, but was not a COC for the shallow or intermediate depth intervals, indicating that this metal is likely not related to facility releases.

- Barium concentrations in the Deep Aquifer are greater than concentrations detected in the shallow and intermediate depth intervals, indicating that this DARA COC is likely not related to facility releases.

- Arsenic concentrations in the Deep Aquifer are higher downgradient of the facility than they are beneath the facility; however, the downgradient concentrations are similar to concentrations observed upgradient of the facility. As the presence of arsenic is strongly influenced by local oxidation/reduction conditions, it is unclear if the observed downgradient concentrations are attributable to facility releases. The cleanup level for arsenic is based on protection of surface water (i.e., the surface water protection level is lower than the drinking water protection level).

- Iron and manganese concentrations increase in concentration across the facility. Concentrations of these metals, which are present in the aquifer matrix, are strongly influenced by local oxidation/reduction conditions. It is unclear if the observed concentrations are related to facility releases. Cleanup levels for these metals are based on protection of surface water (i.e., the surface water protection level is lower than the drinking water protection level),

Based on these considerations, remedial action is not warranted for the DARA. Constituents that may be attributed to facility releases are either very near or below final SWFS cleanup levels in the Deep Aquifer. Many of the metals are present both upgradient and downgradient of the facility at concentrations greater than the final SWFS cleanup levels. Concentrations for many other constituents are higher in the Deep Aquifer than in the Shallow Aquifer. Final SWFS cleanup levels for metals in the DARA are based on protection of surface water rather than drinking water; therefore, groundwater within the DARA has a long flowpath from the facility prior to potential receptor exposure. The soluble concentrations for many of the metals depend on the oxidation/reduction conditions in the Deep Aquifer. Due to the very low concentrations of facility COCs in the DARA, it is unlikely that the COCs have significantly altered the oxidation/reduction conditions in the aquifer. Since there is substantial travel time between the facility and the Duwamish Waterway, it is expected that elevated constituent concentrations in the DARA will naturally be attenuated as oxidation/reduction conditions change within the aquifer; this natural alteration in chemical form is expected to degrade the soluble form into less mobile and hence less toxic forms. For this reason natural attenuation is assumed to be the preferred remedy for the DARA and no further discussion of the DARA will be included in the remedial alternatives developed for the Outside Area.

5.1.3 Inhalation Pathway Interim Measure

As described in Technical Memorandum No. 3, PSC has implemented an IPIM to address potential inhalation risks related to volatile COCs present in soil and groundwater within the Outside Area. The vapor intrusion assessment and mitigation (VIAM) approach described in Technical Memorandum No. 3 is a comprehensive program to identify potential risks related to volatile COCs within the Outside Area and to ensure that the risks are mitigated appropriately. The VIAM approach was developed for incorporation into the final corrective action plan for the facility. Therefore, each of the alternatives addressed in this SWFS incorporates the IPIM, which is based on the VIAM approach described in Technical Memorandum No. 3.

5.2 Outside Area Remedial Alternatives

Current groundwater monitoring data indicate that cleanup levels protective of the vapor pathway are being exceeded in the water table interval within the Outside Area. Although not specifically included in the descriptions of Outside Area remedial alternatives in this section, the VIAM approach discussed in Technical Memorandum No. 3 is incorporated into each remedial alternative under consideration for the Outside Area to mitigate potential impacts associated with the vapor intrusion pathway. The remedial alternatives developed for the Outside Area combine the VIAM approach with one or more of the retained remediation technologies from Technical memorandum No. 4 to achieve remediation objectives.

The following remedial alternatives have been developed for the Outside Area:

- Alternative OA-1: Monitored Natural Attenuation. This alternative relies upon natural biodegradation of COCs and the existing IPIM to mitigate site risks.
- Alternative OA-2: Enhanced Bioremediation, PCB Excavation, SVE, and Surface Cover. This alternative would accelerate natural biodegradation, remediate PCB-affected soil hot spots, place a low permeability cover over affected soil, and incorporate the existing IPIM.
- Alternative OA-3: Enhanced Bioremediation, Hot Spot Excavation, SVE, and Surface Cover. This alternative would excavate hotspots for other COCs in addition to PCB hotspots, and would incorporate the existing IPIM.
- Alternative OA-4: Enhanced Bioremediation, Hydraulic Control, Hot Spot Excavation, SVE, and Surface Cover. This alternative would add hydraulic control of the downgradient groundwater affected by 1,4-dioxane to the actions included in Alternative OA-3, including the existing IPIM.
- Alternative OA-5: Enhanced Bioremediation, Groundwater Recovery and Treatment, Hot Spot Excavation, SVE, and Surface Cover. This alternative adds pump and treat for mass removal of 1,4-dioxane to Alternative OA-4, including the existing IPIM.

Preliminary, conceptual designs have been prepared for the Outside Area remedial alternatives to complete this SWFS. In order to complete the conceptual designs, assumptions have been made as needed based on professional judgment and the limited data available from the RI Report and subsequent investigations. The conceptual designs for the Outside Area remedial alternatives are described in the following subsections. The estimated costs span the estimated project life for each of the alternatives; the project life used for cost estimates are based on the estimated restoration time for each alternative and include monitoring to confirm attainment of cleanup levels.

The groundwater monitoring program described for each Outside Area alternative would be incorporated into all HCIM Area remedial alternatives. The groundwater monitoring program for the Preferred Outside Area alternative would be incorporated into the Site Wide preferred Alternative. As such, the groundwater monitoring costs, which are common to all HCIM Area alternatives, have been included in the costs for the Outside Area alternatives, since the monitoring costs would accrue over the project life for the Outside Area alternatives, which would be maintained for a longer time than the HCIM Area alternatives.

Details for the estimated costs are presented in Appendix A. Detailed descriptions of the alternatives are presented in the following subsections.

5.2.1 Alternative OA-1: Monitored Natural Attenuation

Alternative OA-1 relies primarily on monitored natural attenuation and existing surface cover to address site constituents and potential exposure pathways in the Outside Area. This alternative represents a reference point to assess potential benefits that may result from implementation of the other alternatives included in this SWFS. Under this alternative, MNA would be used to reduce constituent concentrations in impacted groundwater in all Outside Area groundwater remediation areas, including OWTRA-1 through OWTRA-3 and OSIRA-1 through OSIRA-3. Evidence has shown that natural attenuation is capable of degrading TCE and its daughter products within the Outside Area groundwater plume. Other organic COCs, including chloroethanes, petroleum hydrocarbons, aromatics, and PAHs, are known to degrade naturally under appropriate conditions. Metals can also be attenuated through transformation reactions, as discussed in Appendix D.

Available groundwater monitoring data indicate that groundwater COCs originating at or near the facility are currently being attenuated to achieve groundwater cleanup levels prior to reaching the Duwamish Waterway. Completion of the HCIM, which occurred in early 2004, has isolated the former source area from the Outside Area, thereby substantially reducing the release of COCs to the Outside Area. Due to this containment of the source of COCs, it is expected that the concentrations of COCs within the Outside Area groundwater will continue to decline as the result of ongoing natural attenuation processes. Recent groundwater monitoring data from quarterly monitoring events conducted during 2005 and 2006 have shown a dramatic decrease in VOC concentrations immediately downgradient of the barrier wall in most wells. The 2006 HCIM Annual Performance Monitoring Report (Geomatrix, 2007b) indicates that groundwater quality throughout the SWFS area is rapidly improving as a result of the implementation of the HCIM. Declining trends in concentrations of COCs are strongest nearest the PSC facility, but declining VOC trends can be seen as far downgradient as Fourth Avenue South. Additionally, recent groundwater monitoring data indicate that natural attenuation in the area immediately downgradient from the barrier wall is currently attaining the remediation levels defined in Technical Memorandum No. 1 for many site COCs.

MNA is a proven technology that has been effective in reducing concentrations of chlorinated solvents and other COCs in groundwater when appropriate conditions are present. This process relies on the attenuation of groundwater constituents by natural processes, including biodegradation, abiotic degradation, adsorption, and dispersion. Due to the passive nature of this remediation technology, it can be readily implemented with a minimum of institutional issues, such as permitting or arranging for access permissions, and also would have minimal potential for implementation problems, such as fouling. Since MNA is generally noninvasive, it can be readily implemented within the urban environment above the impacted groundwater. Biodegradation of chlorinated solvents and nonchlorinated organics present in the Outside Area is active; biodegradation of the chlorinated solvents accounts for the presence of the cis-1,2-DCE and the VC observed in Outside Area groundwater. Natural attenuation also accounts for the limited extent of groundwater affected by nonchlorinated organics; most of these nonchlorinated organics are fully degraded upgradient of Denver Avenue South, based on observed groundwater monitoring data and preliminary fate and transport modeling. Available monitoring data also indicate that 1,4-dioxane is attenuated to cleanup levels prior to discharge to the Duwamish Waterway, although concentrations within the shallow and intermediate depth intervals exceed the cleanup level near the downgradient extent of the SWFS Area. Based on available site characterization data, MNA generally achieves remediation objectives and, coupled with the other components included in the alternative, addresses the primary exposure pathways for groundwater within the Outside Area. It is anticipated that the affected plume within the Outside Area would fully attain cleanup levels under this alternative, assuming that conditions continue as they are at present and allowing sufficient restoration time; it is estimated that the Outside Area groundwater would be restored to cleanup levels within about 26 years (Figure 5-4).

Alternative OA-1 would rely on surface cover and institutional controls to address impacted soil. OSRA-3, located on the SAD property, includes a 15-foot wide strip of PSC property that is located between the barrier wall and the SAD property line (Figure 2-1). OSRA-2 includes the portion of the PSC facility located between the HCIM barrier wall and South Lucile Street. Alternative OA-1 incorporates the current concrete and asphalt surface cover on the PSC facility and pavement on the SAD property to prevent contact with impacted soil and prevent surface water infiltration in OSRA-2 and OSRA-3. Risks associated with affected soil within OSRA-1, which is located adjacent to the facility on UPRR property, would be addressed by institutional controls. The existing VIAM program (which is a component of Alternative OA-1) would address the remaining exposure pathway for the Outside Area.

Alternative OA-1 is a permanent remedial alternative for groundwater that would gradually decrease the mass of COCs present in the Outside Area. Biodegradation would permanently destroy both chlorinated and nonchlorinated VOCs and most SVOCs. Metals would be converted to less mobile and less toxic forms after natural groundwater conditions return to the area. As part of the fate and transport evaluation completed for this SWFS, the VOC mass flux though the barrier wall was estimated (Appendix B of Technical Memorandum No. 1). It was conservatively estimated that approximately 0.03 lb/day of total site COCs could flow through the barrier wall even under nonpumping conditions (i.e., under nonpumping conditions there would be no inward gradient). Based on modeling results, this flux would not adversely affect attainment of remediation objectives under Alternative OA-1; MNA would be predicted to ultimately attain cleanup levels at the CPOC, based on the predicted mass flux calculated assuming no pumping within the HCIM Area.

Fate and transport modeling of chlorinated VOCs (the most widespread of the COCs) has been completed for Alternative OA-1; the modeling results are detailed in Appendix B of Technical Memorandum No. 1. This modeling was performed using a range of biodegradation rates for the chlorinated VOCs. Using the biodegradation rates that were calculated from a mass flux approach and calibrating the model to the actual monitoring data, the fate and transport modeling indicates that the cleanup levels would be met for chlorinated VOCs at and downgradient from Fourth Avenue South under existing conditions; therefore, under this alternative, chlorinated VOC releases from the facility would not affect the downgradient sources located west of Fourth Avenue South. Monitoring data for chlorinated ethanes and nonchlorinated organic COCs (other than 1,4-dioxane) indicate that natural attenuation is effectively limiting the migration of those constituents.

As the COC mass within the Outside Area decreases, it is expected that the affected groundwater plume within the Outside Area would contract, ultimately attaining groundwater cleanup levels at and downgradient of the CPOC. Based on the conservative modeling evaluation, it is estimated that MNA would attain groundwater cleanup levels at the CPOC (immediately downgradient of the barrier wall) within approximately 26 years. As discussed in Technical Memorandum No. 1, the water table interval has the highest COC concentrations and would take the longest to reach cleanup levels. The modeling results predicted that TCE would be attenuated to below cleanup levels in the Outside Area water table interval within approximately 26 years, while PCE and vinyl chloride would be predicted to decrease to final SWFS cleanup levels within 12 and 9 years, respectively. Concentrations of vinyl chloride and other VOCs in OSRA-3 were rising in 2005 after the wall installation, suggesting that source material was present outside the HCIM Area. However, in 2006, these VOC concentrations started to decrease, suggesting that the amount of source material may have been limited. The modeling was also used to define remediation levels that would need to be attained at the CPOC to ensure that groundwater attains cleanup levels protective of surface water at the Duwamish Waterway. These remediation levels are currently being met at the CPOC for the indicator COCs, and modeling indicates that these remediation levels would be met in the future under Alternative OA-1. For cost estimation purposes, it was assumed that groundwater monitoring would be conducted for 5 years following attainment of final SWFS cleanup levels at the CPOC, for a total project life of 31 years. The projected schedule for Outside Area remediation alternatives is shown on Figure 5-4.

The vapor intrusion mitigation systems currently in place under the VIAM program would be maintained as part of this remedial alternative to ensure that the inhalation pathway is adequately addressed until such time as the groundwater cleanup levels for that pathway are ultimately met throughout the SWFS Area. After it has been confirmed that groundwater concentrations within the water table interval have decreased below cleanup levels based on the inhalation pathway, the VIAM program would be discontinued. For cost estimation purposes, it was assumed that the VIAM program would be maintained for 3 years after attainment of final SWFS cleanup levels at the CPOC; 2 years of groundwater monitoring were assumed to be conducted after discontinuing the VIAM.

Recent groundwater data from 2005 and 2006 quarterly monitoring events indicate that concentrations of VOCs in the monitoring wells immediately downgradient of the barrier wall have fallen significantly since the barrier wall was installed. Several of the wells have seen an order of magnitude drop in VOC concentrations over the last year. These data support the MNA evaluations performed to date and the fate and transport modeling projections of cleanup time frames. However, further monitoring is required to confirm the modeling results and the effectiveness of natural attenuation within the Outside Area.

A monitoring well network is an integral part of MNA. For the Outside Area alternatives, the groundwater monitoring program has been designed to include performance monitoring for the HCIM Area, compliance monitoring at the CPOC, and downgradient monitoring for the Outside Area groundwater remediation areas. The same performance and CPOC monitoring program has been included in each of the Outside Area alternatives since they are common to all remedial alternatives. The groundwater monitoring programs designed for the Outside Area alternatives are summarized on Table 5-1 The three general programs included in the table are as follows:

- HCIM Performance Monitoring: this monitoring element includes monitoring of wells located both inside and outside the barrier wall to assess the effectiveness of the barrier wall in providing containment for the HCIM Area.
- CPOC Monitoring: this monitoring element addresses monitoring of CPOC wells to assess attainment of the cleanup standard for each alternative at the CPOC.
- Outside Area Remediation Monitoring: this program element is specific to the Outside Area remediation alternatives, and includes performance monitoring of wells located downgradient of the CPOC (between the CPOC and Fourth Avenue South) as appropriate for each specific remedial alternative to monitor cleanup of the plume.

When combined, these three elements would provide a comprehensive monitoring program. A minimum of 37 monitoring wells would be included in the monitoring program for each alternative.

For Alternative OA-1, a monitoring well network would be established within the Outside Area, as shown on Figures 5-3 and 5-5. The conceptual design for the monitoring program is outlined in Table 5-1. Monitoring for Alternative OA-1 would include the proposed CPOC wells located immediately downgradient of the HCIM barrier wall and wells located in the HCIM Area (Figure 5-3) and in monitoring wells located downgradient from the CPOC and upgradient from Fourth Avenue South (Figure 5-5). As outlined above, the proposed remediation levels are currently being met at the CPOC. The monitoring well network for this alternative incorporates a total of 37 wells covering the area from the facility to Fourth Avenue South. One CPOC monitoring well would be used to monitor downgradient groundwater quality in the Deep Aquifer. The CPOC wells would be monitored to verify that these remediation levels continue to be attained at the CPOC and that cleanup levels are eventually attained. The Outside Area remediation monitoring wells would monitor concentrations of COCs in the area downgradient from Denver Avenue South to ensure the downward trend continues and that cleanup levels are ultimately achieved. Following sufficient degradation of COCs within the Outside Area to attain cleanup levels at the CPOC, the CPOC and HCIM performance monitoring wells would be over the long term to confirm effective containment of the HCIM Area. The monitoring wells include wells for the water table, shallow, and intermediate depth intervals.

Wells downgradient from the CPOC would be monitored to assess groundwater quality between the CPOC and Fourth Avenue until cleanup levels were attained at the CPOC and in the area downgradient of the CPOC. For cost estimating purposes, it has been assumed that quarterly monitoring of 11 CPOC wells (located at or near the CPOC) and the 12 HCIM performance monitoring wells would be conducted for 5 years, followed by annual sampling for the next 26 years, which is consistent with the estimated project restoration time of 26 years. These wells would be monitored for water levels and water quality parameters, including COCs appropriate for the well depth interval. The 14 downgradient wells were assumed to be monitored semiannually for 10 years followed by annual sampling for the next 21 years. After 31 years (i.e., after 5 years of monitoring has verified attainment of cleanup levels), Outside Area remediation monitoring would be discontinued and both the HCIM performance monitoring and CPOC would be conducted biannually (i.e., once every two years). Groundwater samples would be analyzed for VOCs, SVOCs, 1,4-dioxane, metals, and MNA parameters (alkalinity, ethane, and ethene).

Institutional controls are a key component of most remedies relying on in situ remediation approaches to ensure that human health and the environment are adequately protected during the restoration time. For off-site groundwater plumes in urban areas, institutional controls are not readily implementable and enforceable. In the case of Alternative OA-1 for the period prior to attainment of cleanup levels at the CPOC, some form of institutional or administrative controls would be appropriate. These would include the following:

- Limit withdrawal and use of groundwater within and downgradient from the project area. Currently the City of Seattle has a bylaw preventing the withdrawal of groundwater for use as a drinking water source, and this will serve as the administrative control for groundwater use.

- Where groundwater levels exceed cleanup levels for direct exposure, appropriate personal protective equipment and exposure monitoring for subsurface work conducted in and downgradient from the project area would be necessary to protect workers. This type of control cannot be readily implemented within the Outside Area and would need to be addressed through community awareness and notifications to the City of Seattle. During preliminary discussions, City staff indicated that they cannot enforce such requirements, but that they can put notices in permits and on their permitting documents to provide notification of the contamination issues.

- Maintain the vapor intrusion mitigation systems until monitoring data indicate groundwater is below cleanup levels based on the inhalation pathways (as described in Technical Memorandum 3). The maintenance of vapor intrusion mitigation systems would be a requirement of the facility permit and, therefore, would not be considered an institutional control. In addition, the City would be notified that new buildings in the area where groundwater concentrations exceed the inhalation pathway cleanup levels should be constructed with appropriate vapor barriers.

- Require inspection and maintenance of the current surface cover on the portion of the facility located in the Outside Area and of the pavement on the SAD property. Any construction or development would also be required to maintain the continuity and effectiveness of the surface cover and SAD pavement.

- Require use of appropriate personal protective equipment and compliance with the HAZWOPER requirements specified in 29 CFR 1910.120 for all subsurface work conducted within OSRA-1 through OSRA-3. Since these areas are owned by industrial entities, it is expected that appropriate institutional controls could be negotiated and established with the owners (UPRR and SAD).

- Work with the Seattle Department of Public Health to develop appropriate health advisories or other documentation to disseminate information regarding potential risks associated with the affected groundwater plume.

- Conduct public meetings at appropriate time intervals to provide information regarding potential risks and appropriate measures to mitigate risks to the general public.

The advantages of implementing Alternative OA-1 are:

- OA-1 is readily implementable with a minimum of institutional issues, such as permitting or arranging for access permissions, and minimal implementation problems.

- This alternative would result in destruction of VOCs and reduction in COC mass.

- This alternative would attain cleanup levels at the CPOC.

- Implementation of this alternative would have minimal impacts on the surrounding urban environment.

The disadvantages of Alternative OA-1 are:

- The alternative relies heavily on the success of the HCIM containment system to protect downgradient receptors for a long period of time.
- This alternative relies on the existing IPIM and administrative controls to mitigate off-site risks until cleanup levels are met.
- This alternative requires a relatively long total project lifetime.

5.2.2 Alternative OA-2: Enhanced Bioremediation, PCB Excavation, and SVE

This alternative incorporates active remedial action for both soil and groundwater within the Outside Area (Figure 5-6). Soils within OSRA-1 that have been affected with PCBs would be excavated for off-site disposal. Vadose zone soils within OSRA-3 that have been affected by VOCs would be remediated using SVE. Enhanced anaerobic bioremediation would be implemented to remediate groundwater in the area between the SAD property and the facility. Surface cover would also be placed over a small area within OSRA-2.

The remediation components for OSRA-1 and OSRA-3 are based on soil sampling conducted in off-site areas, as presented in the Off-Site Soil Characterization Report (Geomatrix, 2006d). Additional soil characterization is planned, and PSC recently received approval from Ecology for the March 2007 Revised Additional Off-site Characterization Work Plan (Geomatrix, 2007c), which presents the approach that will be used to further characterize soil and groundwater within the Argo Yard. The subsurface investigation is currently scheduled to be completed in Spring 2007. In general, the highest concentrations of COCs in OSRA-1 soil are present on a parcel of land leased by PSC from UPPR where empty drums were historically stored. This area is impacted with a combination of VOCs, PCBs, SVOCs, and metals at concentrations above cleanup levels. Excavation and off-site disposal would be implemented in one area within the UPRR rail yard, as shown in Figure 5-6, to remove PCB-affected soil. The excavation would be completed to a depth of approximately 5 to 8 feet bgs. It is anticipated that approximately 1,300 bank cubic yards of soil would be removed for off-site disposal. For the purposes of estimating the disposal costs for this SWFS, it was assumed that the excavated soil would be transported to Columbia Ridge Landfill in Arlington, Oregon (a TSCA/RCRA Subtitle C landfill) for disposal.

Constraints within OSRA-1, including the HCIM barrier wall, active rail lines, subsurface utilities, and existing buildings, would prevent the removal of all vadose zone soil impacted by releases from the PSC facility. UPRR prohibits excavation within 12 feet of the centerline of an active railroad track and may require shoring for excavations outside this area. Therefore excavation and soil removal within OSRA-1 is limited to areas at least 12 feet from the centerline of an active track, as shown on Figure 5-6. The structural integrity of the HCIM barrier wall and buildings would be protected by maintaining a minimum 5-foot buffer around the barrier wall. In addition, excavation sidewall slopes of 1.5:1 (horizontal to vertical) would be maintained away from the barrier wall and buildings to minimize the potential to adversely affect existing structures.

Confirmation soil samples would be collected from the sidewalls of the excavation at a frequency of one per 50 linear feet of excavation sidewall. Confirmation samples would be collected from the floor of the excavation at a frequency of one per 400 square feet. A minimum of one confirmation sample would be collected from each excavation sidewall and floor. Confirmation samples would be submitted for laboratory analysis of VOCs, SVOCs, PCBs, and metals. Following completion of soil removal efforts, the excavation would be backfilled with clean fill and compacted.

Following excavation and backfill, protective cover would be placed over affected soil within OSRA-1. A portion of OSRA-2 would also be covered (Figure 5-6). The protective cover would be constructed of asphalt and designed to support heavy traffic typical of the UPRR yard. The purpose of the cover would be to minimize the potential for direct contact with affected soil, limit erosion of affected soil, and to promote runoff. The cover would not be intended to provide the functions of a landfill cap and would not be designed or constructed as a landfill cap.

Alternative OA-2 includes SVE to address vadose zone soils within OSRA-3. The SVE system would be installed in the accessible area between the HCIM barrier wall and the SAD building, as described in Fifty-Percent Design Report for Soil Vapor Extraction/Enhanced Anaerobic Bioremediation (50% Design) report (Geomatrix, 2006e). The design presented in the 50% Design report would be incorporated into Alternative OA-2. A conceptual layout for the SVE system wells is shown on Figure 5-6. Emissions would be controlled using a catalytic oxidizer and scrubber or alternatively with carbon. The SVE system would be operated until VOC recovery reaches asymptotic levels. Confirmation samples would be collected from soil borings completed in the vadose zone to assess attainment of cleanup levels. For cost estimation purposes, it was assumed that the SVE system would be operated for about 1 year.

The final remediation component of Alternative OA-2 is enhanced anaerobic bioremediation of shallow and water table groundwater within OWTRA-1 and the upper portion of OSIRA-1. As shown in the project schedule (Figure 5-4), enhanced bioremediation would be conducted after completing SVE. For this alternative, the enhanced bioremediation design presented in the 50% Design would be implemented. The design is based on recirculation wells to distribute electron donor to the affected groundwater, using a single pumping/injection assembly that would be moved to each recirculation well. As noted in the 50% Design, a pump test would be performed to confirm well spacing. For cost estimation purposes, it was assumed that the electron donor would be emulsified vegetable oil and that three injection events would be required to attain cleanup levels at the CPOC. The enhanced bioremediation system would address the most highly affected groundwater within the Outside Area and support timely attainment of remediation levels and cleanup levels at the CPOC. The enhanced bioremediation layout is shown on Figure 5-6. It has been conservatively assumed that enhanced bioremediation would reduce the restoration time for attainment of final SWFS cleanup levels at the CPOC by about 50% from the time required under MNA (Alternative OA-1). Thus, the projected remediation time for this alternative is 13 years after commencing bioremediation, or about 15 years after implementation of this alternative.

The monitoring program for this alternative is summarized on Table 5-1. HCIM performance monitoring and CPOC monitoring would be the same as described above for Alternative OA-1. The Outside Area remediation monitoring program for this alternative would be similar to the program for Alternative OA-1, but would be completed in a shorter dime due to more rapid groundwater restoration. As shown on the implementation schedule, it is projected that remediation monitoring would be conducted for about 20 years. The monitoring period includes monitoring for 5 years after the projected restoration time of 13 years. The assumed monitoring frequency was semiannual sampling for 5 years and biannual sampling for the following 13 years.

Administrative controls would be incorporated into the alternative to ensure that human health and the environment are adequately protected by Alternative OA-2. These administrative controls would be the same as described for Alternative OA-1 in Section 5.2.1.

The advantages of Alternative OA-2 are:

- The alternative would employ proven technologies for chlorinated VOCs and PCB removal.

- The alternative would enhance the existing anaerobic conditions as opposed to risking disruption of this system.
- This alternative would use an aggressive technology, SVE, to address VOC contamination in vadose zone soils.
- This alternative would result in COC destruction and a reduction in COC mass.
- The alternative would result in meeting cleanup levels in a relatively short time frame.

The disadvantages of OA-2 are:

- The implementation of an SVE system would require a period of 1 year, during which time the property could not be developed.
- This alternative relies on the existing IPIM and administrative controls to mitigate off-site risks.

5.2.3 Alternative OA-3: Enhanced Bioremediation, Hot Spot Excavation, and SVE

Alternative OA-3 incorporates all of the elements described above for Alternative OA-2, and adds excavation of additional areas within the adjacent UPRR rail yard (OSRA-1) that may contain elevated concentrations of COCs other than PCBs (Figure 5-8). The nature and extent of additional excavation are not known at this time; therefore, the volume of additional soil requiring excavation can only be assumed. The projected restoration time for this alternative is approximately 20 years, based on the assumptions presented previously for Alternative OA-2 (see Figure 5-4).

As noted in Section 5.2.2, additional investigations are planned for the Argo Yard (Geomatrix, 2007c). The locations and limits of the additional hot spot excavations cannot be determined until the results of the additional subsurface investigation activities proposed for the OSRA-1 have been received and evaluated. For cost estimating purposes, it was assumed that an additional 5,000 bank cubic yards of soil would be excavated along the PSC facility northeastern and northwestern property boundaries (adjacent to the facility's North Field) for removal of hot spot soil. Since characterization of the Argo Yard has not been completed, the precise location for the hot-spot soil excavation cannot be shown, but the extent of soil removal assumed for cost estimating is shown in Figure 5-7. To estimate disposal costs for this alternative, it was assumed that 50% of the excavated soil would be disposed of as dangerous waste and that 50% would be nondangerous. It was also assumed that the excavated soil would be transported to the Columbia Ridge Landfill in Arlington, Oregon, for treatment and/or disposal.

Confirmation soil samples would be collected from the sidewalls of the excavation at a frequency of one per 50 linear feet of excavation sidewall. Confirmation samples would be collected from the floor of each excavation at a frequency of one per 400 square feet. A minimum of one confirmation sample would be collected from each excavation sidewall and floor. Confirmation samples would be submitted for laboratory analysis of VOCs, SVOCs, PCBs, and metals. Following completion of soil removal efforts, the excavation would be backfilled with clean fill and compacted.

The other remediation components (i.e., enhanced bioremediation, SVE, PCB excavation, and surface cover) included in this alternative are the same as described for Alternative OA-2 in Section 5.2.2. The conceptual design for these components is the same as for Alternative OA-2. The remediation components for Alternative OA-3 are shown on Figure 5-7 and the monitoring well network is shown on Figure 5-5. As shown on Figure 5-4, the implementation schedule projects attainment of final SWFS cleanup levels at the CPOC after about 15 years, and final restoration after about 20 years.

The groundwater monitoring programmed assumed for this alternative is summarized on Table 5-1. The HCIM performance and CPOC monitoring programs are the same as described for Alternative OA-1. The remediation monitoring program for this alternative is the same as described for Alternative OA-2.

Administrative controls would be incorporated into the alternative to ensure that human health and the environment are adequately protected by Alternative OA-3. These administrative controls would be the same as described for Alternative OA-1 in Section 5.2.1.

The advantages of OA-3 are:

- The alternative would employ proven technologies for removal of chlorinated VOCs and PCB.
- The alternative would enhance the existing anaerobic conditions as opposed to risking disruption of this system.
- This alternative would use an aggressive technology, SVE, to address VOC contamination in vadose zone soils.
- This alternative would result in COC destruction and a reduction in COC mass.

- This alternative would address elevated concentrations of COCs other than PCBs in OSRA-1.

- The alternative would result in meeting CULs in a relatively short time frame.

The disadvantages of OA-3 are:

- Implementation of an SVE system would require a period of 1 year, during which time the property could not be developed.

- This alternative would rely on the existing IPIM and administrative controls to mitigate off-site risks.

5.2.4 Alternative OA-4: Enhanced Bioremediation, Hydraulic Control, Hot Spot Excavation, and SVE

Alternative OA-4 combines all of the elements of Alternative OA-3 with a groundwater recovery and treatment system designed to intercept groundwater containing 1,4-dioxane within OSIRA-3 and to prevent further downgradient migration. Detected concentrations of 1,4-dioxane between the CPOC and Denver Avenue South are currently below cleanup levels, indicating that no recent releases of 1,4-dioxane have occurred. However, monitoring data collected from the shallow and intermediate depth intervals downgradient of the facility between Denver Avenue South and Fourth Avenue South indicate that 1,4-dioxane is present at concentrations exceeding the SWFS cleanup level. The monitoring data indicate that the 1,4-dioxane plume exceeding the cleanup level extends to Fourth Avenue South for both depth intervals. Therefore, the hydraulic control wells would be located along Fourth Avenue South (Figure 5-8). The projected implementation schedule for this alternative is shown on Figure 5-3.

Groundwater monitoring data indicate that the width of the shallow groundwater exceeding the SWFS cleanup level at Fourth Avenue South is about 1,000 feet. The width of the plume exceeding the cleanup level in the intermediate depth interval at Fourth Avenue South is about 200 feet. A preliminary analysis of hydraulic containment and capture of 1,4-dioxane-impacted groundwater was conducted using MODFLOW. Modeled hydraulic gradients, hydraulic conductivities, aquifer thickness, and porosity were the same as used in the BIOCHLOR modeling presented in Appendix B. The width of the capture zone for the shallow and intermediate depth intervals was estimated as 70 and 100 feet, respectively. Based on the MODFLOW evaluation, a single well pumping at 10 gpm would have a capture zone width of approximately 70 feet in the shallow interval and 100 feet in the intermediate depth interval. The capture zone widths were used to develop the hydraulic control groundwater recovery system layout shown in Figure 5-8. Based on these estimated single-well capture zones, the conceptual design for the hydraulic control groundwater recovery system includes installation of seven groundwater extraction wells in the shallow interval and one well in the intermediate interval. These wells would be expected to intercept groundwater exceeding the final SWFS cleanup level. These wells would be installed at the downgradient edge of the SWFS Area, along Fourth Avenue South, to prevent the migration of 1,4-dioxane to the Duwamish Waterway.

The locations of the extraction wells are shown on Figure 5-8. The 1,4-dioxane isoconcentration contours shown on Figure 5-8 are based on monitoring data from November 2004; this data set provides a more complete distribution than more recent monitoring data. It was estimated that the radius of influence would be established at a flow rate of 10 gpm from each well (total average flow rate of 80 gpm). For the conceptual design, it was assumed that the extraction wells would be constructed with 6-inch inside diameter, Schedule 80 PVC blank casing and stainless steel wire wrap (0.03-inch slot) well screen (15-foot screen length). The seven shallow wells would be installed to a depth of approximately 40 feet bgs, and the intermediate depth well would be installed to a depth of 80 feet bgs. Dedicated, submersible, groundwater extraction pumps would be installed in the extraction wells. Based on a preliminary assessment of the rate of migration for 1,4-dioxane, it is estimated that the hydraulic control system would be operated for a period of 10 years in order to intercept the 1,4-dioxane plume exceeding the SWFS cleanup level.

The projected implementation schedule for this alternative is included on Figure 5-3. While this alternative would recover 1,4-dioxane, the time required to attain cleanup levels and to complete site restoration would be the same as for Alternatives OA-2 and -3, as overall restoration would depend primarily on biodegradation of groundwater constituents between the facility and 4th Avenue South. The estimated time to complete restoration under this alternative would be about 20 years.

Based on the predicted average flow rate required for hydraulic control (80 gpm), it has been assumed that the groundwater treatment system would be sized to treat a flow rate of 120 gpm. The public sewer does not have sufficient capacity to accommodate this flow rate, and extracted groundwater could not be discharged to the King County Metro sewers. Thus, it would be necessary to obtain a NDPES discharge permit for direct discharge to the Duwamish Waterway. Since the discharge rate would adversely affect the capacity of the storm sewers, it has been assumed that it would be necessary to construct a new discharge line and diffuser to the

Duwamish Waterway. Constituents identified in the groundwater that exceed cleanup levels (based on protection of surface water) include 1,4-dioxane, VC, BEHP, iron, and manganese. It has been assumed that it would be necessary to treat the groundwater to attain the SWFS cleanup levels prior to discharge to the Duwamish Waterway. Based on the isoconcentration contours shown on Figure 5-8, it is estimated that the hydraulic control wells would recover approximately 23 lb of 1,4-dioxane over 10 years of operation, for an average recovery rate of 0.23 lb/yr.

Of the contaminants present in groundwater recovered for hydraulic control, 1,4-dioxane is the most difficult to treat. Several treatment technologies are available for ex situ treatment of 1,4-dioxane, including photocatalytic oxidation systems and advanced oxidation processes that involve UV/Ox or O_3/Ox. Initial capital costs for a UV/Ox system would be significantly less than O_3/Ox and photocatalytic oxidation systems. However, operating costs for a UV/OX system are approximately double those of the other available systems due to the significant power requirements of the UV system. For cost estimating purposes, it is assumed that an O_3/Ox system would be used to destroy 1,4-dioxane within the extracted groundwater. The O_3/Ox unit would also remove VC and BEHP. Metals (iron and manganese) would be removed upstream of the O3/Ox unit to reduce oxidant demand; metals would be removed using an ion exchanger. Regenerant from the ion exchange system (spent brine containing iron and manganese) was assumed to be discharged to the King County POTW. As noted above, it was assumed that a NPDES permit would be needed to allow direct discharge to the Duwamish Waterway.

Due to the extensive treatment needed for recovered groundwater, and the time of operation, it would be necessary to construct a secure building to house the system. While it may be possible to purchase a parcel of land near the groundwater extraction wells for construction of the groundwater treatment system, it was assumed that it would be necessary to install the treatment system on the PSC facility, as this property is presently available. Conveyance piping to direct recovered groundwater to the treatment system would consist of 6-inch diameter HDPE piping installed below grade in public rights-of-way. Discharge from the treatment system would be directed to the Duwamish Waterway via an underground 6-inch HDPE line constructed beneath public rights-of-way. An automated, PLC-based control system would be used to control pumping wells and the treatment system. It has also been assumed that a new building approximately 1,500 ft^2 in area would be constructed for the treatment system.

This alternative incorporates all the elements described in Section 5.2.3 for Alternative OA-3, including enhanced bioremediation, soil vapor extraction, excavation of PCB soils and hot spots within OSRA-1, and placement of additional surface cover. These elements are shown on Figure 5-8. The estimate restoration time (Figure 5-3) for this alternative is about 18 years, which is the same as for Alternatives OA-2 and -3. The monitoring program for this alternative is summarized on Table 5-1. The number of wells, analytes, and sampling frequency, would be include the programs described above for Alternative OA-2. In addition to monitoring described for Alternative OA-2, monitoring of the hydraulic control system would include collection of samples from each recovery well (8 samples) during each groundwater monitoring event. Samples collected from the recovery wells would be analyzed only for 1,4-dioxane. Administrative controls would be incorporated into the alternative to ensure that human health and the environment are adequately protected by Alternative OA-4. These administrative controls would be the same as described for Alternative OA-1 in Section 5.2.1.

The advantages of OA-4 are:

- The alternative would employ proven technologies for chlorinated VOCs, PCBs, and 1,4-dioxane removal.
- This alternative would prevent groundwater containing 1,4-dioxane at concentrations above the SWFS CULs from reaching the Duwamish Waterway
- The alternative would enhance the existing anaerobic conditions as opposed to risking disruption of this system.
- This alternative would use an aggressive technology, SVE, to address VOC contamination in vadose zone soils.
- This alternative would result in COC destruction and a reduction in COC mass.
- This alternative would address elevated concentrations of COCs other than PCBs in OSRA-1.
- The alternative would result in meeting CULs in a relatively short time frame.

The disadvantages of OA-4 are:

- Implementation of an SVE system would require a period of 1 year, during which time the property could not be developed.
- This alternative would require an extensive pipeline system to convey water from the hydraulic control wells to a treatment system on PSC property and then back to the

Duwamish Waterway for discharge, resulting in a greater nuisance and a greater risk to surrounding landowners/users.

- This alternative would rely on the existing IPIM and administrative controls to mitigate off-site risks until cleanup levels are met.

5.2.5 Alternative OA-5: Enhanced Bioremediation, Groundwater Recovery and Treatment, Hot Spot Excavation, and SVE

Alternative OA-5 includes all of the elements described above for Alternative OA-4 and adds additional groundwater recovery and treatment to reduce the mass of 1,4-dioxane present within OSIRA-3. Groundwater within the area with the highest concentrations of 1,4-dioxane would be recovered under this alternative. As shown on Figure 5-9 the conceptual design for the additional groundwater recovery system includes the installation of two additional groundwater extraction wells within the shallow depth interval and one additional well in the intermediate depth interval, in addition to the wells described for Alternative OA-4 in Section 5.2.4. Based on the isoconcentration contours presented on Figure 5-9, the highest concentrations of 1,4-dioxane occur mostly to the east of 5th Avenue South in both the shallow and intermediate depth intervals. These isoconcentration contours are based on monitoring data from November 2004; this data set provides a more complete distribution than more recent monitoring data. The highest concentration contours for the intermediate depth interval are located north of the highest concentration contours for the shallow depth interval. Based on the estimated radius of influence of wells completed in the shallow and intermediate depth intervals, the mass removal wells would intercept the groundwater most highly impacted by 1,4-dioxane. The projected implementation schedule for this alternative is shown on Figure 5-4.

Similar MODFLOW analysis discussed for Alternative OA-4 in Section 5.2.4 was conducted to determine the capture zone widths used to develop the groundwater recovery system layout shown in Figure 5-9. Two shallow and one intermediate wells would be required to intercept the high concentration contour. As for Alternative OA-4, each shallow and intermediate extraction well would be pumped at approximately 10 gpm to capture and recover the highest 1,4-dioxane concentrations in each depth interval.

The extraction wells would be constructed with 6-inch inside diameter, Schedule 80 PVC blank casing and stainless steel wire wrap (0.03-inch slot) well screen. The intermediate well would be installed to a depth of approximately 80 feet bgs, with 15 feet of screen installed from the bottom of the boring. The shallow wells would be installed to a depth of about 40 feet bgs, with a 15-foot screen placed near the bottom of the boring. Dedicated, submersible, groundwater extraction pumps would be installed in the extraction wells. The extracted groundwater would be collected, treated, and discharged as described for Alternative OA-4. The capacity of the groundwater treatment system would be increased to 165 gpm, which would provide 50% greater capacity than expected pumping volumes; the treatment process would be the same as described for Alternative OA-4. The pump testing described for Alternative OA-4 would be included in this alternative to ensure the design adequately intercepts and recovers groundwater affected by 1,4-dioxane. Based on the upgradient extent of the 1,4-dioxane plume and the estimated groundwater velocity of approximately 190 ft/yr in the shallow depth interval and the intermediate interval west of approximately Maynard Avenue South, it is anticipated that the mass removal wells located along 5th Avenue South would be operated for 5 years to enable capture of groundwater within the highest contour shown on Figure 5-9. The total estimated recovery for the hydraulic control and mass removal systems is about 23 lb of 1,4-dioxane over the 10-year operation period.

The monitoring program for this alternative is summarized on Table 5-1. The monitoring program described for Alternatives OA-2 and OA-3 would be included in Alternative OA-5. Additionally, groundwater samples would be collected from the downgradient recovery wells during each monitoring event. The two pump and treat wells could be monitored for 5 years, and the 8 samples from the recovery wells would be analyzed for 1,4-dioxane. The monitoring frequency for the recovery wells would be the same as the frequency for the overall monitoring program, as described for Alternative OA-2. Administrative controls would be incorporated into the alternative to ensure that human health and the environment are adequately protected by Alternative OA-5. These administrative controls would be the same as described for Alternative OA-1. The estimated restoration time (Figure 5-4) for this alternative is about 20 years, which is the same as for Alternatives OA-2, OA-3, and OA-4.

The advantages of Alternative OA-5 are:

- The alternative would employ proven technologies for chlorinated VOCs, PCBs, and 1,4-dioxane removal.
- Of all the alternatives OA-5 would remove the most 1,4-dioxane.
- The alternative would enhance the existing anaerobic conditions as opposed to risking disruption of this system.
- This alternative would use an aggressive technology, SVE, to address VOC contamination in vadose zone soils.

- This alternative would result in COC destruction and a reduction in COC mass.
- This alternative would address elevated concentrations of COCs other than PCBs in OSRA-1.
- The alternative would result in meeting CULs in a relatively short time frame.

The disadvantages of OA-5 are:

- The implementation of an SVE system would take a period of 1 year, during which time the site could not be developed.
- This alternative would require an extensive pipeline system to convey water from the hydraulic control wells to a treatment system on PSC property and then back to the Duwamish Waterway for discharge, resulting in a greater nuisance and a greater risk to surrounding landowners/users.
- This alternative would rely on the existing IPIM and administrative controls to mitigate off-site risks until cleanup levels were met.

5.3 EVALUATION OF OUTSIDE AREA REMEDIAL ALTERNATIVES

The primary objectives for the five remedial alternatives considered for the Outside Area are to prevent direct contact with site COCs, reduce constituent concentrations sufficiently to meet remediation levels at the proposed CPOC, and, ultimately, attain cleanup levels in Outside Area groundwater. Based on data collected from existing wells, the remediation levels established in Technical Memorandum No. 1 (which were established for organic Class 3 COC[3]) are currently being met at the proposed CPOC located immediately downgradient of the HCIM barrier wall. It is expected that the remediation levels will continue to be attained at this CPOC. However, groundwater cleanup levels for many COCs are not being met at the CPOC.

This section compares and evaluates the remedial alternatives based on the MTCA criteria of protectiveness and risk reduction, permanence, cost, long-term effectiveness, management of short-term risks, technical and administrative implementability, public concerns, and restoration time frame, as discussed in Section 2. In the subsections below, the alternatives are evaluated relative to each other. The alternatives have also been rated relative to each criterion in Table 5-2; in this table, each alternative was given a numerical rating ranging from 1 to 5, with 5

[3] Class 3 compounds are defined as COCs that would potentially reach the Duwamish Waterway at concentrations greater than cleanup levels protective of surface water.

indicating the best performance. A rating of 5 means that the alternative is expected to perform very well for the criterion being evaluated, while a rating of 1 indicates it is expected to perform poorly. A rating of 1 does not mean that the alternative would not adequately meet the criterion; it only means that the alternative may be less efficient or slower in attaining adequate performance for that criterion.

All of the remedial alternatives under consideration would likely attain the remediation objectives outlined in Technical Memorandum No. 4 and summarized in Section 2, with the exception of Alternative OA-1, which does not address direct contact of impacted soil within the adjacent UPRR rail yard (OSRA-1). Direct contact with affected soil in OSRA-1 would be addressed in the remaining alternatives by maintaining the existing facility surface cover system and pavement over affected soil, excavating soil from the UPRR rail yard for off-site disposal, repaving the area, and placing surface cover over soils on PSC property. All of the alternatives include institutional controls on PSC and UPRR property, as described above for Alternative OA-1. The surface cover and pavement also minimize potential dust generation in addition to preventing runoff of affected soils. All five alternatives include the IPIM program outlined in Technical Memorandum No. 3 to assess potential vapor exposure and to reliably intercept or mitigate vapor intrusion to limit potential inhalation exposures. Monitored natural attenuation and/or the other remedial alternatives under consideration would be expected to reduce concentrations for all COCs in groundwater below remediation levels (protective of surface water at the Duwamish Waterway) at the proposed CPOC. If remediation levels were achieved, human and ecological receptors using surface water would not be exposed to unacceptable risks related to the facility.

In the following subsections, each of the remedial alternatives is compared to the evaluation criteria described in Section 3. These comparisons summarize the primary factors that address each criterion. The evaluation has been summarized for all evaluation criteria in Table 5-2.

5.3.1 Protectiveness and Risk Reduction Evaluation

In general terms, the protectiveness and risk reduction criterion involves the degree to which remedial alternatives protect human health and the environment and reduce risks posed by the contamination. All of the alternatives under consideration would be expected to significantly reduce risks and be protective of human health and the environment. However, the alternatives differ in overall protectiveness and risk reduction. Since the Class 3 COCs in groundwater immediately downgradient of the HCIM Area are currently below remediation levels, all of the alternatives would be fully protective of the Duwamish Waterway. Ultimately, all of the Outside Area alternatives are expected to attain cleanup levels at the proposed CPOC.

The rating of the alternatives for this criterion is shown on Table 5-2. Alternative OA-1 was rated the lowest (2) of the five alternatives, because it would not prevent direct contact with impacted soil within OSRA-1 and would degrade COCs more slowly than the other alternatives, which would increase potential risks over alternatives that more rapidly degrade constituents. The remaining Alternatives (OA-2 through OA-5) would include excavation and off-site disposal of impacted soil within the UPRR rail yard, which would reduce the risk of direct contact with impacted soil. Alternatives OA-3, OA-4, and OA-5 would include excavation of hot spot soils in addition to the excavation of only PCB-affected soils included in Alternative OA-2.

The highest rating (5) for this criterion was given to Alternatives OA-4 and OA-5, which would remove COC mass in the downgradient 1,4-dioxane plume using groundwater extraction and treatment technology. Alternatives OA-1, OA-2, and OA-3 rely upon attenuation processes to attain cleanup levels in the 1,4-dioxane plume. Alternatives OA-2 and OA-3 would incorporate enhanced anaerobic bioremediation and SVE to reduce the mass of the COCs that represent the greatest potential risks in the most impacted portion of the Outside Area and are considered to be highly protective. Although Alternatives OA-4 and OA-5 were rated highest, because they would actively address the downgradient 1,4-dioxane plume, they would not be expected to provide substantially greater protectiveness or risk reduction than Alternative OA-3, as indicated by the rating. Alternative OA-3 was rated as a 4, higher than Alternative OA-2 (3), due to excavation of hot spot soils within OSRA-1, which was not included in Alternative OA-2.

5.3.2 Permanence

The permanence criterion, as defined in Section 3, involves the degree to which the remedial alternative would reduce the toxicity and mobility of affected media through permanent destruction of hazardous substances. All of the alternatives would rely on ongoing in situ biodegradation processes to destroy chlorinated VOCs and other organic constituents in groundwater. All of the alternatives also would rely upon restoration of natural redox conditions within Outside Area groundwater to permanently convert the soluble and mobile forms of metals to less soluble and less mobile forms. Since all alternatives were considered to provide a high degree of permanence for groundwater COCs, they were all rated between 3 and 5 for this criterion. Alternative OA-1 was rated the lowest (3) of the alternatives because it would not actively address contaminant concentrations in subsurface soil. Alternatives OA-2 and OA-3 were both rated second highest (4) since they would provide the same degree of permanence; they would provide a greater degree of permanence than Alternative OA-1 due to implementation of SVE, which would permanently destroy volatile soil constituents. Volatile constituents recovered using SVE would be adsorbed to activated carbon and be permanently destroyed during carbon regeneration. Excavation and off-site landfill disposal of affected soil is not considered a permanent remedial approach, since the COCs would not be destroyed but would be contained within an engineered landfill.

Alternatives OA-4 and OA-5 are rated highest (5) for permanence because these two alternatives would provide the highest degree of removal and destruction of COCs in groundwater and provide the same degree of permanence for soil as Alternative OA-3. Alternatives OA-4 and OA-5 would recover and permanently destroy 1,4-dioxane in the downgradient plume. While Alternative OA-5 would include groundwater recovery within the most highly contaminated portion of the plume, it would not be expected to recover and destroy more 1,4-dioxane than Alternative OA-4.

5.3.3 Cost

Net Present Value cost estimates were prepared for the five Outside Area remedial alternatives, as presented in Table 5-3 and described in Appendix A. The NPV costs combine initial costs for implementation of an alternative with future costs for phased implementation of components, and for future operation, maintenance, and monitoring that would occur over the life of the alternative. NPV cost estimates allow the alternatives to be compared on an equal basis. Implementation costs include the costs associated with property access (i.e., property purchase or gaining access or easements to conduct the remediation, building demolition, and utility relocation); engineering and planning; purchasing equipment, materials, and chemicals; permitting; preparing regulatory agency reports; construction; transportation and disposal; and site restoration (buildings and landscaping). Recurring costs include costs that would occur over the life of the remediation, and include costs for operation and maintenance labor, materials and chemicals used in remediation; periodic replacement and repair of remediation equipment; long-term property access (e.g., rental); power, water, and waste disposal; water quality monitoring; agency review; and project management and reporting. The NPV costs are based on the estimated life of each remedial alternative. Costs for the ongoing implementation of the VIAM approach are included in all five alternatives. NPV costs were estimated using a net discount rate of 2.5%, as recommended by Ecology. Details for the NPV calculations are presented in Appendix A.

As shown on Table 5-3, the estimated NPV costs (100-year project life) for Outside Area alternatives range from $4.9 million to $16.4 million. The NPV costs for Alternatives OA-1, OA-2, and OA-3 ranged from $3.2 million to $5.5 million, while costs for Alternatives OA-4 and OA-5 were $13.3 million and $14 million, respectively. The increased costs for Alternatives OA-4 and OA-5 arise from interception and recovery of 1,4-dioxane in the downgradient plume; the average cost for these two alternatives is approximately 2.4 times the average cost of Alternatives OA-2 and OA-3, which would provide nearly the same benefits. Alternative OA-1 has the lowest NPV cost, resulting in the highest rating for this criterion (5). The NPV costs for Alternatives OA-4 and OA-5 are both an order of magnitude greater than costs for the other alternatives, and were both rated lowest (1) for cost. As the potential benefits that would accrue from implementation of either Alternative OA-4 or Alternative OA-5 are minimal, the substantially higher costs for these two alternatives are considered disproportionate. Alternatives OA-2 and OA-3 were given intermediate ratings (4 and 3, respectively). The hot spot excavation in Alternative OA-3 would not be expected to reduce the restoration time for the Outside Area; the restoration time is determined primarily by the time needed for restoration of groundwater to cleanup levels. The concentrations of metals in groundwater would be expected to degrade to background levels after redox conditions return to natural levels (i.e., as redox conditions revert to the natural state, the mobile and toxic forms would be expected to convert to less mobile and less toxic forms). In addition, further characterization of soil contamination in OSRA-1 is needed before the extent of the hot spot excavation can be determined, rendering cost estimates for Alternative OA-3 more uncertain than for Alternative OA-2. Therefore, Alternative OA-3 was rated lower than OA-2.

5.3.4 Long-Term Effectiveness

Assessing long-term effectiveness involves the degree of certainty and reliability of the alternative to maintain its effectiveness over the long term. This criterion also involves whether treatment residue would remain from the alternative that would require management. Passive alternatives that would require minimal operation and maintenance would be favored over alternatives requiring active, long-term attention to maintain effectiveness. Alternatives that would rapidly remove COCs from the area would be favored over alternatives relying on long-term implementation of engineered systems. All five alternatives under consideration would incorporate the same institutional controls; therefore, the institutional controls for each alternative would have essentially the same effectiveness and reliability and are not considered in rating for this criterion. In assessing this criterion, long-term effectiveness was considered as effectiveness beyond 10 years, the expected operation life of the groundwater extraction and treatment components of Alternatives OA-4 and OA-5.

As shown in Table 5-2, Alternatives OA-4 and OA-5 were rated highest for this criterion, because they would be essentially equivalent for long-term effectiveness. These alternatives would provide the most rapid COC removal (through excavation and groundwater extraction and treatment); after shutdown of the active groundwater extraction and treatment component, they would rely upon passive processes for ultimate attainment of cleanup levels in all groundwater remediation areas. Alternatives OA-2, OA-3, OA-4, and OA-5 would generate contaminated soils for off-site management; Alternative OA-2 would produce a smaller volume of affected soil, but would rely on in-place management of a larger volume of affected soil. Alternative OA-1 would not generate residuals requiring off-site management, but would not be as effective in the long term as the other alternatives because it would rely upon in-place management of impacted soils within OSRA-1. The engineered disposal facility used for long-term management of affected soil would provide greater long-term effectiveness than in-place management.

Based on these considerations, Alternative OA-1 was rated lowest (2) for long-term effectiveness and Alternatives OA-4 and OA-5 were both rated highest (5). The remaining two alternatives were rated intermediate, with Alternative OA-3 rated higher (4) than Alternative OA-2 (rated 3), because Alternative OA-3 would involve shipping a larger volume of affected soil to an engineered landfill rather than relying on in-place management of impacted soils.

5.3.5 Management of Short-Term Risks

Short-term risk refers to potential risks to human health and the environment during implementation of an alternative. Although it is possible to design remedial actions to mitigate or minimize potential risks, it is not possible to eliminate risks through design or actions. In assessing this criterion, it has been assumed that alternatives have been designed to incorporate appropriate and proven methods to mitigate potential short-term risks. However, regardless of the approach taken, some remedial actions (e.g., excavation, even if done in a totally enclosed and properly ventilated tent) would potentially create more short-term risk than an alternative that did not disturb contaminated soil. Specific measures to mitigate potential short-term risk are not discussed in this section. Appropriate mitigation measures have been included in the conceptual designs discussed in this report, and potential short-term risks are evaluated based on the conceptual designs presented.

Alternative OA-1 is rated highest (5) for management of short-term risk, because it would not require significant additional subsurface activities (e.g., excavation, installation of wells, etc.) and has the lowest potential for short-term exposure of workers or the public to soil and groundwater COCs. At the other end of the rating, as shown on Table 5-2, Alternatives OA-4 and OA-5 both received the lowest possible score (1), because both alternatives would have equivalently high potential for short-term risks. Both would require an extensive amount of construction,, much of it in public roads, and transfer of contaminated groundwater through pipelines installed in public rights-of-way.

Alternatives OA-2 and OA-3 were rated intermediate (4 and 3, respectively), as short-term risks would accrue from excavation and management of impacted soil from OSRA-1. Alternative OA-3 was rated lower than Alternative OA-2, because OA-3 would involve excavating a greater volume of soil. The increased excavation would increase potential risks due to potential exposure to more contaminants and increased duration of construction. Alternatives OA-2 and OA-3 are equivalent in their approach to remediation of affected groundwater and are, therefore, equivalent in potential short-term risks for the groundwater remediation portion of the alternatives.

5.3.6 Technical and Administrative Implementability

This criterion involves both technical and administrative issues related to design, permitting, construction, and operation of the remedial alternatives. Factors considered in assessing the alternatives against this criterion include administrative/regulatory requirements, impact on existing land uses, the means for implementing and enforcing institutional controls, constructability of the components, and requirements for extensive construction or ongoing operation and maintenance. For the Outside Area, constructability is a key consideration, as most of the property is not owned by PSC, thereby requiring cooperation of landowners and/or municipal government. Since all alternatives include the same institutional controls, they are all equivalent for implementability of the institutional controls.

All of the alternatives rely on proven remediation technologies and no significant technical hurdles are anticipated during their implementation. Natural biodegradation reactions have been proven to be active within the Outside Area, which supports inclusion of MNA and enhanced bioremediation in the Outside Area alternatives. As shown in Table 5-2, Alternative OA-1 was rated highest of all the alternatives (5) for this criterion, because it would rely on existing natural biodegradation processes to address chlorinated VOCs in Outside Area groundwater and require the least intrusive construction, operation, and monitoring activities. This alternative would require access only for installation and periodic monitoring of new monitoring wells. Alternatives OA-2 and OA-3 received equal and intermediate ratings (3), because the technical implementability of both alternatives is similar. Both alternatives would include the excavation and off-site disposal of impacted soil from OSRA-1 (on UPRR property), and the SVE and enhanced bioremediation systems would be located on PSC property. The 50% design is already completed for the SVE component of both alternatives. However, these two alternatives would be more difficult to implement than Alternative OA-1. Permitting requirements for Alternatives OA-2 and OA-3 would include a Notice to Construct to the PSCAA prior to construction of the SVE system and an injection permit for enhanced bioremediation. It is anticipated that obtaining these permits would not present significant technical or administrative hurdles.

Alternatives OA-4 and OA-5 were both rated very low (1) for this criterion due to the very substantial difficulties associated with implementation of the downgradient groundwater extraction and treatment components. Extensive permitting would be needed for both alternatives, because they would require NPDES permitting and extensive access to public rights-of-way. Additionally, it would be necessary to obtain approval from both the Corps of Engineers and Ecology for placement of a diffuser in the Duwamish Waterway. This permitting step would be lengthy and could delay implementation by several years. Both engineering and construction would be very difficult for these alternatives due to placement of collection and discharge lines beneath roadways and near underground utilities. It would also be necessary to acquire access to easements along the Duwamish Waterway to construct the discharge line. It may also be necessary to address water rights issues related to recovery of groundwater in the downgradient area. These issues would complicate the engineering, permitting, and construction and lengthen the time required for implementation by at least 2 years.

5.3.7 Public Concerns

Potential community concerns with implementation of each remedial alternative are assessed for this criterion, including general concerns of the public and specific concerns of neighboring landowners. It is expected that the primary public concerns associated with most of the Outside Area alternatives would be from neighboring landowners, due to the heavy urban development of the area and the possible need to gain access to private properties (e.g., UPRR rail yard and SAD property) in order to implement the alternatives. For Alternatives OA-2, and OA-3, the primary public concerns are expected to be related to the transportation of potentially dangerous wastes over public roadways, VOC releases to ambient air, odors, and noise. Additional public concerns are likely to be related to traffic alterations during any construction or other work in public roads. Alternative OA-1 would have none of these concerns. For Alternatives OA-4 and OA-5, significant additional concerns would be expected due to the extensive construction that would be needed to install wells, collection piping, and discharge piping. This construction would significantly disturb traffic on city roadways and create noise.

For this criterion, a higher rating (i.e., 5) indicates the lowest expected public concern (greatest acceptance) and a low rating (i.e., 1) indicates the greatest expected public concern (least acceptance). Alternative OA-1 received an intermediate rating (3) for this criterion, because it is a generally passive remediation approach; most of the activity that may invoke public concern would be during groundwater monitoring, which is already being conducted in the area. In addition, this alternative also has the potential to create public concern due to the longer time period required for the IPIMs to be maintained. Alternatives OA-2 and OA-3 rated fairly high (4), but are not scored as 5 due to the potential public concern associated with the transportation of impacted soil over public roads and the potential for odor and noise during implementation. Alternatives OA-4 and OA-5 also involve transportation of impacted soil over public roads and the potential for odor and noise during implementation, but were given the lowest rating (1) for public concern because implementation of both alternatives would significantly affect the public through extensive underground pipeline construction in the public roadways. The groundwater injection activities associated with enhanced anaerobic bioremediation and the SVE system in Alternatives OA-2, OA-3, OA-4, and OA-5 would be implemented on PSC property, generally out of the view of the public. Therefore, it is not anticipated that these activities would cause significant public concern. The blower for the SVE system would be surrounded by an enclosure to reduce noise levels.

5.3.8 Reasonable Restoration Time Frame

Restoration time frame involves the urgency of achieving remediation objectives and the practicability of attaining remediation objectives in a shorter time frame, with consideration given to a number of factors, including site risks, site use and potential use, availability of alternative water supply, effectiveness and reliability of institutional controls, and toxicity of hazardous substances at the site. The community including and surrounding the Outside Area is served by Seattle Public Utilities, which supplies all drinking and process water used in the area. As noted in the RI Report, groundwater beneath the entire SWFS Area is not a water supply aquifer. Potentially significant risks associated with the Outside Area are being addressed by the VIAM approach; characterization data show that COCs related to the facility are attenuated to below cleanup levels prior to reaching the Duwamish Waterway. The remediation levels for Class 3 COCs defined in Technical Memorandum No. 1 are currently being met at the proposed CPOC and are predicted to be met in the long term. For many of the site COCs, the four alternatives incorporating enhanced bioremediation are expected to be equivalent in the time required to attain cleanup levels at the CPOC.

As presented in Table 5-2, Alternative OA-1 was rated low (1), because it would not include active remediation to reduce the time frame required to reach cleanup levels. Alternative OA-2 was rated higher than OA-1 (2) for this criterion, because it would include enhanced bioremediation, SVE, and excavation and off-site disposal of PCB-impacted soil from OSRA-1, but lower than OA-3 because it would remove only PCB-affected soils. Alternative OA-3 was rated higher (3) than Alternative OA-2, because it would add excavation of hot spot soils in OSRA-1. The downgradient groundwater recovery system included in Alternatives OA-4 and OA-5 would accelerate attainment of groundwater cleanup levels for 1,4-dioxane in downgradient groundwater; Alternatives OA-4 and OA-5 were, therefore, rated highest (4). None of the alternatives was given the highest possible rating since all would require substantial time to achieve cleanup levels.

5.4 Selection of Outside Area Preferred Remedial Alternative

Selection of a preferred alternative under MTCA requires that preference be given to alternatives that use permanent solutions to the maximum extent practicable, provide for a reasonable restoration time frame, and consider public concerns. According to MTCA (WAC 173-340-200), a permanent solution or permanent cleanup action means an action in which cleanup standards can be met without further action being required at the site involved, other than the approved disposal of any residue from the treatment of hazardous substances.

The MTCA rules also specify that a baseline alternative be defined as that remedial alternative that permanently destroys site COCs to the maximum extent practicable and achieves the shortest restoration time frame. The baseline alternative is to be used as a basis for comparing other remedial alternatives and selecting the preferred alternative. For the Outside Area, five remedial alternatives have been established as potentially applicable. Although all of the alternatives would permanently destroy most COCs, Alternative OA-5 would have the highest level of permanence because it would destroy the largest quantity of COCs within the shortest time. Therefore, Alternative OA-5 will be considered the baseline alternative for the Outside Area.

5.4.1 Comparison of Outside Area Alternatives

As shown in Table 5-2, Alternative OA-3 received the highest total ranking. Alternative OA-2 scored only 1 point below Alternative OA-3, while Alternative OA-1 scored 2 points below. The baseline alternative, Alternative OA-5, was tied for the lowest rating among the alternatives. Alternatives OA-4 and -5 are very similar; both would include groundwater extraction and treatment technology for the 1,4-dioxane plume, but both would incur significant costs to achieve control of the plume and would significantly inconvenience the public during construction. Alternative OA-3, the highest ranked alternative, includes all components of Alternatives OA-4 and OA-5 other than recovery and treatment of groundwater impacted by 1,4-dioxane. The costs for recovery of the 1,4-dioxane plume are disproportionate to the reduction of risk gained from this action when compared to Alternative OA-3.

Although the baseline alternative (Alternative OA-5) would reduce the time to achieve cleanup levels for 1,4-dioxane, the restoration time for other COCs would be essentially the same as for Alternatives OA-2, OA-3, and OA-4, since all would rely on monitored attenuation (following enhanced bioremediation) to achieve cleanup levels for most constituents. The four alternatives with enhanced bioremediation are expected to be fully effective in achieving remediation objectives for the Outside Area.

5.4.2 Preferred Outside Area Remedial Alternative

Based on the comparison presented above, the preferred remedial alternative for the Outside Area is Alternative OA-2. This alternative would provide permanent destruction of most groundwater COCs, including the halogenated VOCs that pose the most significant potential risk to human health and the environment. Soil known to be impacted by PCB releases from the facility in the adjacent UPRR rail yard (OSRA-1) would be excavated and removed for off-site disposal. Exposed soils would be covered by pavement. Enhanced bioremediation and SVE would permanently remove and destroy COCs in soil and groundwater between the HCIM barrier wall and the SAD building and also address any potential VOCs beneath the SAD building. Existing biodegradation processes would address organic COCs other than 1,4-dioxane in the remaining Outside Area groundwater remediation areas. Metals would be expected to degrade to background levels after redox conditions returned to natural levels following degradation of other organic COCs. The 1,4-dioxane plume present in the shallow and intermediate depth intervals is a detached plume, as groundwater in these zones immediately downgradient from the facility is below the cleanup level. It is expected that the 1,4-dioxane plume would continue to be attenuated as it migrates toward the Duwamish Waterway.

Although 1,4-dioxane cleanup levels may be exceeded for the short term, monitoring data indicate that cleanup levels for 1,4-dioxane would ultimately be achieved by Alternative OA-2. The VIAM approach would address the inhalation pathway until COC concentrations in groundwater were reduced below cleanup levels.

This remediation approach is readily implementable; a number of the containment and monitoring components are currently in place. Although it would be necessary to negotiate an access agreement with UPRR to allow excavation and removal of PCB-impacted soil in the Argo Yard, PSC does not foresee significant difficulties in obtaining the agreement. Preliminary discussions have already been conducted with UPRR regarding potential remedial actions in the Argo yard. Long-term operation and maintenance would include routine inspection and maintenance of the barrier wall and surface cover, as well as operation and maintenance of the SVE and ISB systems. Much of the monitoring well network needed to implement Alternative OA-2 is already in place. A well-established groundwater monitoring program is already in place for the Outside Area that would be expanded and continued under Alternative OA-2. This alternative would not interfere with the anticipated remedial measures that may be implemented downgradient of the Outside Area.

The preferred alternative is essentially the same as Alternative OA-3, which includes excavation of affected soil other than the presently identified PCB-affected area. As noted previously, additional investigations are planned to characterize additional soil contamination within OSRA 1. If additional soil contamination attributable to PSC were to be identified from this investigation, the preferred alternative could be readily modified to include the additional soil excavation that was assumed to be included in Alternative OA-3. Thus, Alternative OA-3 would be implemented as a contingent remedy, depending on the findings of the planned investigation to be completed in the spring or summer of 2007.

The preferred remedial alternative for the Outside Area would fully attain remediation objectives:

- The preferred alternative would prevent direct contact with soils and inhalation of dust in areas affected by the facility by removing impacted soils in the Argo yard, providing surface cover over affected soils in other areas, and by implementing institutional controls that would require appropriate health and safety precautions for future subsurface construction.

- The preferred alternative would reduce risks due to inhalation of vapors by incorporating institutional controls requiring vapor intrusion provisions for future buildings that may be occupied.
- The preferred alternative would protect human and ecological receptors from releases from the facility, since remediation levels are currently being attained at the proposed CPOC.
- The preferred alternative would ultimately reduce constituent concentrations to achieve groundwater cleanup levels at the proposed CPOC.
- The preferred alternative would not adversely affect existing land use within the Outside Area.
- The preferred alternative would not create nuisance conditions within the Outside Area and would not affect future remediation efforts for downgradient source areas.
- The preferred alternative would be fully compatible with existing interim measures (both the HCIM and IPIMs) and with the preferred alternative for the HCIM Area.

In addition, the preferred alternative provides:

- A readily implementable remediation approach that can be fully constructed and implemented with minimal delays for engineering, permitting, and construction. This is especially important due to the complex, densely developed urban environment present throughout the Outside Area;
- An active approach using proven, robust technologies the would result in permanent destruction of the most significant soil and groundwater COCs and most other organic COCs;
- A comprehensive monitoring well network that would confirm the effectiveness of the alternative and also identify any problems prior to creating actual risks to human health and the environment;
- A reliable, low-maintenance remediation approach using proven, robust technologies;
- A comprehensive approach, outlined in Technical Memorandum No. 3, to address the inhalation pathway until cleanup levels are achieved;
- An approach that would create minimal short-term risks and have minimal potential for causing public concern about exposure to site constituents during construction.

The preferred alternative (OA-2) for the Outside Area is fully compatible with the preferred alternative for the HCIM area and is compliant with MTCA regulations.

The preferred remedial alternative for the Outside Area would comply with the requirements of the Permit and achieve the environmental indicator standards for controlling potential exposure to both soil and groundwater for media affected by releases from the facility. The preferred alternative would comply with MTCA (WAC 173-340), the Dangerous Waste Regulations (WAC 173-303), and the RCRA regulations. Cleanup levels and remediation levels established in accordance with the MTCA regulations would be achieved. The preferred alternative would provide permanent destruction of key facility COCs. Dangerous wastes would potentially be generated from implementation of the alternative, primarily from the excavation of affected soil in the Argo yard, and the installation of SVE, extraction, and monitoring wells.

The preferred alternative would address all potential exposure pathways, including migration to surface water, direct exposure to soil, and inhalation of vapors migrating into buildings through soil excavation and disposal, SVE, enhanced anaerobic bioremediation, natural attenuation, and the VIAM approach. Therefore, the preferred alternative for the Outside Area would achieve the environmental indicator goals. In conjunction with the preferred alternative to the HCIM Area, this alternative would comprehensively address historic releases related to the facility.

6.0 SITE WIDE REMEDIATION

The overall objective of the SWFS is to identify the preferred approach for remediation of releases from the facility within the SWFS Area. As noted previously, the HCIM effectively separated the areas affected by historic releases by providing highly effective hydraulic control and containment around near-facility affected media. Due to the differences in hydrogeology created by the containment barrier, the generally higher levels of contamination within the contained area, and the different potential exposure pathways, the SWFS was separated into two parts. Separate "mini-feasibility studies" were done for the HCIM Area and for the Outside Area. The FS conducted for the HCIM Area addressed the releases and affected media located inside the HCIM barrier wall, which encompasses portions of property owned by three different parties (PSC, SAD, and Aronson). The FS conducted for the Outside Area, which encompasses hundreds of different property owners, addressed media affected by migration of COCs originally released within the facility or on property leased by PSC. Primary releases occurred predominantly within the HCIM Area, which served as a secondary source for the Outside Area prior to construction of the barrier wall. Limited primary releases also occurred on property located east of the facility that was leased from UPRR for facility use. Implementation of the HCIM essentially removed the primary source of COCs being actively released to the Outside Area. The preferred remedial alternatives selected in this SWFS Report for each of these two areas must be combined to develop a comprehensive, site wide remediation approach that addresses all affected media and potential exposure pathways within the SWFS Area that are associated with the facility.

The approach for combining the two preferred remedial alternatives into a comprehensive remediation approach addressing Site Wide issues is presented in Section 6.1. The discussion presented below also shows that the costs for implementation of a more "permanent" alternative are disproportionate to the benefits that may accrue. The general approach anticipated to implement the comprehensive remediation approach proposed in this SWFS is described in Section 6.2.

6.1 PREFERRED REMEDIATION APPROACH

The preferred remedial alternatives selected in this SWFS for the HCIM Area and for the Outside Area would be implemented together to comprehensively remediate releases from the facility within the SWFS Area. The preferred remedial alternative for the HCIM Area includes:

- A totally enclosing, low-permeability subsurface barrier wall which has already been implemented and which surrounds the facility and near-facility affected groundwater;
- A groundwater recovery and treatment system to maintain an inward hydraulic gradient;
- A low-permeability surface cover (or equivalent cover such as buildings) that would completely cover the entire area enclosed by the barrier wall;
- Natural anaerobic bioremediation of COCs within the HCIM Area
- A monitoring program utilizing existing and new wells to monitor groundwater quality as needed to support the anaerobic bioremediation;
- A monitoring well network to assess groundwater levels inside and outside the barrier wall to confirm hydraulic containment (Table 6-1); and
- Institutional controls to restrict groundwater use within the enclosed area, restrict and regulate subsurface work conducted within the enclosed area, require vapor barriers as part of building construction within the HCIM Area, and require maintenance of the barrier wall, surface cover, and monitoring well system.

The preferred remedial alternative for the Outside Area includes:

- SVE to remediate subsurface soils located between the HCIM barrier wall and the SAD property to accelerate removal of volatile soil COCs and soil gas;
- Enhanced bioremediation for shallow groundwater located between the HCIM barrier wall and the SAD property to accelerate biodegradation of chlorinated VOCs;
- Placement of additional surface cover over affected soil areas located on PSC and, as appropriate, UPRR property;
- Excavation and off-site disposal of PCB-affected soil that has been identified on the UPRR property east of the facility;
- If necessary, based o the results of currently planned investigations, excavation and off-site disposal of soil on the UPRR property that has been affected by releases of facility COCs;
- A comprehensive monitoring well network and monitoring program to assess groundwater quality along the CPOC and in areas downgradient from the CPOC (Table 6-1);
- The existing IPIM VIAM program that addresses the inhalation pathway within the Outside Area; and

- Administrative controls, institutional controls, and public communications to restrict groundwater recovery within the Outside Area, limit the potential for exposure to affected soil, and notify the public of hazards of subsurface work conducted below the water table within areas warranted based on concentrations of COCs in groundwater.

Details concerning these alternatives, including a general description of the conceptual designs, are presented in Sections 4 and 5.

The preferred Site Wide remediation approach, consisting of Alternative HA-1 and Alternative OA-2, is shown in Figure 6-1. The estimated cost for the preferred Site Wide remediation approach is summarized in Table 6-2. The remediation alternatives for the two areas complement each other and combine to fully address affected media, COCs, and potential exposure pathways within the SWFS Area. The barrier wall and surface cover for the HCIM Area would effectively contain primary source areas for soil and groundwater, thereby minimizing the potential for exposures via direct contact and via groundwater migration/direct contact. The barrier wall and surface cover for the HCIM Area are low maintenance and constructed of natural materials with a very long effective life. The groundwater recovery and treatment system within the barrier wall would provide hydraulic containment, even though passive containment (no pumping) by the barrier wall alone would achieve remediation objectives. The surface cover would likely require periodic maintenance due to settlement and cracking due to weather and traffic. The only likely cause for failure of the barrier wall would be an earthquake directly affecting the facility location; based on the evaluation presented in this SWFS, a reasonable worst-case failure scenario would be creation of up to four large cracks in the barrier wall that would allow groundwater to flow from the contained area. Based on conservative modeling, if this type of barrier wall failure were to occur, existing concentrations for facility COCs would attain cleanup levels (based on protection of surface water) prior to discharge to the Duwamish Waterway. However, the water table depth interval immediately downgradient of the facility would exceed cleanup levels protective of the inhalation pathway.

Affected soil within the UPRR property would be remediated by excavation and disposal within a properly designed and operated landfill. Excavations would be backfilled with clean soil and covered with asphalt or concrete surface cover. Affected soil areas that cannot be accessed for excavation would be paved over and institutional controls, enforceable by UPRR, would be implemented to minimize potential risks associated with the soils.

Anaerobic bioremediation is occurring naturally within the HCIM Area and has reduced chlorinated VOC concentrations in the shallow and water table depth intervals to below remediation levels protective of the Duwamish Waterway. While anaerobic bioremediation would not achieve cleanup levels, it would continue to reduce constituent concentrations within these saturated zones. Ultimately the facility will be redeveloped, and the existing surface cover would be incorporated into the development or replaced with cover that performs the same function, such as a building, parking structure, or parking lot. It is projected that the facility could be returned to productive use within 1 to 2 years after commencing active remedial action.

As outlined above, the passive anaerobic bioremediation that is occurring within the HCIM Area will continue to degrade COCs over the long term; however, Alternative HA-1 would not result in attainment of cleanup levels in the HCIM Area within the foreseeable future. This is also the case for all other alternatives evaluated. The COCs within the HCIM Area include VOCs, SVOCs, metals, and PCBs. VOCs, including DNAPL, extend from the ground surface down to the Silt Aquitard at depths of up to 90 feet. The passive anaerobic degradation has resulted in remediation levels being met but is not expected to reduce concentrations of VOCs significantly in the interbedded silt and sand of the Intermediate Aquifer due to the DNAPL concentrations within the silt layers. In addition, this technology would not be effective for metals or PCBs and only marginally effective for SVOCs. As a result, the HCIM Area will remain impacted with COCs at relatively high concentrations for the foreseeable future. This is consistent with many contaminated sites in the Seattle area, including Gas Works Park, Puget Sound Resources sites, and many others where technologies are not available to practicably attain cleanup levels.

Natural attenuation that occurs within the Outside Area is predicted to attain cleanup levels at the CPOC shown on Figure 6-1 within about 26 years, as discussed in Section 5. The most recent monitoring data (Geomatrix, 2007b) indicate that groundwater quality downgradient of the HCIM Area is rapidly improving throughout most of the Outside Area. It is expected that the enhanced bioremediation included in the Preferred Alternative would reduce this time by 50%, resulting in attainment of cleanup levels for organic constituents within about 13 years. It is expected that concentrations of other organics downgradient of the CPOC would also attain cleanup levels as the secondary source area is treated by enhanced bioremediation and natural biodegradation continues. Metals within the groundwater would revert to natural levels after degradation of organics is sufficient to allow the redox potential to increase to natural levels. Although the Preferred Alternative does not actively remediate 1,4-dioxane in the downgradient plume, monitoring data have shown that the 1,4-dioxane plume is detached from the facility, indicating that releases were stopped several years ago. It is expected that 1,4-dioxane in the downgradient plume will continue to be attenuated, with concentrations achieving cleanup levels at 4th Avenue South within about 10 years. While the cleanup level for 1,4-dioxane (which is based on protection of surface water) would not be met during this time, the restoration time is considered reasonable given the small amount of 1,4-dioxane present in groundwater and the high cost and invasive construction needed to recover it.

Conservative fate and transport modeling has also predicted that the remediation levels already being met at the CPOC and the natural attenuation process would control any facility-related COCs in groundwater from migrating to the Duwamish Waterway at concentrations exceeding cleanup levels protective of surface water. The IPIMs that have been implemented in the Outside Area adequately address the inhalation pathway, thus ensuring that the SWFS Area preferred remediation approach will be protective of human health until cleanup levels are attained at the CPOC.

Modeling conducted for the preferred remedial alternatives indicates that the limited flux of COCs that would occur through the barrier wall would degrade under natural conditions to attain cleanup levels prior to reaching the CPOC. The IPIMs would be maintained until it has been confirmed that cleanup levels protective of the inhalation pathway have been attained in the water table groundwater interval at all the IPIM locations. Finally, the groundwater monitoring network for the combined remedial alternatives would be sufficiently robust to identify any deviations from the predicted model and in sufficient time to address any problems. The comprehensive groundwater monitoring program included in the SWFS Area preferred remediation approach would be conducted for 5 years beyond initial attainment of cleanup levels at the CPOC, a period of time sufficient to confirm that remediation has been completed. The final remediation approach proposed for the SWFS Area (Figure 6-1) provides a comprehensive solution to historic releases and meets regulatory requirements under RCRA and MTCA.

The preferred remediation approach for the SWFS Area would be compatible with potential remedial actions that are likely to be implemented in the comingled plume area located downgradient from Fourth Avenue South. The fate and transport evaluation conducted for this SWFS indicates that constituents released from the facility will be attenuated to achieve cleanup levels based on protection of surface water prior to the point where groundwater discharges to surface water. Most of the attenuation has been shown to occur upgradient of Fourth Avenue South. The groundwater containment provided by Alternative HA-1 has detached the plume from the source area; monitoring data collected since completion of the HCIM have already shown substantial decreases in COC concentrations downgradient from the facility.

Conservative modeling and calculations done for this SWFS predict that the remediation approach for the SWFS Area will achieve cleanup levels at the proposed CPOC, located just immediately outside the barrier wall.

6.2 DISPROPORTIONATE COST ANALYSIS

The MTCA regulations will be followed to determine whether further remediation is warranted inside the HCIM Area following the disproportionate cost analysis 173-340-360(3)(e). The most-often cited example of a disproportionate cost is a landfill where the large volumes of refuse, typically with a wide variety of contaminants, could be cleaned up only by excavating and moving the refuse to another engineered landfill. The costs to remove all refuse to a different landfill are disproportionate to the reduction of risk. The landfill case has been adopted by EPA as a presumptive remedy, in that the model remedy assumes that the landfill would be left in place and the appropriate remedy is capping. Ecology follows the EPA presumptive remedy approach for landfills.

As outlined above, the COCs within the HCIM Area are highly varied in nature and broadly distributed over the entire HCIM Area and to a depth of approximately 90 feet, of which about 80 feet are below the water table. Thus, on the order of 300,000 cubic yards of soil are impacted with a broad range of COCs having substantially different characteristics. The soil has been impacted either directly (from soil contamination or DNAPL) or indirectly in that the soil contains contaminated groundwater.

A variety of remedial alternatives were evaluated in Technical Memorandum 5 as part of the six alternatives to address soils and groundwater within the HCIM Area; however, none of the alternatives would successfully reduce concentrations of the broad range of COCs to attain cleanup levels over the full areal and vertical extent of impacted soil and groundwater within the HCIM Area. The technologies that are included in the six HCIM Area alternatives are:

- Enhanced anaerobic biodegradation,
- In situ chemical oxidation,
- Soil vapor extraction,

- Steam injection/stripping, and
- Groundwater extraction and treatment to remove contaminant mass.

The preferred alternative for the HCIM Area (Alternative HA-1) includes passive or natural anaerobic biodegradation with no other cleanup technology other than the existing HCIM containment system. Enhanced anaerobic bioremediation was proposed (Alternative HA-2) and enhanced anaerobic degradation, ISCO, and steam injection were paired with dewatering and SVE in Alternatives HA-3, HA-4, HA-5, and HA-6 to aggressively remediate the COCs in the HCIM Area. Alternative HA-6 also included excavation of hot spot shallow soils and Alternative HA-5 included a final phase of enhanced anaerobic bioremediation after allowing the heated soil and groundwater to cool to acceptable levels.

All the technologies were reviewed in the public literature to document cleanup performance expectations. Based on the existing literature, none of the technologies or combination of technologies would be expected to meet cleanup levels within the foreseeable future in the HCIM Area, either in the Shallow Aquifer (shallow and water table zone) or the Intermediate Aquifer. Although these alternatives could potentially meet cleanup levels in the Shallow Aquifer, at least in depths less than 40 feet, the inability of any alternative to significantly reduce concentrations in the highly interbedded silt and clay below 40 feet depth (the Intermediate Aquifer) would result in recontamination of the Shallow Aquifer through groundwater mixing and chemical diffusion. Thus, at best, cleanup levels would be achieved only temporarily for VOCs in the uppermost groundwater, but not for metals and PCBs.

Since it is not technically possible to meet cleanup levels in a reasonable time frame, all alternatives must assume maintenance of the existing containment system to be protective of human health and the environment. All of the alternatives would meet the remediation levels protective of the Duwamish Waterway under the highly conservative scenario of an earthquake causing major breaks in the barrier wall (as many as 12 breaks).

Implementation of any of the five alternatives other than Alternative HA-1 would be difficult, be extremely costly, result in potential for short-term risks to on-site workers and the public, and delay redeveloping the property, a major objective for PSC. Unless cleanup levels can be met, all alternatives would pose a similar risk; there would be no significant reduction in risk over Alternative HA-1, the least aggressive remediation alternative. The remediation objectives in Section 2.2 of this Technical Memorandum include Ecology's preference that reduction in contaminant concentrations is a beneficial result of the final remediation alternative if this can be practically done. COC concentration reduction would occur by implementation of the Preferred Alternative through natural anaerobic biodegradation of VOCs. Concentrations of VOCs have been and will continue to be reduced within the HCIM Area. However, the reduction of concentrations would be limited by the fact that the halogenated VOCs, the main risk drivers, are likely distributed throughout a broad cross section of the hydrostratigraphy and present in DNAPL ganglia. As a result, cleanup levels will not be met in the foreseeable future. As discussed in Technical Memorandum No. 1, diffuse DNAPL in heterogeneous soils, such as the interbedded silts and sands of the Intermediate Aquifer at the facility, cannot be effectively remediated. As long as DNAPL exists within the subsurface, concentrations of VOCs in the groundwater will continue to be elevated and the HCIM will need to remain in place. In other words, even an extremely costly and disruptive remediation approach inside the HCIM (such as Alternative HA-6) would not reduce COC concentrations and resultant risks to the point that the HCIM could be removed.

The baseline alternative for the HCIM area is Alternative HA-6, which would use steam injection throughout the Intermediate and Shallow Aquifers, SVE to address water table soils, long-term contaminant removal through pumping, and excavation of soil hotspot. Alternative HA-6 would not result in attainment of cleanup levels at an NPV cost of about $45.8 million or nearly 6 times the cost of implementing Alternative HA-1 and after an implementation period of as long as 20 years. This alternative would also destroy biological activity for a period as short as 2 years and as long as 20 years after completing steam injection; this would at best delay and at worst eliminate biodegradation reactions inside the barrier wall. As a result, there is nothing to be gained by implementation of Alternative HA-6 when compared to Alternative HA-1. Alternative HA-1 could be implemented within 1 year, allowing the property to be redeveloped and productive for 14 years before implementation of Alternative HA-6 could be completed. Ultimately, the HCIM barrier wall is critical to long-term control of COC migration from the facility and to protection of human health and the environment.

MTCA's disproportionate cost analysis can be performed quantitatively or qualitatively. For this SWFS, the qualitative approach to evaluating a case for a disproportionate cost analysis is appropriate. To help in this analysis, the EPA guidance (EPA, 1993) on technical impracticability in evaluating reduction in DNAPL was used. EPA has developed guidance to evaluating the potential benefits of source removal, including DNAPL. The criteria for evaluating DNAPL removal benefits are outlined below.

- Reduction of DNAPL mobility – It is beneficial to perform DNAPL reduction if the DNAPL is mobile and leaving it in place results in an increased risk that the DNAPL will continue to migrate. At the facility, DNAPL migration appears to have stabilized prior to the construction of the subsurface barrier wall. With the wall in place, there is no risk of DNAPL migration or migration of any other facility contaminants.

- Reduced Longevity – EPA guidance says that the up-front costs and effectiveness of source removal must be compared to the long-term costs (O&M costs) of controls without additional source reduction. This estimate can use the net-present worth cost basis to determine if a true benefit can be realized by upfront source removal. For the SWFS, the technology to treat COCs within the barrier wall to cleanup levels is not available. The best scenario would be a partial reduction in concentrations; however, after implementing any technology, halogenated VOCs would still remain in the subsurface as DNAPL and groundwater impacts would still present a risk of migration. Completing extensive and costly source reduction would not be sufficient to allow removal of any of the HCIM measures; therefore, the costs of implementing such source removal would add costs without any benefit of reduced costs of the HCIM operation.

- Reduction of contaminant mass discharge to receptors – The HCIM already addresses migration of COCs to receptors. Because of the widespread nature of the DNAPL, partial source reduction would not be effective in reducing concentrations of COCs in groundwater significantly; therefore, there would be no net gain in benefits for the dollars spent.

- Enhanced efficiency of complementary remediation technologies – If the HCIM did not exist, there might have been some benefit if source reduction could reduce groundwater concentrations to levels that could be addressed by another remediation alternative, such as monitored natural attenuation (MNA). However, partial source reduction would not reduce COCs sufficiently to use complementary technologies other than containment; the existing HCIM would still be needed, thereby providing no benefit. In fact, the analysis indicates that the barrier wall combined with MNA in the area outside the wall is effective in controlling groundwater migration without the need for the groundwater extraction and treatment technology. Therefore long-term operating costs for the existing HCIM can be minimized with the existing system. Additional source reduction would not have any impact on these long-term operation costs.

- Economic benefits – EPA further provides guidance on evaluating other potential economic benefits including:

  - Can you obtain earlier site closure and return of groundwater to beneficial use? – As outlined above, there currently is no technology that would allow the HCIM Area to be "clean closed" in the foreseeable future.

- Can you lower annual overall life cycle costs? – All potential source reduction technologies are costly, and none of them would result in any reduction in life-cycle costs.
- Can long-term liability and accrued environmental reserves be removed? – Since there is not a technology or group of technologies that could clean up the HCIM Area, the long-term liability would not be reduced significantly.
- Will the land value be enhanced? – contamination within the HCIM Area will remain above cleanup levels for a very long time with or without additional source reduction. No increase in value or decrease in liability would result from partial source removal. In addition, the property is currently lying idle and is not available for redevelopment and productive use until the final remedy has been implemented. The baseline alternative would take many more years to implement than the Preferred Alternative, so in this case, the more aggressive cleanup approach would cause more loss of value than a simpler, faster cleanup.
- Will future land use transaction be easier due to fewer encumbrances? – Performing costly source reduction would not be successful in meeting cleanup goals or in reducing any institutional controls on the HCIM Area, nor would future land use transactions become easier.

- Environmental Stewardship – From a stewardship basis, it would seem that reduction in COC concentrations should be considered the "right thing to do" and is consistent with Ecology policy. However, at the HCIM Area, source concentration reduction is occurring through natural anaerobic degradation and additional source reduction would not have an appreciable positive impact to the environment or provide reduction in long-term risk, even if extremely costly remedial measures were implemented. In fact, implementation of source control/reduction technologies would greatly increase the risk of accidents, spills, and releases during the implementation period, and some technologies could risk the barrier wall integrity or upset natural degradation processes that are occurring. In addition, the property is sitting idle and implementing an aggressive remedy would only delay the process of putting this site back into productive use. For this case, like the landfill example, further remediation of the source would provide no appreciable benefits.

Alternative HA-1 is the best long-term remediation option to address the broad range of COCs found throughout the areal and vertical extent of the HCIM Area. Subsurface barrier walls are true long-term solutions and have proven effective for the entire period of their use as containment features, which is at least 50 years. While they may fail due to catastrophic events, such as earthquakes, such events would only decrease, not eliminate, the barrier effectiveness. The barrier would continue to limit groundwater flow after an earthquake event. Surface cover has an equally long life span and can be adapted to a variety of site uses. The passive or natural anaerobic bioremediation included in the Preferred Alternative for the HCIM Area has reduced VOC concentrations to below remediation levels and will continue to reduce constituent mass within the contained area.

The benefits of groundwater extraction for the HCIM Area are questionable, because the primary migration pathway of VOCs with the barrier wall in place is vapor diffusion. Since the halogenated VOCs primarily degrade by anaerobic processes, shutting down the groundwater extraction system would enhance the reducing conditions in the HCIM Area and could be the best and most efficient approach to long-term reductions in VOC concentrations. Any COC reductions would be slow and not result in cleanup levels being met in a reasonable time frame.

6.3 IMPLEMENTATION

A preliminary plan has been developed for implementation of the preferred remediation approach for the facility. An incremental approach would be taken to implement the preferred remediation alternatives for the HCIM and Outside Areas. This incremental implementation approach has been developed to minimize potential risks to human health and the environment and to confirm that the assumptions and predictions made during this SWFS and the conceptual design of the remedial alternatives are accurate. The existing HCIM would be maintained active and in good working order prior to full implementation of the preferred remediation approach outlined in Section 6.1. As previously noted, the IPIM included in the preferred Outside Area alternative would be maintained active until cleanup levels are attained within the Outside Area.

The preliminary implementation plan outlined here would be developed more fully as part of the CAP that will be prepared after Ecology approval of the final SWFS Report. The institutional and administrative controls included in the preferred alternatives would be implemented upon approval of the CAP by Ecology.

The following approach is proposed for implementation of the preferred Site Wide remediation approach:

1. Maintain the HCIM and the IPIMs as currently operated and as appropriate to maintain effectiveness and address known risks.

2. Develop and implement institutional controls as described above for Alternatives HA-1 and OA-2.

3. Install appropriate surface cover within the PSC properties to cover affected soil.

4. Implement the planned (modified as necessary following completion of site characterization) excavation and soil disposal on the UPRR property.

5. Install additional monitoring wells along the CPOC, as identified in Section 5 for Alternative OA-2.

6. Commence groundwater monitoring, as described in Section 4 for Alternatives HA-2 and in Section 5 for Alternative OA-2.

7. Implement SVE in the area between the HCIM barrier wall and the SAD property, as described in Section 5 for Alternative OA-2.

8. Monitor the SVE system and collect confirmation samples as appropriate to confirm COC removal.

9. Implement enhanced bioremediation as described in Section 5 for Alternative OA-2.

The implementation approach outlined above would be developed in more detail in the CAP and in final design documents. The above outline is intended to summarize the general approach anticipated for the preferred Site Wide remediation approach. This approach and design may change during final engineering and finalization of implementation plans.

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TABLES

TABLE 4-1a

SHALLOW AND WATER TABLE DEPTH INTERVAL REMEDIATION LEVELS BASED ON DIFFERENT BARRIER WALL DAMAGE SCENARIOS

PSC Georgetown Facility
Seattle, Washington

concentrations in micrograms per liter (μg/L)

Constituent	Constituent Class [1]	SWFS CUL (mg/L)	Maximum Measured Concentration (mg/L)	Failure Scenario and Remediation Level (mg/L)				Basis for Remediation Levels
				Single 6-Inch Crack	Four 6-Inch Cracks	Twelve 6-Inch Cracks	Complete Wall Failure	
Tetrachloroethene	HAL VOC	0.2	282	20,000	4,000	280	20	BIOCHLOR Model - Ethenes
Trichloroethene	HAL VOC	0.8	612	35,000	5,000	610	40	BIOCHLOR Model - Ethenes
cis-1,2-Dichloroethene	HAL VOC	165	14,500	100,000 [2]	35,000 [2]	21,000 [2]	1,200 [2]	BIOCHLOR Model - Ethenes
trans-1,2-Dichloroethene	HAL VOC	1,691	7,120	100,000 [2]	35,000 [2]	21,000 [2]	1,200 [2]	BIOCHLOR Model - Ethenes
1,1-Dichloroethene	HAL VOC	25	106	100,000 [2]	35,000 [2]	21,000 [2]	1,200 [2]	BIOCHLOR Model - Ethenes
Vinyl chloride	HAL VOC	2.04	15,400	1,000,000	35,000	15,000	900	BIOCHLOR Model - Ethenes
1,1,1-Trichloroethane	HAL VOC	11	1,980	>10,000,000 [3]	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
1,1-Dichloroethane	HAL VOC	47	2,040	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
1,2-Dichloroethane	HAL VOC	30.6	1,100	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
Chloroethane	HAL VOC	461	1,530	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
Chloroform	HAL VOC	28	82	6,000,000	1,500,000	500,000	9,400	BIOCHLOR Model
1,1,2-Trichlorotrifluoroethane	HAL VOC	11,000	2,170					
Dichlorodifluoromethane	HAL VOC	2,904	15					
1,2-Dichlorobenzene	MISC	14	51.5	12,500	3,100	1,040	63	BIOSCREEN, No Degradation
1,4-Dichlorobenzene	MISC	2.5	25	2,200	550	180	11	BIOSCREEN, No Degradation
1,4-Dioxane	MISC	94.9	207	84,000	21,000	7,000	425	BIOSCREEN, No Degradation
2,4-Dimethylphenol	MISC	28.5	921	25,000	6,300	2,100	130	BIOSCREEN, No Degradation
2-Methylphenol	MISC	13	282	11,500	2,800	960	59	BIOSCREEN, No Degradation
4-Methylphenol	MISC	108	1,930	96,000	23,000	8,000	480	BIOSCREEN, No Degradation
Aroclor 1016	MISC	0.005	15.4	4.5	1.1	0.4	0.023	BIOSCREEN, No Degradation
Aroclor 1232	MISC	0.005	25.9	4.5	1.1	0.4	0.023	BIOSCREEN, No Degradation
Carbon disulfide	MISC	0.92	9.76	821	200	68	4.2	BIOSCREEN, No Degradation
Cyanide	MISC	10	48.9	8,900	2,200	740	45	BIOSCREEN, No Degradation
Methylphenol	MISC	1,650	2,680	1,400,000	360,000	120,000	7,400	BIOSCREEN, No Degradation
Pentachlorophenol	MISC	2.5	48.7	2,250	560	180	11	BIOSCREEN, No Degradation

TABLE 4-1a

SHALLOW AND WATER TABLE DEPTH INTERVAL REMEDIATION LEVELS BASED ON DIFFERENT BARRIER WALL DAMAGE SCENARIOS

PSC Georgetown Facility
Seattle, Washington

concentrations in micrograms per liter (μg/L)

Constituent	Constituent Class [1]	SWFS CUL (mg/L)	Maximum Measured Concentration (mg/L)	Failure Scenario and Remediation Level (mg/L)				Basis for Remediation Levels
				Single 6-Inch Crack	Four 6-Inch Cracks	Twelve 6-Inch Cracks	Complete Wall Failure	
Phenol	MISC	118	6,630	100,000	26,000	8,700	530	BIOSCREEN, No Degradation
1,2,4-Trimethylbenzene	Non-HAL HC	78	951	69,000	17,000	5,700	350	BIOSCREEN, No Degradation
1,3,5-Trimethylbenzene	Non-HAL HC	55.7	755	49,000	12,000	4,100	250	BIOSCREEN, No Degradation
1-Methyl naphthalene	Non-HAL HC	2.1	2.82	5,753,425	1,467,123	489,041	28,767	Ratio to ethylbenzene RL
2-Hexanone	Non-HAL HC	99	523	>10,000,000	>10,000,000	>10,000,000	1,356,164	Ratio to ethylbenzene RL
2-Methylnaphthalene	Non-HAL HC	2.1	21.7	5,753,425	1,467,123	489,041	28,767	Ratio to ethylbenzene RL
Benzene	Non-HAL HC	11.7	103	>10,000,000	>10,000,000	>10,000,000	4,400,000	BIOSCREEN Model
Benzo(a)anthracene	Non-HAL HC	0.02	0.0212	54,795	13,973	4,658	274	Ratio to ethylbenzene RL
Benzo(b)fluoranthene	Non-HAL HC	0.019	0.0417	53,151	13,553	4,518	266	Ratio to ethylbenzene RL
Benzo(k)fluoranthene	Non-HAL HC	0.018	0.0938	49,315	12,575	4,192	247	Ratio to ethylbenzene RL
Benzoic acid	Non-HAL HC	42	649	>10,000,000	>10,000,000	9,780,822	575,342	Ratio to ethylbenzene RL
C10-C12 (EPH) Aromatics	Non-HAL HC	---	2,160					
C8-C10 (EPH) Aliphatics	Non-HAL HC	---	2,360					
C8-C10 (EPH) Aromatics	Non-HAL HC	---	11,700					
C8-C10 (VPH) Aromatics	Non-HAL HC	---	28,600					
Chrysene	Non-HAL HC	0.018	0.0741	49,315	12,575	4,192	247	Ratio to ethylbenzene RL
Cumene	Non-HAL HC	7.3	76	20,000,000	5,100,000	1,700,000	100,000	Ratio to ethylbenzene RL
Dibenzo(a,h)anthracene	Non-HAL HC	0.016	77.6	44,384	11,318	3,773	222	Ratio to ethylbenzene RL
Diesel	Non-HAL HC	500	224,000	>10,000,000	>10,000,000	>10,000,000	6,849,315	Ratio to ethylbenzene RL
Ethylbenzene	Non-HAL HC	7.3	21,900	20,000,000	5,100,000	1,700,000	100,000	BIOSCREEN Model
Gasoline	Non-HAL HC	800	161,000	>10,000,000	>10,000,000	>10,000,000	10,958,904	Ratio to ethylbenzene RL
Indeno(1,2,3-cd)pyrene	Non-HAL HC	0.02	0.0592	54,795	13,973	4,658	274	Ratio to ethylbenzene RL
Lube Oil	Non-HAL HC	500	1,490	>10,000,000	>10,000,000	>10,000,000	6,849,315	Ratio to ethylbenzene RL
Methyl isobutyl ketone (MIBK)	Non-HAL HC	170	806	>10,000,000	>10,000,000	>10,000,000	2,328,767	Ratio to ethylbenzene RL
Naphthalene	Non-HAL HC	12	362	32,876,712	8,383,562	2,794,521	164,384	Ratio to ethylbenzene RL
n-Hexane	Non-HAL HC	1	4.21	2,739,726	698,630	232,877	13,699	Ratio to ethylbenzene RL

TABLE 4-1a

SHALLOW AND WATER TABLE DEPTH INTERVAL REMEDIATION LEVELS BASED ON DIFFERENT BARRIER WALL DAMAGE SCENARIOS

PSC Georgetown Facility
Seattle, Washington

concentrations in micrograms per liter (µg/L)

Constituent	Constituent Class [1]	SWFS CUL (mg/L)	Maximum Measured Concentration (mg/L)	Failure Scenario and Remediation Level (mg/L)				Basis for Remediation Levels
				Single 6-Inch Crack	Four 6-Inch Cracks	Twelve 6-Inch Cracks	Complete Wall Failure	
Propylbenzene	Non-HAL HC	7.3	172	>10,000,000	5,100,000	1,700,000	100,000	Ratio to ethylbenzene RL
sec-Butylbenzene	Non-HAL HC	4.6	202	12,577,111	3,207,163	1,069,054	62,886	Ratio to ethylbenzene RL
Styrene	Non-HAL HC	0.5	47.4	1,369,863	349,315	116,438	6,849	Ratio to ethylbenzene RL
Toluene	Non-HAL HC	9.8	66,900	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOSCREEN Model
Xylenes (Total)	Non-HAL HC	141	15,900	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOSCREEN Model
Arsenic	Metals	0.051	16.7					
Barium	Metals	4	32.9					
Chromium	Metals	10	12.5					
Copper	Metals	3.1	7.35					
Iron	Metals	1,000	79,400					
Lead	Metals	2.5	10.1					
Nickel	Metals	8.2	9.14					

Notes:
1. Constituent class: HAL VOC = halogenated vlatile organic compound; MISC = miscellaneous; non-HAL HC = nonhalogenated hydrocargon.
2. Remediation level is for total dichloroethenes.
3. > = Remediation level is greated than the indicated concentration.

TABLE 4-1b

INTERMEDIATE DEPTH INTERVAL REMEDIATION LEVELS BASED ON DIFFERENT BARRIER WALL FAILURE SCENARIOS

PSC Georgetown Facility
Seattle, Washington

concentrations in micrograms per liter (μg/L)

Constituent	Constituent Class[1]	SWFS CUL (mg/L)	Maximum Measured Concentration (mg/L)	Failure Scenario and Remediation Level (mg/L)				Basis for Remediation Level
				Single 6-Inch Crack	Four 6-Inch Cracks	Twelve 6-Inch Cracks	Complete Wall Failure	
Tetrachloroethene	HAL VOC	0.20	40.3	>10,000,000[2]	>10,000,000	5,000,000	200,000	BIOCHLOR Model - Ethenes
Trichloroethene	HAL VOC	0.79	143,000	>10,000,000	>10,000,000	5,000,000	400,000	BIOCHLOR Model - Ethenes
cis-1,2-Dichloroethene	HAL VOC	165	85,400	>10,000,000[3]	>10,000,000[3]	>10,000,000[3]	20,000,003	BIOCHLOR Model - Ethenes
trans-1,2-Dichloroethene	HAL VOC	1,691	12,800	>10,000,000[3]	>10,000,000[3]	>10,000,000[3]	20,000,003	BIOCHLOR Model - Ethenes
1,1-Dichloroethene	HAL VOC	25	1,380	>10,000,000[3]	>10,000,000[3]	>10,000,000[3]	20,000,003	BIOCHLOR Model - Ethenes
Vinyl chloride	HAL VOC	2.04	67,200	>10,000,000	>10,000,000	>10,000,000	2,000,000	BIOCHLOR Model - Ethenes
1,1,1-Trichloroethane	HAL VOC	11	16.5	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
1,1-Dichloroethane	HAL VOC	47	1,040	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
1,2-Dichlorobenzene	Misc	14	197	12,500	3,100	1,000	64	BIOSCREEN, No Degradation
2,4-Dimethylphenol	Misc	28.5	444	25,000	6,300	2,100	130	BIOSCREEN, No Degradation
2-Methylphenol	Misc	13	302	11,600	2,900	970	59	BIOSCREEN, No Degradation
4-Methylphenol	Misc	108	2,230	96,000	24,000	8,000	490	BIOSCREEN, No Degradation
Carbon disulfide	Misc	0.92	46.6	800	200	69	4.2	BIOSCREEN, No Degradation
Cyanide	Misc	10	64.9	8,900	2,200	750	46	BIOSCREEN, No Degradation
Phenol	Misc	118	4,670	100,000	26,500	8,800	540	BIOSCREEN, No Degradation
1,2,4-Trimethylbenzene	Non-HAL HC	78	475	69,000	17,000	5,800	350	BIOSCREEN, No Degradation
Benzene	Non-HAL HC	11.7	73.6	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOSCREEN Model
Diesel	Non-HAL HC	500	1,500	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOSCREEN Model
Ethylbenzene	Non-HAL HC	7.3	2,200	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOSCREEN Model
Lube Oil	Non-HAL HC	500	516	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOSCREEN Model
Styrene	Non-HAL HC	0.5	6.1	450	110	37	2.3	BIOSCREEN, No Degradation
Toluene	Non-HAL HC	9.8	3,520	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOSCREEN Model
Xylenes (Total)	Non-HAL HC	141	884	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOSCREEN Model
Arsenic	Metals	0.051	17.8					

TABLE 4-1b

INTERMEDIATE DEPTH INTERVAL REMEDIATION LEVELS
BASED ON DIFFERENT BARRIER WALL FAILURE SCENARIOS
PSC Georgetown Facility
Seattle, Washington

concentrations in micrograms per liter (µg/L)

Constituent	Constituent Class[1]	SWFS CUL (mg/L)	Maximum Measured Concentration (mg/L)	Failure Scenario and Remediation Level (mg/L)				Basis for Remediation Level
				Single 6-Inch Crack	Four 6-Inch Cracks	Twelve 6-Inch Cracks	Complete Wall Failure	
Barium	Metals	4	64					
Chromium	Metals	10	76					
Copper	Metals	3.1	25.3					
Iron	Metals	1,000	75,000					
Lead	Metals	2.5	7.13					
Manganese	Metals	100	268					
Nickel	Metals	8.2	67.2					
Vanadium	Metals	20	41					

Notes:
1. HAL VOC = halogenated volatile organic compounds; MISC = miscellaneous; non-HAL HC = nonhalogenated hydrocargon.
2. >Remediation level is greater than the indicated concentration.
3. Remediation level is for total dichloroethenes.

TABLE 4-2

NATURAL ATTENUATION INDICATOR PARAMETERS

PSC Georgetown Facility
Seattle, Washington

Well	Date	DO (mg/L)	Redox Potential (mV)	Carbon Dioxide (mg/L)	Ethane (µg/L)	Ferric Iron (mg/L)	Ferrous Iron (mg/L)	Iron (µg/L)	Methane (µg/L)	Nitrate (as N) (mg/L)	Nitrite (as N) (mg/L)
Background Monitoring Wells											
CG-3	5/20/2002	---[1]	---	7.39	<10[2]	3.14	<0.5	---	57.1	<0.2	<0.2
	8/7/2002	---	---	6.34	<10	0.695	1.06	---	277	<0.2	<0.2
	11/12/2002	---	---	6.16	<10	<0.5	1.15	---	23.2	<0.2	<0.2
	10/23/2003	0.44	14	---	---	---	---	---	---	---	---
	2/4/2003	---	---	8.45	<10	0.867	0.955	---	89.1	<0.2	<0.2
	5/15/2003	---	---	<5	<10	0.87	1.35*	2,220	3.88	<0.2	<0.2
CG-101-S1	11/9/1999	---	---	18.6	<2	---	---	<100	35.8	---	0.116
	2/8/2000	---	---	<10	<2	<0.5	<1	---	<2	---	0.28
	8/14/2000	---	---	9.68	<10	---	<0.5	<150	7.38	<0.1	<0.1
	11/8/2000	---	---	8.8	<10	---	<0.5	<150	2.12	<0.1	<0.1
	2/26/2001	---	---	<5	<10	<0.5	<0.5	---	7.3	<0.1	<0.1
	5/17/2001	---	---	61.6	<10	8.99	---	<150	<1.2	<0.1	<0.1
	8/14/2001	---	---	<5	<10	<0.5	<0.5	---	22	<0.1	<0.1
	11/8/2001	---	---	7.04	<10	<0.5	<0.5	---	<1.2	0.183	<0.1
	2/5/2002	---	---	5.28	<10	<0.5	<0.5	---	<1.2	0.235	<0.1
	5/22/2002	---	---	5.46	<10	<0.5	<0.5	---	<1.2	<0.2	<0.2
	7/31/2002	---	155	7.92	<10	<0.5	<0.5	---	12.6	<0.2	<0.2
	11/13/2002	8.16	248	14.1	<10	<0.5	<0.5	---	<1.2	0.464	<0.2
	2/5/2003	---	529	6.34	<10	<0.5	<0.5	---	<1.2	<0.2	<0.2
	5/15/2003	---	---	13.6	<10	2.89	0.04 *	2903	29.5	<0.2	<0.2
	10/23/2003	5.8	196	---	---	---	---	---	---	---	---
	10/28/2004	5.34	412	---	---	---	---	---	---	---	---
	11/2/2005	0.27	364	---	---	---	---	---	---	---	---
CG-106-WT	5/20/2002	---	---	22	<10	<0.5	<0.5	---	7.91	0.319	<0.2
	7/30/2002	---	---	10.6	<10	<0.5	<0.5	---	13.1	0.241	<0.2
	11/12/2002	---	---	<5	<10	---	---	0.313	32.7	0.259	<0.2
	2/7/2003	---	---	20.8	<10	<0.5	<0.5	---	34.9	0.638	<0.2
	5/15/2003	---	---	7.39	<10	<0.15	---	<0.15	<1.2	0.242	<0.2
	10/22/2003	3.9	183	---	<10	---	0.07	<0.3	9.9	<0.2	<0.2
	2/17/2004	---	---	---	<10	0.1	0.1	<0.3	1.66	0.563	---
	10/28/2004	2.78	409	---	<10	<1	<0.001	<0.3	15.6	<0.2	---
	2/16/2005	---	---	---	<10	---	<0.3	<0.3	<1.2	0.317	---
	10/31/2005	0.63	430	---	<0.35	<1	0.55	0.0189	15	<0.008	---
	2/22/2006	3.46	452	---	<0.38	<1	---	0.008	12	1.8	---
	11/6/2006	---	---	---	<0.5	1	---	0.029	0.61	3.1	---
CG-106-I	5/21/2002	---	---	9.68	<10	6.97	<0.5	1.32	30,600	<0.2	<0.2
	7/30/2002	---	---	17.6	<10	1.27	<0.5		34,400	<0.2	<0.2
	11/12/2002	---	---	8.62	<10	1.68	---	---	33,100	<0.2	<0.2
	2/7/2003	---	---	11.6	<10	---	<0.5	---	41,100	<0.2	<0.2
	5/15/2003	---	---	7.04	<10	0.29	---	1.24	29,900	<0.2	<0.2
	10/22/2003	0.35	-103	---	<10	0.58	1.6	2.18	31,600	<0.2	---
	2/17/2004	---	---	---	<10	0.86	1.21	1.39	29,000	<0.2	---
	10/28/2004	0.17	311	---	<10	0	1.64	1.59	35,200	<0.2	---
	2/16/2005	---	---	---	<10	0.45	1.31	1.76	35,800	<0.2	---
	10/31/2005	0.21	473	---	1.1	<1	1.07	1.72	21,000	<0.008	---
	2/22/2006	0.23	486	---	2.3	<1	1.4	1.61	27,000	<0.008	---
	11/6/2006	---	---	---	0.42	<1	1.45	1.69	26,000	<0.008	---
CG-106-D	5/22/2002	---	---	7.92	<10	13	<0.5	---	861	<0.2	<0.2
	7/30/2002	---	---	30.8	<10	0.817	<0.5	---	1020	<0.2	<0.2
	11/12/2002	---	---	<5	<10	---	---	0.51	475	<0.2	<0.2
	2/7/2003	---	---	15.3	<10	1.21	<0.5	---	1180	<0.2	<0.2
	5/15/2003	---	---	8.27	<10	0.123	---	0.483	1030	<0.2	<0.2
	10/22/2003	0.35	-77	---	<10	0.345	0.37	0.715	898	<0.2	---
	2/17/2004	---	---	---	<10	1.96	0.54	0.466	1220	<0.2	---
	10/28/2004	0.32	488	---	<10	-0.467	1.12	0.653	1030	<0.2	---
	2/16/2005	---	---	---	<10	0.74	0.6	1.34	829	<0.2	---
	10/31/2005	---	---	---	<0.35	<1	0.49	0.583	210	<0.008	---
	2/22/2006	0.18	503	---	<0.38	<1	0.61	0.564	1100	<0.008	---
	11/6/2006	---	---	---	<0.10	1	0.25	0.492	150	<0.008	---

TABLE 4-2

NATURAL ATTENUATION INDICATOR PARAMETERS

PSC Georgetown Facility
Seattle, Washington

Well	Date	DO (mg/L)	Redox Potential (mV)	Carbon Dioxide (mg/L)	Ethane (µg/L)	Ferric Iron (mg/L)	Ferrous Iron (mg/L)	Iron (µg/L)	Methane (µg/L)	Nitrate (as N) (mg/L)	Nitrite (as N) (mg/L)
HCIM Area Groundwater Monitoring Wells											
CG-1-S1	2/27/2001	---	---	---	<10	---	--	---	2970	---	---
	10/20/2003	0.44	-108	---	---	---	---	---	---	---	---
	11/16/2004	0.37	437	---	---	---	---	---	---	---	---
	11/15/2005	0.4	153	---	---	---	---	---	---	---	---
CG-1-I	2/27/2001	---	---	---	<10	---	--	---	28400	---	---
	11/16/2004	0.41	465	---	---	---	---	---	---	---	---
	11/15/2005	0.24	43	---	---	---	---	---	---	---	---
CG-1-D	11/18/2004	0.68	533	---	---	---	---	---	---	---	---
	11/15/2005	0.31	14	---	---	---	---	---	---	---	---
CG-10-S1	2/27/2001	---	---	---	<10	---	---	---	210	---	---
	10/20/2003	0.53	377	---	---	---	---	---	---	---	---
CG-146-WT	11/16/2004	0.32	450	---	---	---	---	---	---	---	---
	11/15/2005	0.34	123	---	---	---	---	---	---	---	---
	5/22/2006	---	---	---	320	---	---	---	14000	---	---
CG-146-80	11/17/2004	0.4	482	---	---	---	---	---	---	---	---
	11/15/2005	0.53	11	---	---	---	---	---	---	---	---
	5/15/2006			---	12	---	---	---	33000	---	---
CG-148-WT	5/25/2006	---	---	---	0.86	---	---	---	7200	---	---
CG-148-57	5/25/2006	---	---	---	0.76	---	---	---	25000	---	---
CG-150-WT	11/16/2004	0.48	451	---	---	---	---	---	---	---	---
	11/15/2005	0.25	103	---	---	---	---	---	---	---	---
CG-150-68	11/18/2004	0.75	496	---	---	---	---	---	---	---	---
	11/15/2005	0.26	52	---	---	---	---	---	---	---	---
CG-152-WT	5/15/2006	---	---	---	43	---	---	---	6400	---	---
CG-152-79	5/17/2006	---	---	---	1.4	---	---	---	35000	---	---

Notes:
1. -- = Not available.
2. < = analyte not detected at detection limit specified.
3. * Field Test

TABLE 4-3

HCIM AREA GROUNDWATER MONITORING PROGRAM

PSC Georgetown Facility
Seattle, Washington

Alternative	Purpose	Number of Wells	Length of Monitoring (years)
HA-1: Active Hydraulic Containment	--	none	--
HA-2: Enhanced Anaerobic Bioremediation	Bioremediation Performance Monitoring	4	6
HA-3: Enhanced Anaerobic Bioremediation/Dewatering/SVE	Bioremediation Performance Monitoring	4	6
HA-4: ISOC/Dewatering/SVE	ISOC Performance Monitoring	4	6
HA-5: Steam Stripping/Dewatering/SVE/Enhanced Anaerobic Bioremediation	Bioremediation Performance Monitoring	4	11
	Steam Stripping Performance Monitoring	5	
HA-6: Steam Stripping/Dewatering/SVE/Excavation	Steam Stripping Performance Monitoring	5	15

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TABLE 4-4a

ESTIMATED REMEDIATION TIME FRAMES FOR HCIM ALTERNATIVES PER COC WATER TABLE AND SHALLOW GROUNDWATER DEPTH INTERVALS

PSC Georgetown Facility
Seattle, Washington

Constituent[1]	Final SWFS Cleanup Level (µgL)	Maximum Detected Concentration (µgL)	Half Life[2] (yr)	Estimated Remediation Time[3] (years)					
				Alternative HA-1	Alternative HA-2	Alternative HA-3	Alternative HA-4	Alternative HA-5	Alternative HA-6
Chloroethane	461	1,530	1.0	15 - 20	10 - 20	7 - 20	7 - 20	3 - 5	3 - 5
Chloroform	28	82	2.4	10 - 25	5 - 25	5 - 25	5 - 25	1 - 25	1 - 25
1,1-Dichloroethane	47	2,040	0.31	10 - 20	7 - 20	5 - 20	5 - 20	3 - 20	3 - 20
1,1-Dichloroethene	25	106	0.58[4]	10 - 20	7 - 20	5 - 20	5 - 20	3 - 20	3 - 20
1,2-Dichloroethane	30.6	1,100	0.31	10 - 20	7 - 20	5 - 20	5 - 20	3 - 20	3 - 20
cis-1,2-Dichloroethene	165	14,500	0.58[4]	225 - 250	225 - 250	200 - 250	200 - 250	150 - 250	150 - 250
trans-1,2-Dichloroethene	1,691	7,120	0.5	200 - 250	200 - 250	175 - 250	175 - 250	125 - 250	125 - 250
Tetrachloroethene	0.2	282	5.3	100 -150	75 -150	50 -150	50 -150	30 -150	30 -150
Trichloroethene	0.8	612	7.2	200 - 300	200 - 300	175 - 300	175 - 300	125 - 300	125 - 300
1,1,1-Trichloroethane	11	1,980	0.83	10 - 20	7 - 20	5 - 20	5 - 20	3 - 20	3 - 20
Vinyl chloride	2.04	15,400	3	300 - 350	275 - 350	250 - 350	225 - 350	175 - 350	175 - 350
Benzene	11.7	103	1.1	5 - 10	3 - 10	2 - 10	1 - 10	39092.0	39092.0
Benzo(a)anthracene	0.02	0.0212	Biodeg[5]	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5
Benzo(b)fluoranthene	0.019	0.0417	Biodeg	5 - 10	3 - 10	3 - 10	3 - 10	3 - 10	3 - 10
Benzo(k)fluoranthene	0.018	0.0938	Biodeg	10 - 30	7 - 30	7 - 30	7 - 30	7 - 30	7 - 30
Benzoic acid	42	649	0.015[5]	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5
Chrysene	0.018	0.0741	Biodeg	3 - 10	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10
Cumene	7.3	76	1.6[4]	10 - 20	7 - 10	7 - 10	7 - 10	7 - 10	7 - 10
Dibenzo(a,h)anthracene	0.016	77.6	Biodeg	15 - 25	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25
Diesel	500	224,000	Biodeg	30 - 60	25 - 60	20 - 60	20 - 60	20 - 60	20 - 60
Ethylbenzene	7.3	21,900	1.6	30 - 60	25 - 60	20 - 60	15 - 60	15 - 60	15 - 60
Gasoline	800	161,000	Not. Det.[7]	20 - 60	15 - 60	15 - 60	10 - 60	5 - 60	5 - 60
2-Hexanone	99	523	26[4]	65 - 150	60 - 150	60 - 150	60 - 150	45 - 150	45 - 150
Indeno(1,2,3-cd)pyrene	0.02	0.0592	Biodeg	10 - 50	7 - 50	7 - 50	7 - 50	7 - 50	7 - 50
1-Methyl naphthalene	2.1	2.82	4.4	5 - 20	5 - 20	5 - 20	5 - 20	5 - 20	5 - 20
2-Methylnaphthalene	2.1	21.7	4.4[4]	15 - 50	10 - 50	10 - 50	10 - 50	10 - 50	10 - 50

TABLE 4-4a

ESTIMATED REMEDIATION TIME FRAMES FOR HCIM ALTERNATIVES PER COC
WATER TABLE AND SHALLOW GROUNDWATER DEPTH INTERVALS

PSC Georgetown Facility
Seattle, Washington

Constituent[1]	Final SWFS Cleanup Level (µgL)	Maximum Detected Concentration (µgL)	Half Life[2] (yr)	Estimated Remediation Time[3] (years)					
				Alternative HA-1	Alternative HA-2	Alternative HA-3	Alternative HA-4	Alternative HA-5	Alternative HA-6
Lube Oil	500	1,490	Not Det.	50 - 75	45 - 75	45 - 75	45 - 75	30 - 75	30 - 75
Methyl isobutyl ketone (MIBK)	170	806	26	60 - 100	55 - 100	50 - 100	50 - 100	40 - 100	40 - 100
Naphthalene	12	362	0.53	3 - 10	3 - 10	3 - 10	3 - 10	1 - 10	1 - 10
n-Hexane	1	4.21	Biodeg	5 - 15	3 - 15	3 - 15	3 - 15	1 - 15	1 - 15
Propylbenzene	7.3	172	1.6[4]	10 - 25	7 - 25	7 - 25	5 - 25	3 - 25	3 - 25
sec-Butylbenzene	4.6	202	1.6[4]	10 - 25	7 - 25	7 - 25	5 - 25	3 - 25	3 - 25
Styrene	0.5	47.4	1.6[4]	10 - 50	10 - 50	10 - 50	10 - 50	7 - 50	7 - 50
Toluene	9.8	66,900	0.98	25 - 50	20 - 50	15 - 50	12 - 50	7 - 50	7 - 50
1,2,4-Trimethylbenzene	78	951	ND[8]	100 - 150	100 - 150	75 - 150	75 - 150	50 - 150	50 - 150
1,3,5-Trimethylbenzene	55.7	755	ND	100 - 150	100 - 150	75 - 150	75 - 150	50 - 150	50 - 150
Xylenes (Total)	141	15,900	1.2	15 - 20	10 - 20	10 - 20	7 - 20	5 - 20	5 - 20
Carbon disulfide	0.92	9.76	Not Det.	5 - 10	5 - 10	5 - 10	5 - 10	1 - 5	1 - 5
Cyanide	10	48.9	Biodeg	5 - 10	3 - 10	5 - 10	5 - 10	1 - 5	1 - 5
1,2-Dichlorobenzene	14	51.5	ND	100 - 150	100 - 150	75 - 150	75 - 150	50 - 150	50 - 150
1,4-Dichlorobenzene	2.5	25	ND	100 - 150	100 - 150	75 - 150	75 - 150	50 - 150	50 - 150
1,4-Dioxane	94.9	207	ND	100 - 150	100 - 150	75 - 150	75 - 150	20 -150	15 - 150
2,4-Dimethylphenol	28.5	921	0.11[4]	5 - 10	5 - 10	5 - 10	5 - 10	3 - 10	3 - 10
2-Methylphenol	13	282	0.11	5 - 10	5 - 10	5 - 10	5 - 10	3 - 10	3 - 10
4-Methylphenol	108	1,930	0.08	5 - 10	5 - 10	5 - 10	5 - 10	3 - 10	3 - 10
Methylphenol	1,650	2,680	0.11[4]	5 - 10	5 - 10	5 - 10	5 - 10	3 - 10	3 - 10
Pentachlorophenol	2.5	48.7	ND	100 - 150	100 - 150	75 - 150	75 - 150	50 - 150	50 - 150
Phenol	118	6,630	0.11	5 - 10	5 - 10	5 - 10	5 - 10	3 - 10	3 - 10
Arsenic	0.051	16.7	ND	---	---	---	---	---	
Barium	4	32.9	ND	---	---	---	---	---	
Chromium	10	12.5	ND	---	---	---	---	---	
Copper	3.1	7.35	ND	---	---	---	---	---	

TABLE 4-4a

ESTIMATED REMEDIATION TIME FRAMES FOR HCIM ALTERNATIVES PER COC WATER TABLE AND SHALLOW GROUNDWATER DEPTH INTERVALS

PSC Georgetown Facility

Seattle, Washington

Constituent[1]	Final SWFS Cleanup Level (µgL)	Maximum Detected Concentration (µgL)	Half Life[2] (yr)	Estimated Remediation Time[3] (years)					
				Alternative HA-1	Alternative HA-2	Alternative HA-3	Alternative HA-4	Alternative HA-5	Alternative HA-6
Iron	1,000	79,400	ND	---	---	---	---	---	
Lead	2.5	10.1	ND	---	---	---	---	---	
Nickel	8.2	9.14	ND	---	---	---	---	---	
Aroclor 1016	0.005	15.4	ND	---	---	---	---	10 - 15	
Aroclor 1232	0.005	25.9	ND	---	---	75 - 150	---	10 - 15	

Notes:

1. Only constituents that have been detected in the water table/shallow groundwater depth interval above the final SWFS cleanup level in the HCIM Area are listed in the table.
2. When available, half lives are as used for modeling fate and transport of COCs. For COCs not modeled, half lives are the average values for anaerobic biodegradation taken from Aronson, 1997.
3. Remediation time frames estimated considering: (1) COC half lives (when available); (2) ratio of maximum detected concentration to cleanup level; (3) expected performance of remediation technologies at sites similar to the HCIM Area.
4. No available half life data. Half lives are estimated based on available data for similar compound.
5. Biodeg. = literature sources indicate constituent biodegrades under anaerobic conditions; however, biodegradation rates were available only for aerobic conditions.
6. Calculated from data taken from the CHEMFATE web site (Syracuse Research Corporation, esc.syrres.com/scripts/CHFcgi.exe).
7. Not Det. = Not determined. No suitable data identified; degradation rate could not be determined.
8. ND = No degradation.

TABLE 4-4b

ESTIMATED REMEDIATION TIME FRAMES FOR HCIM ALTERNATIVES PER COC
INTERMEDIATE GROUNDWATER DEPTH INTERVAL

PSC Georgetown Facility
Seattle, Washington

Constituent	SWFS CUL (µgL)	Maximum Detected Concentration (µgL)	Half Life (years)	Estimated Remediation Time Frames (years)[1]					
				HA-1	HA-2	HA-3	HA-4	HA-5	HA-6
1,1-Dichloroethane	47	1,040	0.31	3 - 10	3 - 10	3 - 10	3 - 10	1 - 10	1 - 10
1,1-Dichloroethene	25	1,380		3 - 10	3 - 10	3 - 10	3 - 10	1 - 10	1 - 10
cis-1,2-Dichloroethene	165	85,400	0.58	225 - 250	225 - 250	225 - 250	225 - 250	200 - 250	200 - 250
trans-1,2-Dichloroethene	1,691	12,800		200 - 250	200 - 250	200 - 250	200 - 250	175 - 250	175 - 250
Tetrachloroethene	0.20	40.3	5.3	50 -75	50 -75	50 -75	50 -75	30 -75	30 -75
Trichloroethene	0.79	143,000	7.2	200 - 250	200 - 250	200 - 250	200 - 250	150 - 250	150 - 250
1,1,1-Trichloroethane	11	16.5	0.83	1 - 5	1 - 5	1 - 5	1 - 5	0 - 5	0 - 5
Vinyl chloride	2.04	67,200	3.0	250 - 300	250 - 300	250 - 300	250 - 300	200 - 300	200 - 300
Benzene	11.7	73.6	1.1	5 - 10	5 - 10	5 - 10	5 - 10	1 - 10	1 - 10
Diesel	500	1,500	Biodeg[2]	30 - 60	30 - 60	30 - 60	30 - 60	20 - 60	20 - 60
Ethylbenzene	7.3	2,200	1.6	20 - 30	20 - 30	20 - 30	20 - 30	15 - 30	15 - 30
Lube Oil	500	516		50 - 100	50 - 100	50 - 100	50 - 100	30 - 100	30 - 100
Styrene	0.5	6.1	1.6[3]	10 - 25	10 - 25	10 - 25	10 - 25	7 - 25	7 - 25
Toluene	9.8	3,520	0.98	10 - 15	10 - 15	10 - 15	10 - 15	7 - 15	7 - 15
1,2,4-Trimethylbenzene	78	475	ND[4]	100 - 150	100 - 150	100 - 150	100 - 150	75 - 150	75 - 150
Xylenes (Total)	141	884	1.2	5 -10	5 -10	5 -10	5 -10	1 -10	1 -10
Carbon disulfide	0.92	46.6	Not Det.[5]	5 - 10	5 - 10	5 - 10	5 - 10	1 - 5	1 - 5
Cyanide	10	64.9	Biodeg	5 - 10	5 - 10	5 - 10	5 - 10	1 - 10	1 - 10
1,2-Dichlorobenzene	14	197	ND	100 - 150	100 - 150	100 - 150	100 - 150	75 - 150	75 - 150
2,4-Dimethylphenol	28.5	444	0.11	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10
2-Methylphenol	13	302	0.11	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10
4-Methylphenol	108	2,230	0.08	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10
Phenol	118	4,670	0.11	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10
Arsenic	0.051	17.8	ND	---[6]	---	---	---	---	---
Barium	4	64	ND	---	---	---	---	---	---
Chromium	10	76	ND	---	---	---	---	---	---
Copper	3.1	25.3	ND	---	---	---	---	---	---
Iron	1,000	75,000	ND	---	---	---	---	---	---
Lead	2.5	7.13	ND	---	---	---	---	---	---
Manganese	100	268		---	---	---	---	---	---
Nickel	8.2	67.2	ND	---	---	---	---	---	---
Vanadium	20	41		---	---	---	---	---	---

Notes:

1. Remediation time frames estimated based on: (1) COC half lives (when available); (2) ratio of maximum detected concentration to CUL; (3) performance of remediation technologies at sites similar to the HCIM Area
   Only constituents that have been detected in the water table/shallow groundwater depth interval above the cleanup level in the HCIM Area are listed in the table.
2. Biodeg. = literature sources indicate constituent biodegrades under anaerobic conditions; however, biodegradation rates were only identified for aerobic conditions.
3. No available half life data. Half lives are based on available data for similar compound.
4. ND = No degredation
5. Not Det. = Not determined. No suitable data identified; degradation rate could not be determined.
6. --- = limited or no mass reduction, cleanup levels unlikely to be obtained

TABLE 4-5

EVALUATION OF HCIM AREA REMEDIAL ALTERNATIVES

PSC Georgetown Facility
Seattle, Washington

Standards/Criteria	Alternative Rating[1]					
	HA-1 Active Hydraulic Containment	**HA-2** Enhanced Anaerobic Bioremediation	**HA-3** Enhanced Anaerobic Bioremediation/Dewatering/SVE	**HA-4** In Situ Chemical Oxidation/ Dewatering/ SVE	**HA-5** Steam Stripping/ Enhanced Anaerobic Bioremediation/ Dewatering/ SVE	**HA-6** Steam Stripping/ Dewatering/ SVE/Excavation
Protectiveness and Risk Reduction	3	3	3	3	3	4
Permanence	1	2	3	3	4	4
Cost	5	4	3	2	1	1
Long-term Effectiveness	1	2	2	2	3	3
Management of Short-Term Risks	5	4	3	2	1	1
Technical and Administrative Implementability	5	4	3	2	1	1
Public Concern	4	5	4	4	3	2
Restoration Timeframe	2	3	3	3	4	4
TOTAL[2]	**26**	**27**	**24**	**21**	**20**	**20**

Notes:
1. Alternatives are rated from 5 to 1, with a rating of 5 indicating the highest or most favorable performance for that criterion.
2. In accordance with EPA guidance for each criterion and the MTCA regulations, all standards and/or criteria are considered equal; no weighting is given any individual criterion.

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TABLE 4-6

NET PRESENT VALUE COST SUMMARY HCIM AREA[1]

PSC Georgetown Facility
Seattle, Washington

HCIM Area Remedial Alternatives	Net Present Value Cost	Net Present Value Cost (High)	Net Present Value Cost (Low)
HA-1: Active Hydraulic Containment	$7,211,300	NA	NA
HA-2: Enhanced Anaerobic Bioremediation	$9,249,800	$9,303,000	$9,202,100
HA-3: Enhanced Anaerobic Bioremediation/Dewatering/SVE	$14,283,300	$15,411,400	$13,101,700
HA-4: ISCO/Dewatering/SVE	$15,278,400	$16,870,900	$13,575,500
HA-5: Steam Stripping/Enhanced Anaerobic Bioremediation/Dewatering/SVE	$45,040,900	$56,111,400	$27,757,500
HA-6: Steam Stripping/Dewatering/SVE/Excavation	$45,827,200	$57,177,400	$27,853,600

Notes:
1. All costs are in 2007 dollars. Detailed estimated are presented in Appendix A.

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TABLE 5-1

OUTSIDE AREA GROUNDWATER MONITORING PROGRAM

PSC Georgetown Facility
Seattle, Washington

Alternative	HCIM Performance Monitoring		CPOC Monitoring		Outside Area Remediation Monitoring	
	Number of Wells	Length of Monitoring (years)	Number of Wells	Length of Monitoring (years)	Number of Wells	Length of Monitoring (years)
OA-1: Monitored Natural Attenuation	12	100	11	100	14	31
OA-2: Enhanced Bioremediation, PCB Excavation, SVE, and Surface Cover	12	100	11	100	14	18
OA-3: Enhanced Bioremediation, Hot Spot Excavation, SVE, and Surface Cover	12	100	11	100	14	18
OA-4: Enhanced Bioremediation, Hydraulic Control, Hot Spot Excavation, SVE, and Surface Cover	12	100	11	100	14	18
OA-5: Enhanced Bioremediation, Groundwater Recovery and Treatment, Hot Spot Excavation, SVE, and Surface Cover	12	100	11	100	14	18

Notes:
1. The 8 hydraulic control wells would be monitored for 10 years; the downgradient well network would be monitored for 18 years.
2. Four of the hydraulic control wells (along Fourth Avenue South) would be monitored for 10 years; the 3 pump and treat wells would be monitored for 5 yearas; the downgradient monitoring well network would be monitored for 18 years.

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TABLE 5-2

EVALUATION OF OUTSIDE AREA REMEDIAL ALTERNATIVES
PSC Georgetown Facility
Seattle, Washington

Standards/Criteria	Alternative Rating[1]				
	OA-1	OA-2	OA-3	OA-4	OA-5
	Monitored Natural Attenuation & IPIM	Enhanced Anaerobic Bioremediation, PCB Excavation, SVE, Surface Cover, & IPIM	Enhanced Anaerobic Bioremediation, PCB & Hot Spot Excavation, SVE, Surface Cover, & IPIM	Enhanced Anaerobic Bioremediation, Hydrolic Control, Hot Spot Excavation, SVE, Surface Cover, & IPIM	Enhanced Bioremediation, Groundwater Recovery and Treatment, Hot Spot Excavation, SVE, Hydraulic Control/Mass Removal, Surface Cover, & IPIM
Protectiveness and Risk Reduction	2	3	4	5	5
Permanence	3	4	4	5	5
Cost	5	4	3	1	1
Long-term Effectiveness	2	3	4	5	5
Management of Short-Term Risks	5	4	3	1	1
Technical and Administrative Implementability	5	3	3	1	1
Public Concern	3	4	4	1	1
Restoration Timeframe	1	2	3	4	4
TOTAL[2]	**26**	**27**	**28**	**23**	**23**

Notes:
1. Alternatives are rated from 5 to 1, with a rating of 5 indicating the highest or most favorable performance for that criterion.
2. In accordance with EPA guidance and the MTCA regulations, all standards and/or criteria are considered equal; no weighting is given to any individual criterion.

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TABLE 5-3

NET PRESENT VALUE COST SUMMARY OUTSIDE AREA[1]

PSC Georgetown Facility
Seattle, Washington

Outside Area Remedial Alternatives	Net Present Value Cost[1]
OA-1: Monitored Natural Attenuation and IPIM	$4,912,900
OA-2: Enhanced Anaerobic Bioremediation, PCB Excavation, SVE, Surface Cover, and IPIM	$5,594,900
OA-4: Enhanced Anaerobic Bioremediation, PCB & Hot Spot Excavation, SVE, Surface Cover, & IPIM	$7,117,600
OA-4: Enhanced Anaerobic Bioremediation, Hydrolic Control, Hot Spot, Excavation, SVE, Surface Cover, and IPIM	$14,000,600
OA-5: Enhanced Bioremediation, Groundwater Recovery and Treatment, Hot Spot Excavation, SVE, Hydraulic Control/Mass Removal and IPIM	$16,426,800

Notes:
1. All costs are in 2007 dollars. Detailed estimates are included in Appendix A.

Geomatrix

TABLE 6-1

PREFERRED ALTERNATIVE GROUNDWATER MONITORING PROGRAM
PSC Georgetown Facility
Seattle, Washington

Alternative	HCIM Performance Monitoring		CPOC Monitoring		Downgradient Remediation Monitoring	
	Number of Wells	Length of Monitoring (years)	Number of Wells	Length of Monitoring (years)	Number of Wells	Length of Monitoring (years)
HA-1: Active Hydraulic Containment	--	--	--	--	--	--
OA-2: Enhanced Bioremediation, PCB Excavation, SVE, and Surface Cover	12	100	11	100	14	20

TABLE 6-2

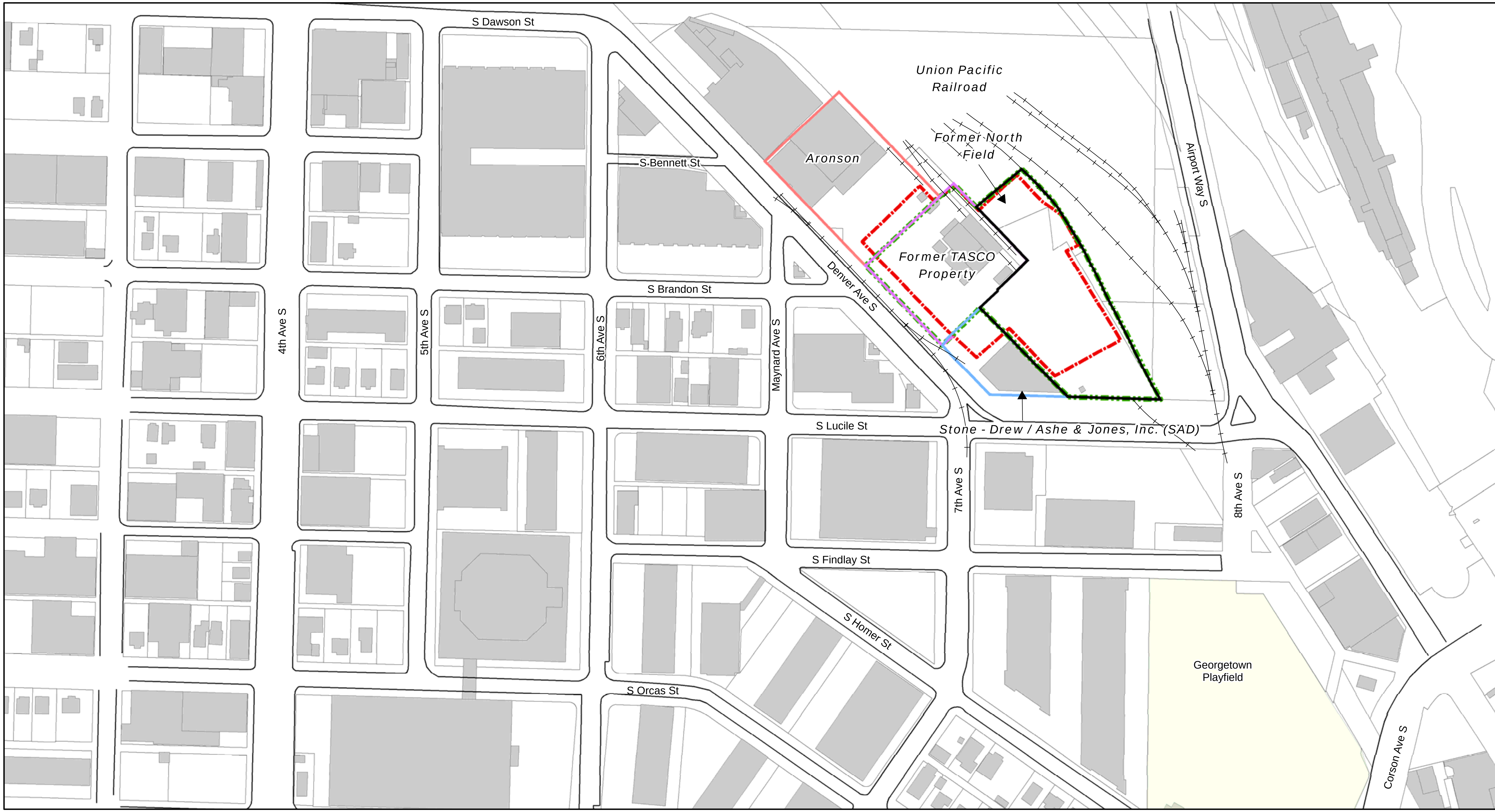
ESTIMATED COSTS FOR PREFERRED SITE-WIDE REMEDIATION APPROACH

PSC Georgetown Facility
Seattle, Washington

Alternative	Net Present Value Cost
HA-1	$7,556,900
OA-2	$5,594,900
Total Cost	**$13,151,800**

Geomatrix

FIGURES



Explanation

- Union Pacific Railroad Tracks
- HCIM Area
- Facility
- Building
- Former TASCO
- Stone-Drew / Ashe & Jones, Inc (SAD) Property
- Aronson Property
- PSC Property

SITE LAYOUT
PSC Georgetown Facility
Seattle, Washington

By: APS	Date: 04/06/07	Project No. 8770
Geomatrix		Figure 1-1

S:\8770_2006\011_TechMemo5\Fig1-1_SiteLayout.mxd

Explanation

- Barrier Wall
- Site Wide Feasibility Study Area
- Parcel Boundary
- HCIM Soil Remediation Area 2
- HCIM Soil Remediation Area 1
- Outside Soil Remediation Area 1
- Outside Soil Remediation Area 2
- Outside Soil Remediation Area 3

N

SOIL REMEDIATION AREAS
PSC Georgetown Facility
Seattle, Washington

By: APS	Date: 04/09/07	Project No. 8770
Geomatrix		Figure 2-1

S:\8770_2006\011_TechMemo5\Fig2-1_SoilRemediationAreas.mxd

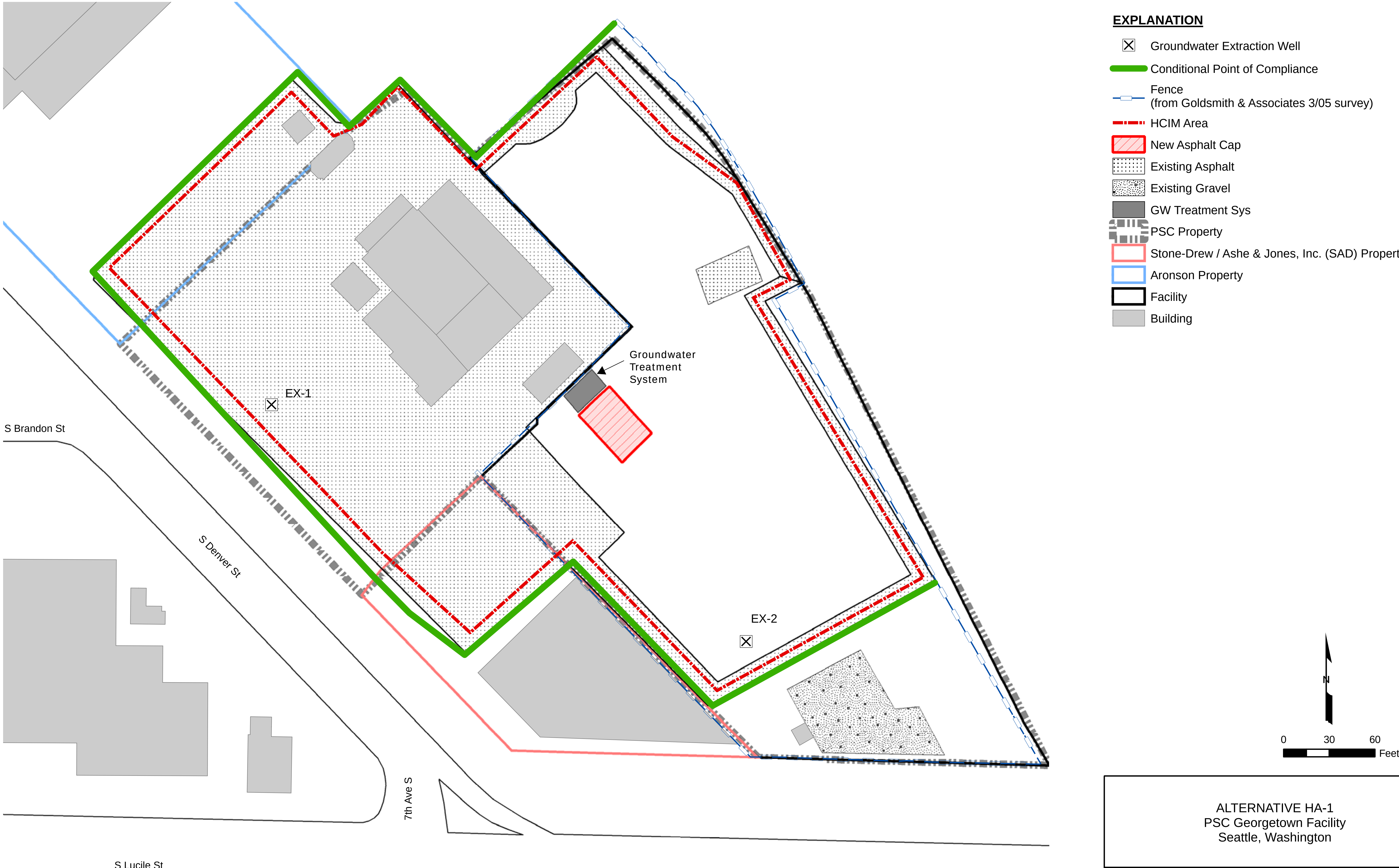
Explanation

- Barrier Wall
- Site Wide Feasibility Study Area
- Parcel Boundary
- HCIM Area
- Suspected DNAPL Area

HCIM GROUNDWATER REMEDIATION AREA
PSC Georgetown Facility
Seattle, Washington

By: APS	Date: 04/09/07	Project No. 8770
Geomatrix		Figure 2-2

S:\8770_2006\011_TechMemo5\Fig2-2_HCIM_GW_RemArea.mxd

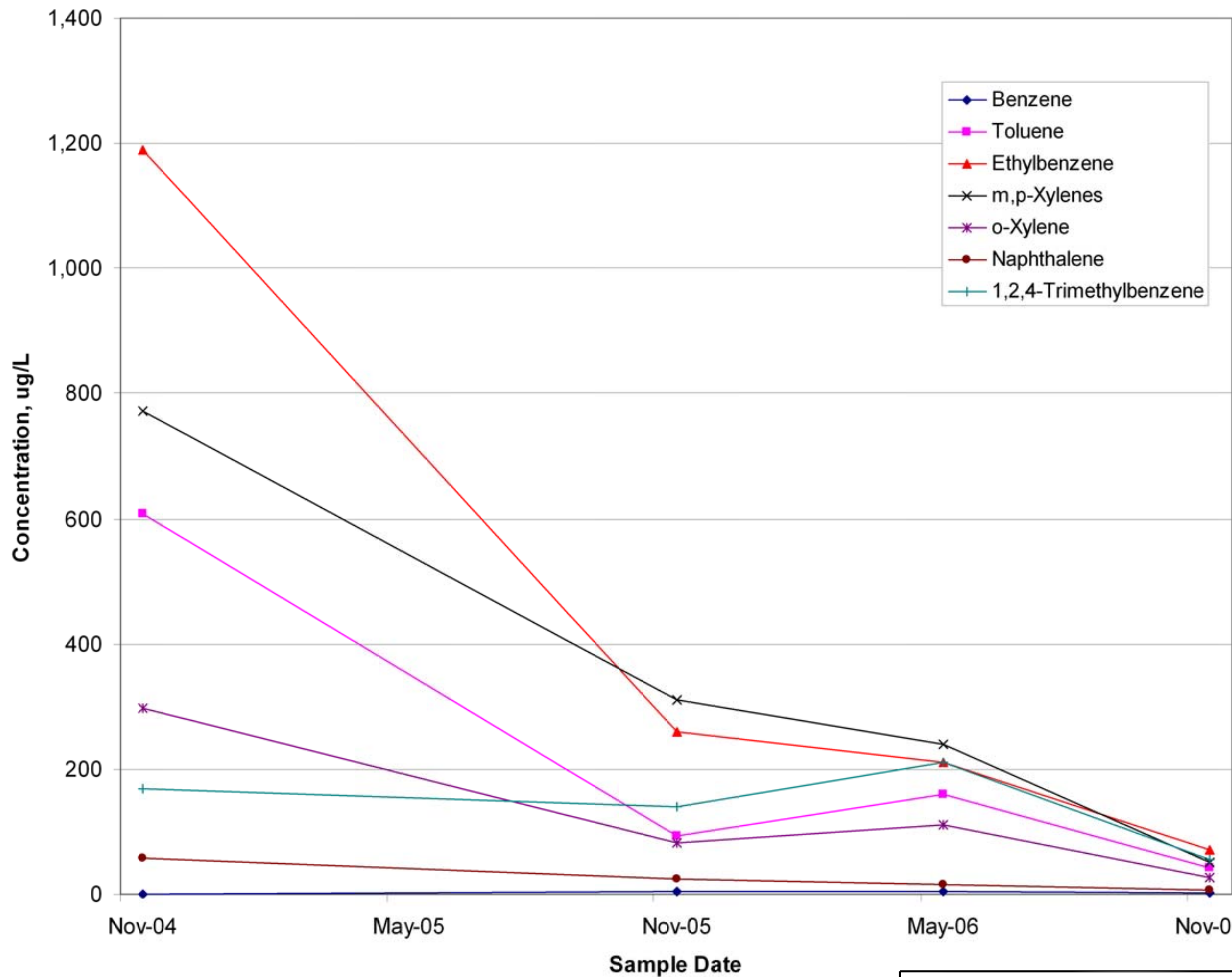


ALTERNATIVE HA-1
PSC Georgetown Facility
Seattle, Washington

By: APS | Date: 04/09/07 | Project No. 8770

Geomatrix | Figure 4-1

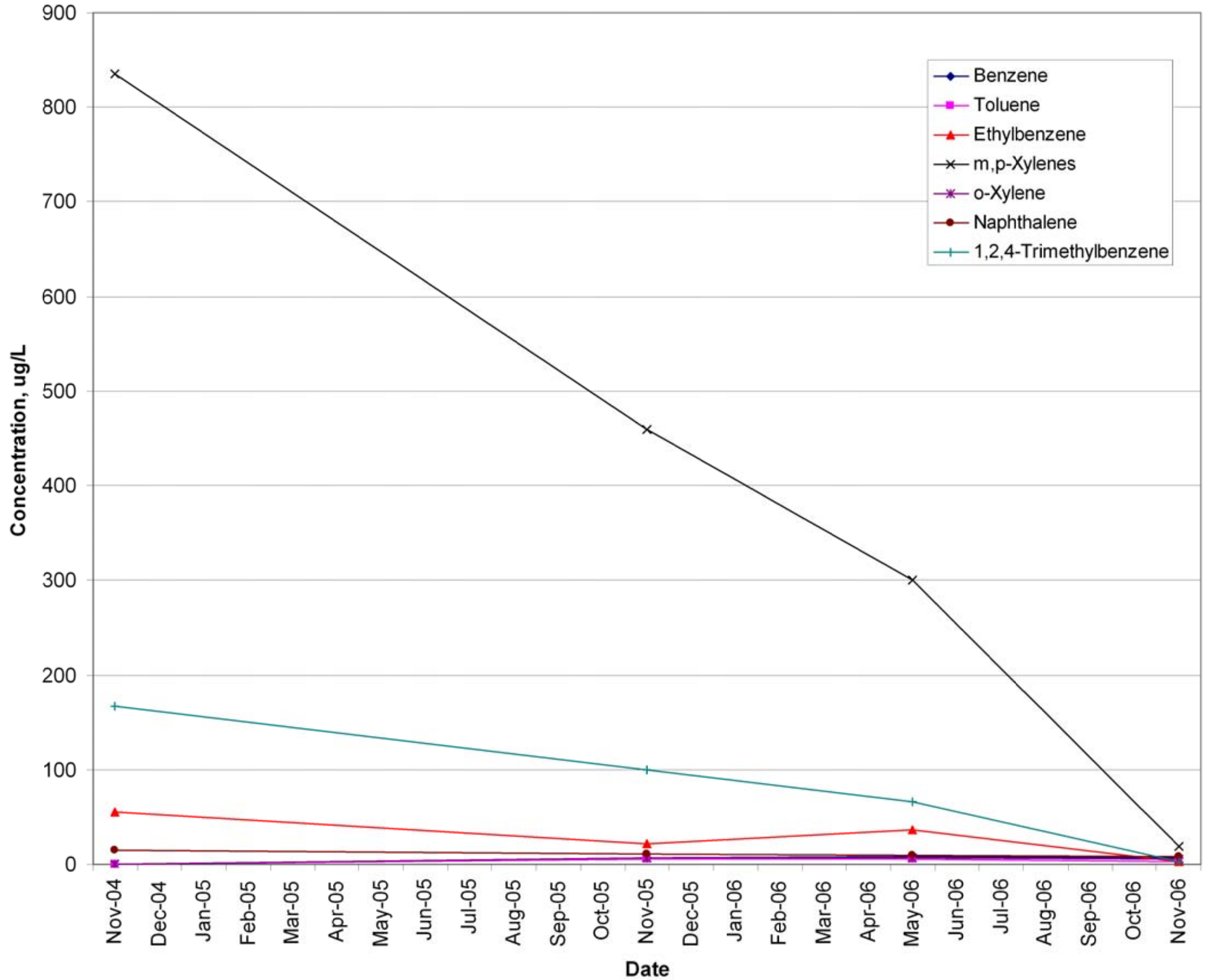
S:\8770_2006\011_TechMemo5\Alternative HA-1.mxd



NONCHLORINATED ORGANIC COMPOUND
CONCENTRATION TRENDS IN CG-150-WT
PSC Georgetown Facility
Seattle, Washington

By: APS	Date: 04/09/07	Project No. 8770
Geomatrix		Figure 4-2

Plot Date: 04/09/07 - 11:37am, Plotted by: astenberg
Drawing Path: S:\8770_2006\011_TechMemo5\, Drawing Name: Figure 4-2 CG-150-WT_Chart.dwg

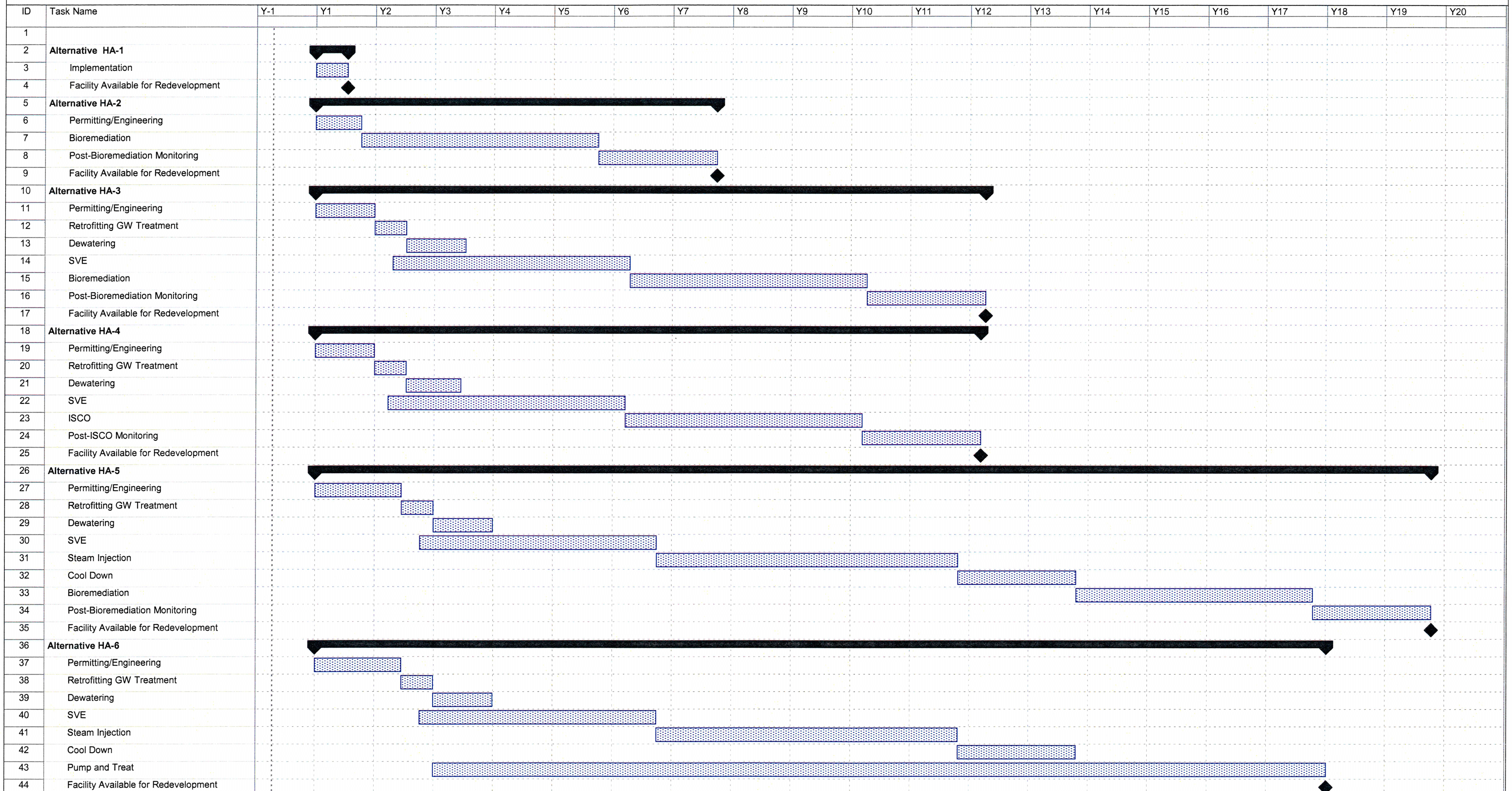


NONCHLORINATED ORGANIC COMPOUND CONCENTRATION TRENDS IN CG-146-WT
PSC Georgetown Facility
Seattle, Washington

By: APS	Date: 04/09/07	Project No. 8770
Geomatrix		Figure 4-3

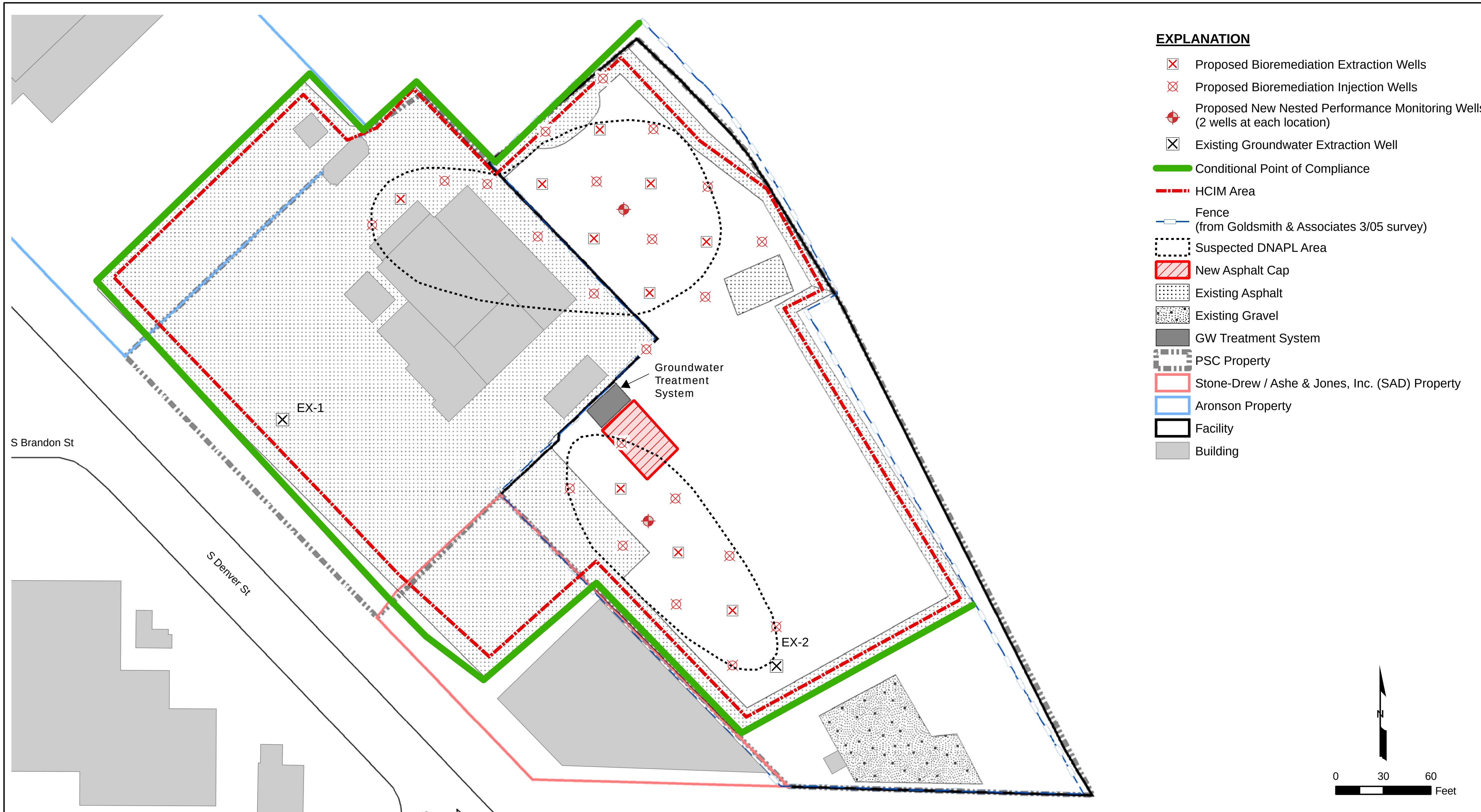
Plot Date: 04/09/07 - 11:40am, Plotted by: astenberg
Drawing Path: S:\8770_2006\011_TechMemo5\, Drawing Name: Figure 4-3 CG-146-WT_Chart.dwg

FIGURE 4-4
IMPLEMENTATION SCHEDULE, HCIM AREA ALTERNATIVES
PSG Georgetown Facility
Seattle, Washington



Project: Fig-4-4-Schedule - HA Alts-v3
Date: Wed 4/11/07

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary | Deadline



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ALTERNATIVE HA-2
PSC Georgetown Facility
Seattle, Washington

By: APS	Date: 04/09/07	Project No. 8770
Geomatrix		Figure 4-5

ALTERNATIVE HA-3
PSC Georgetown Facility
Seattle, Washington

By: APS | Date: 04/09/07 | Project No. 8770

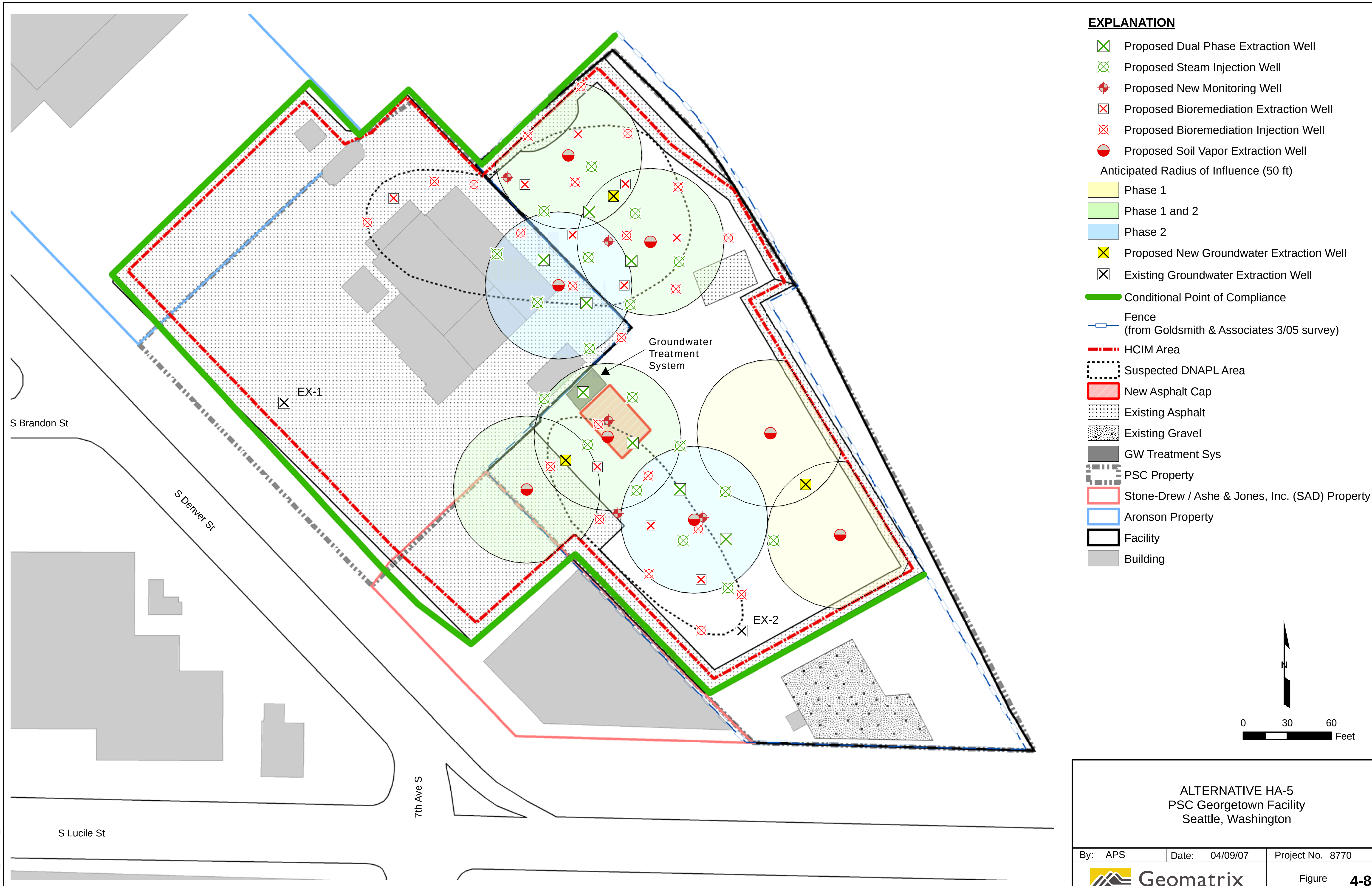
Geomatrix

Figure 4-6

ALTERNATIVE HA-4
PSC Georgetown Facility
Seattle, Washington

By: APS	Date: 04/09/07	Project No. 8770
Geomatrix		Figure 4-7

S:\8770_2006\011_TechMemo5\Alternative HA-4.mxd

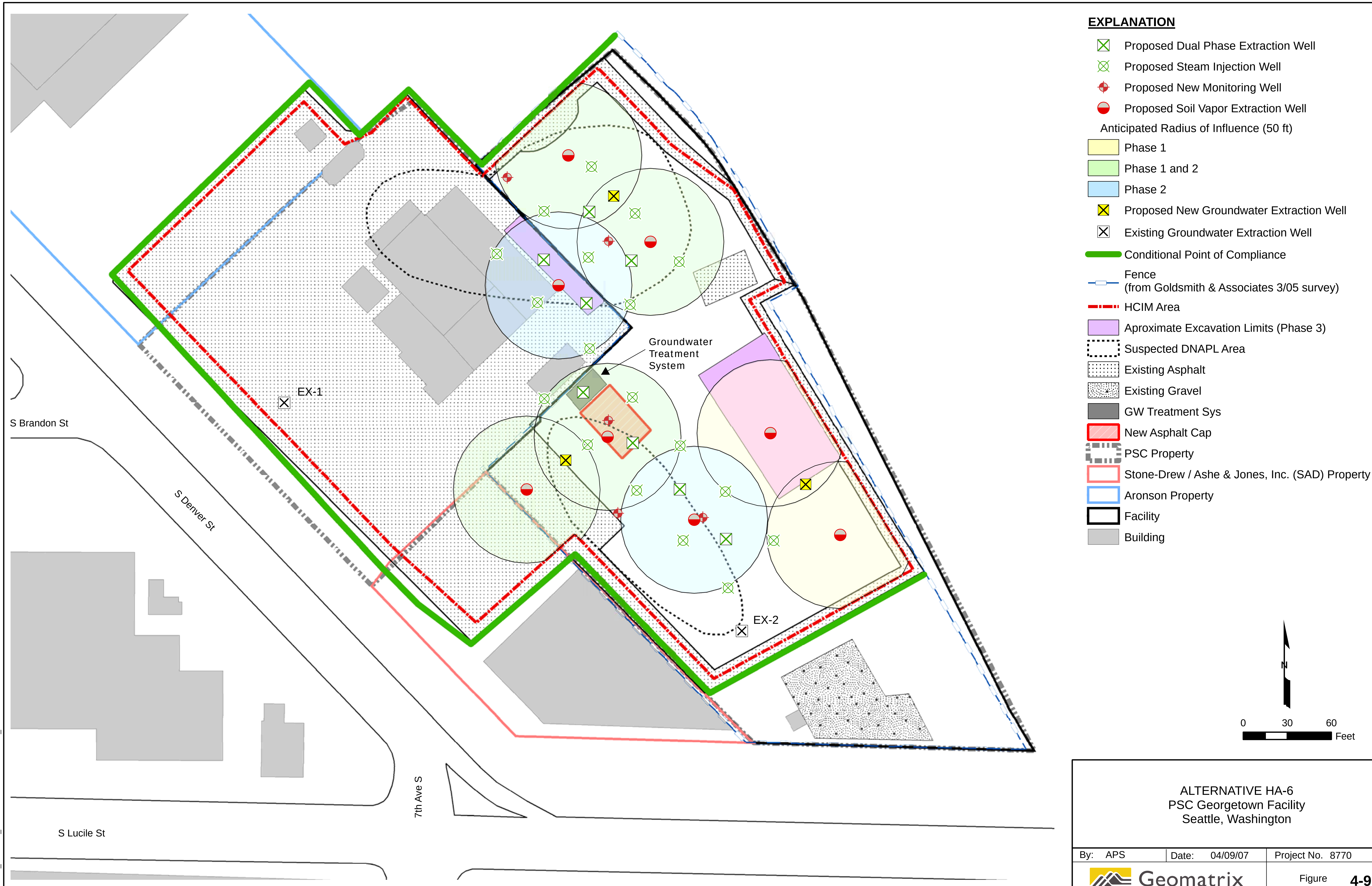


ALTERNATIVE HA-5
PSC Georgetown Facility
Seattle, Washington

By: APS | Date: 04/09/07 | Project No. 8770

Geomatrix

Figure 4-8

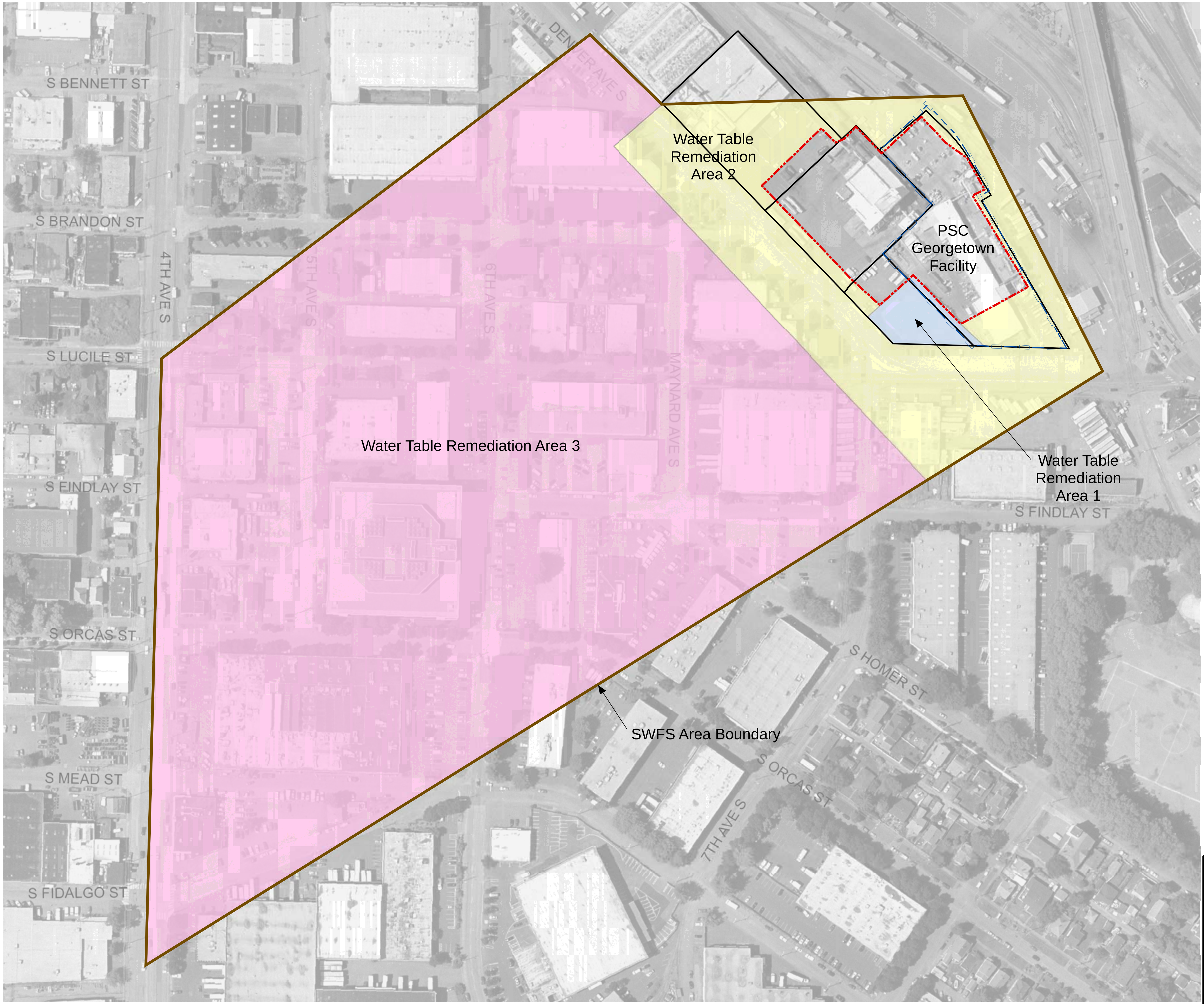


ALTERNATIVE HA-6
PSC Georgetown Facility
Seattle, Washington

By: APS | Date: 04/09/07 | Project No. 8770

Geomatrix

Figure 4-9



EXPLANATION

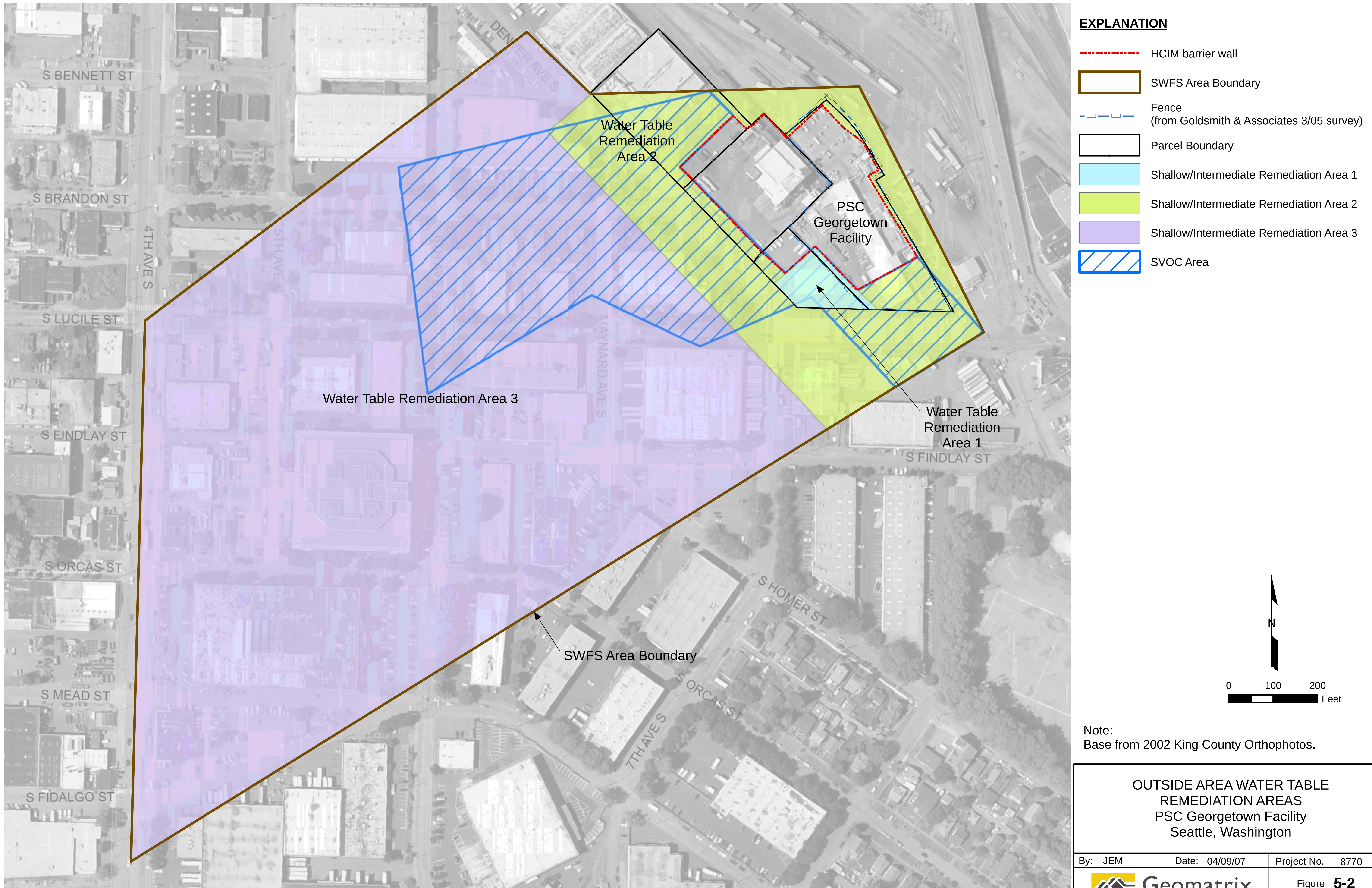
- HCIM barrier wall
- SWFS Area Boundary
- Fence (from Goldsmith & Associates 3/05 survey)
- Parcel Boundary
- Water Table Remediation Area 1
- Water Table Remediation Area 2
- Water Table Remediation Area 3

Note:
Base from 2002 King County Orthophotos.

OUTSIDE AREA WATER TABLE REMEDIATION AREAS
PSC Georgetown Facility
Seattle, Washington

By: JEM	Date: 04/09/07	Project No. 8770
Geomatrix		Figure **5-1**

S:\8770_2006\011_TechMemo5\Fig5-1_OA_WT_RemAreas.mxd



Note:
Base from 2002 King County Orthophotos.

OUTSIDE AREA WATER TABLE REMEDIATION AREAS
PSC Georgetown Facility
Seattle, Washington

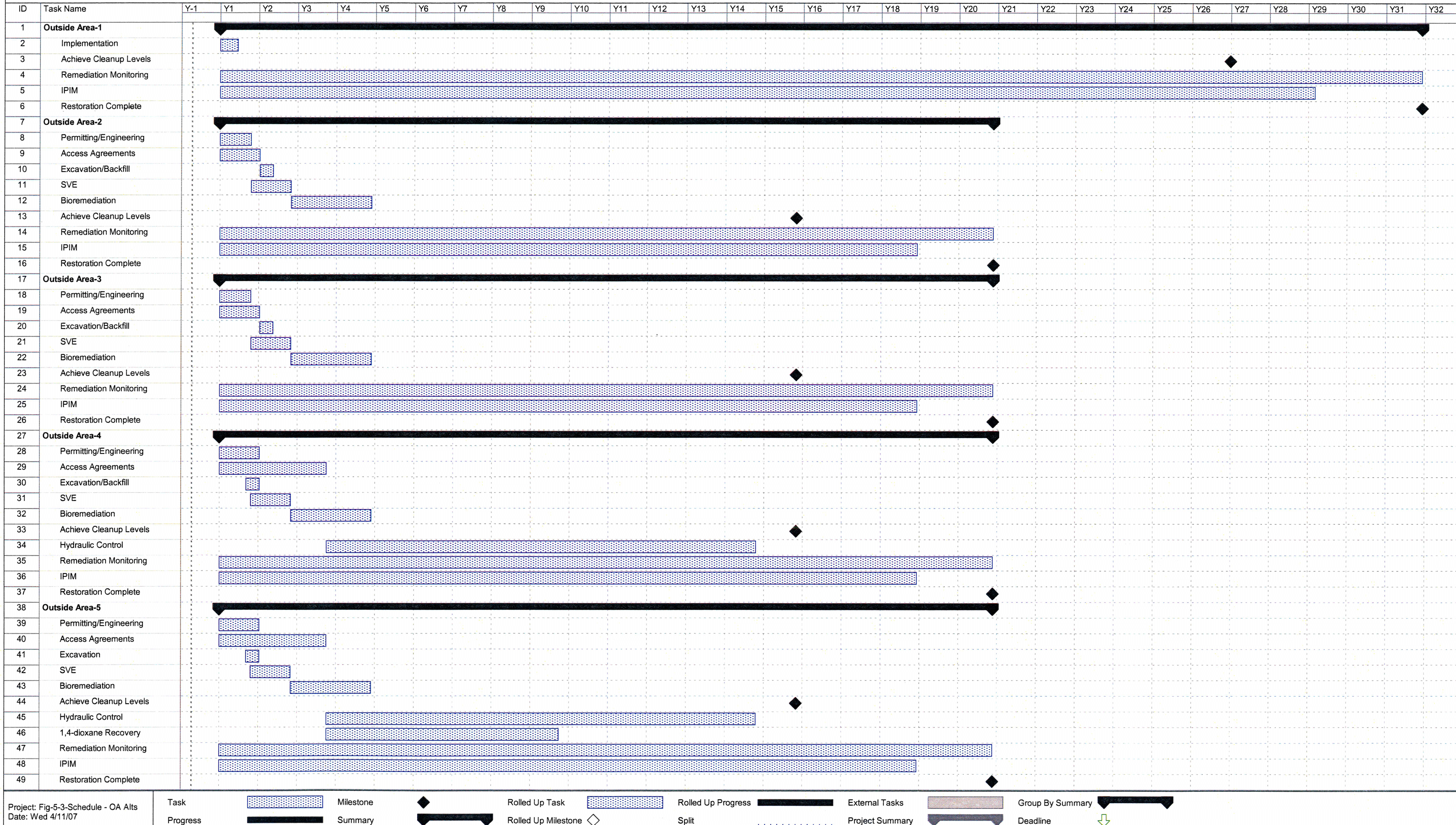
By: JEM | Date: 04/09/07 | Project No. 8770

Geomatrix

Figure 5-2

S:\8770_2006\011_TechMemo5\Fig5-2_OA_SHnINT_RemAreas.mxd

FIGURE 5-3
IMPLEMENTATION SCHEDULE, OUTSIDE AREA ALTERNATIVES
PSC Georgetown Facility
Seattle, Washington



Note: For each of these alternatives, HCIM performance monitoring and COPC monitoring would be conducted beyond the time lines shown above.

ALTERNATIVE OA-1
PSC Georgetown Facility
Seattle, Washington

By: JEM	Date: 04/09/07	Project No. 8770
Geomatrix		Figure 5-4

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ALTERNATIVE OA-1
EXTENDED MONITORING WELL NETWORK
PSC Georgetown Facility
Seattle, Washington

By: JEM | Date: 04/09/07 | Project No. 8770

Geomatrix

Figure 5-5

ALTERNATIVE OA-2
PSC Georgetown Facility
Seattle, Washington

By: JEM | Date: 04/09/07 | Project No. 8770

Geomatrix

Figure 5-6

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ALTERNATIVE OA-3
PSC Georgetown Facility
Seattle, Washington

By: JEM | Date: 04/09/07 | Project No. 8770

Geomatrix

Figure 5-7

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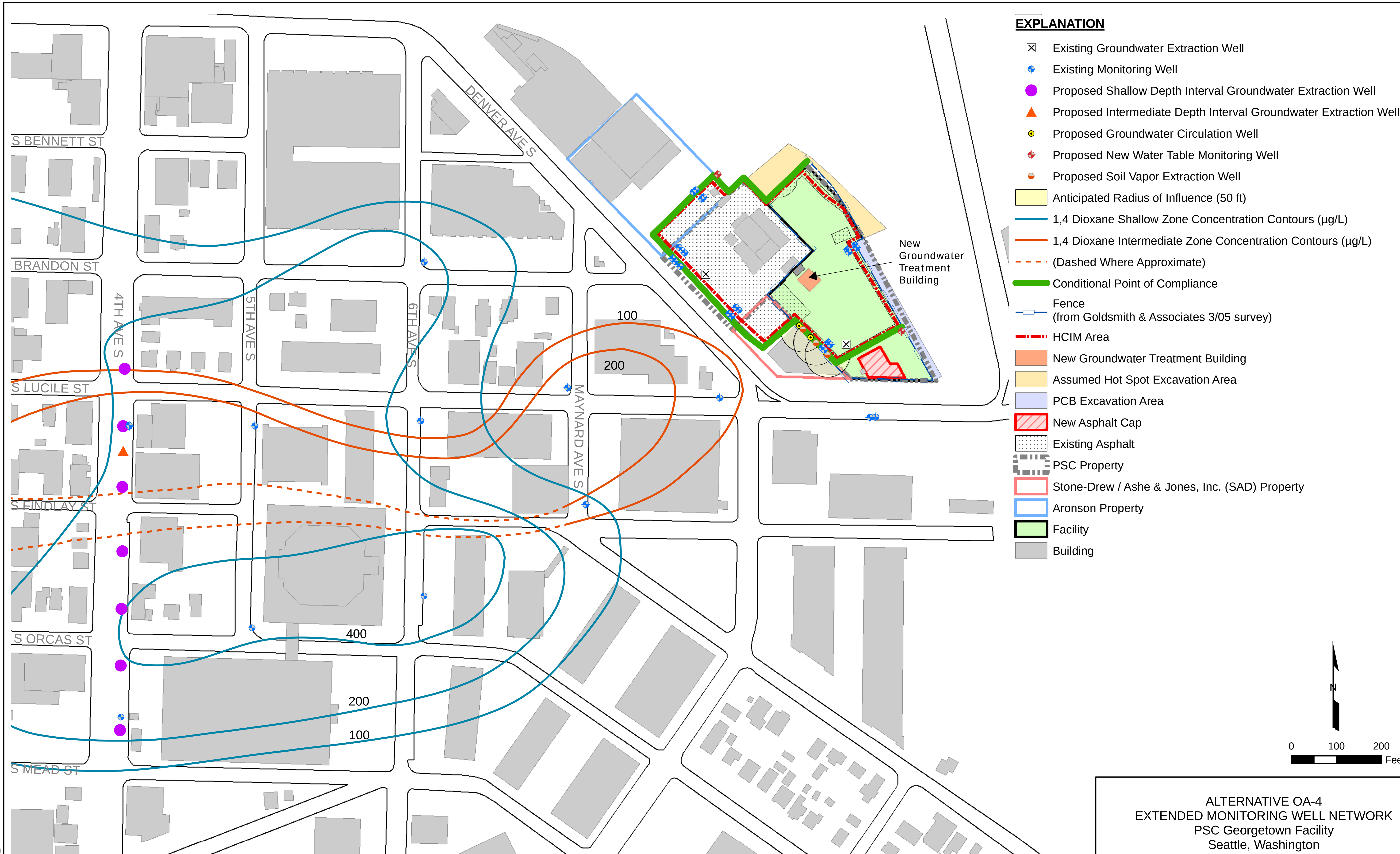


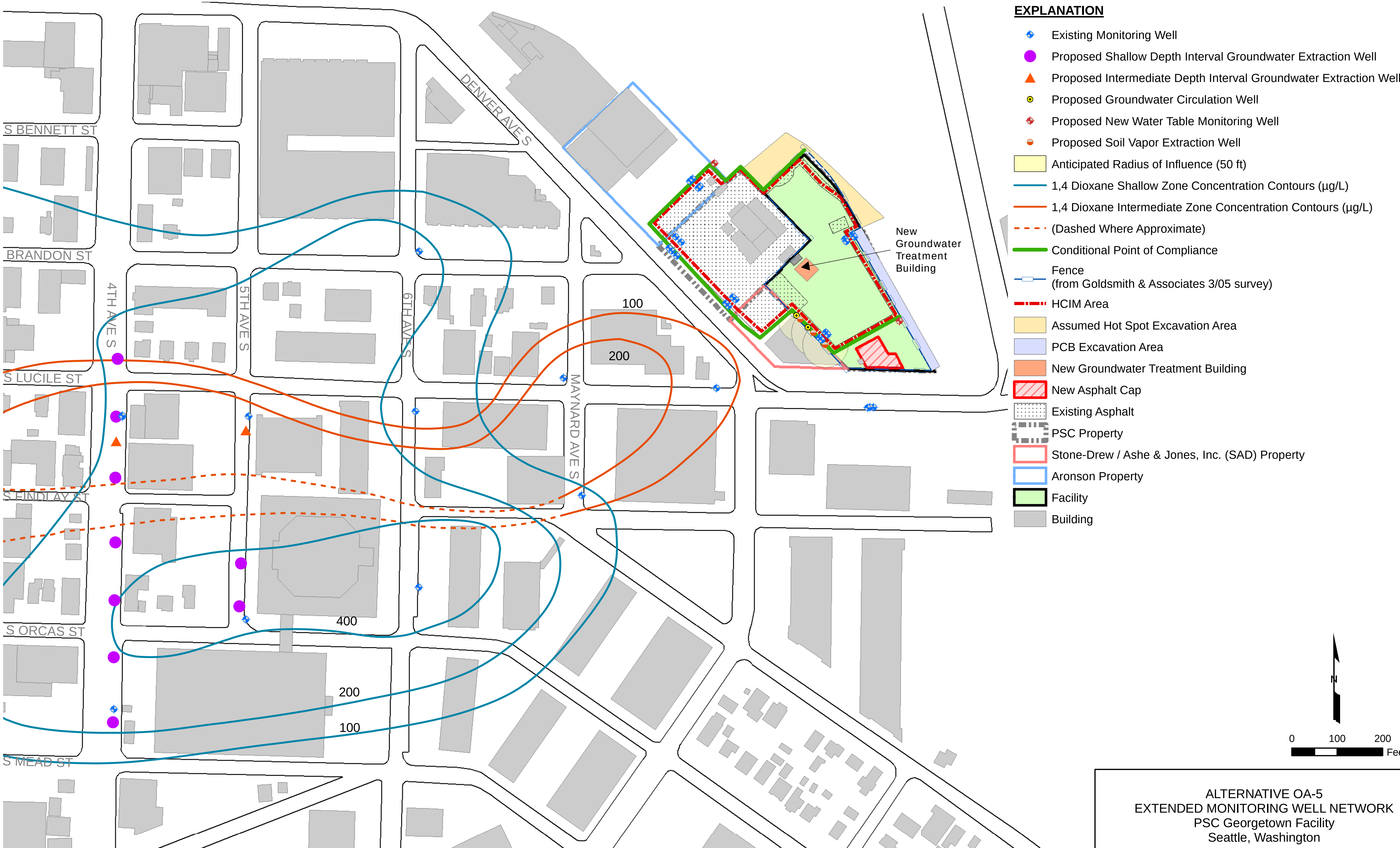
ALTERNATIVE OA-4
EXTENDED MONITORING WELL NETWORK
PSC Georgetown Facility
Seattle, Washington

By: JEM | Date: 04/09/07 | Project No. 8770

Geomatrix

Figure 5-8

S:\8770_2006\011_TechMemo5\Alternative OA-4.mxd



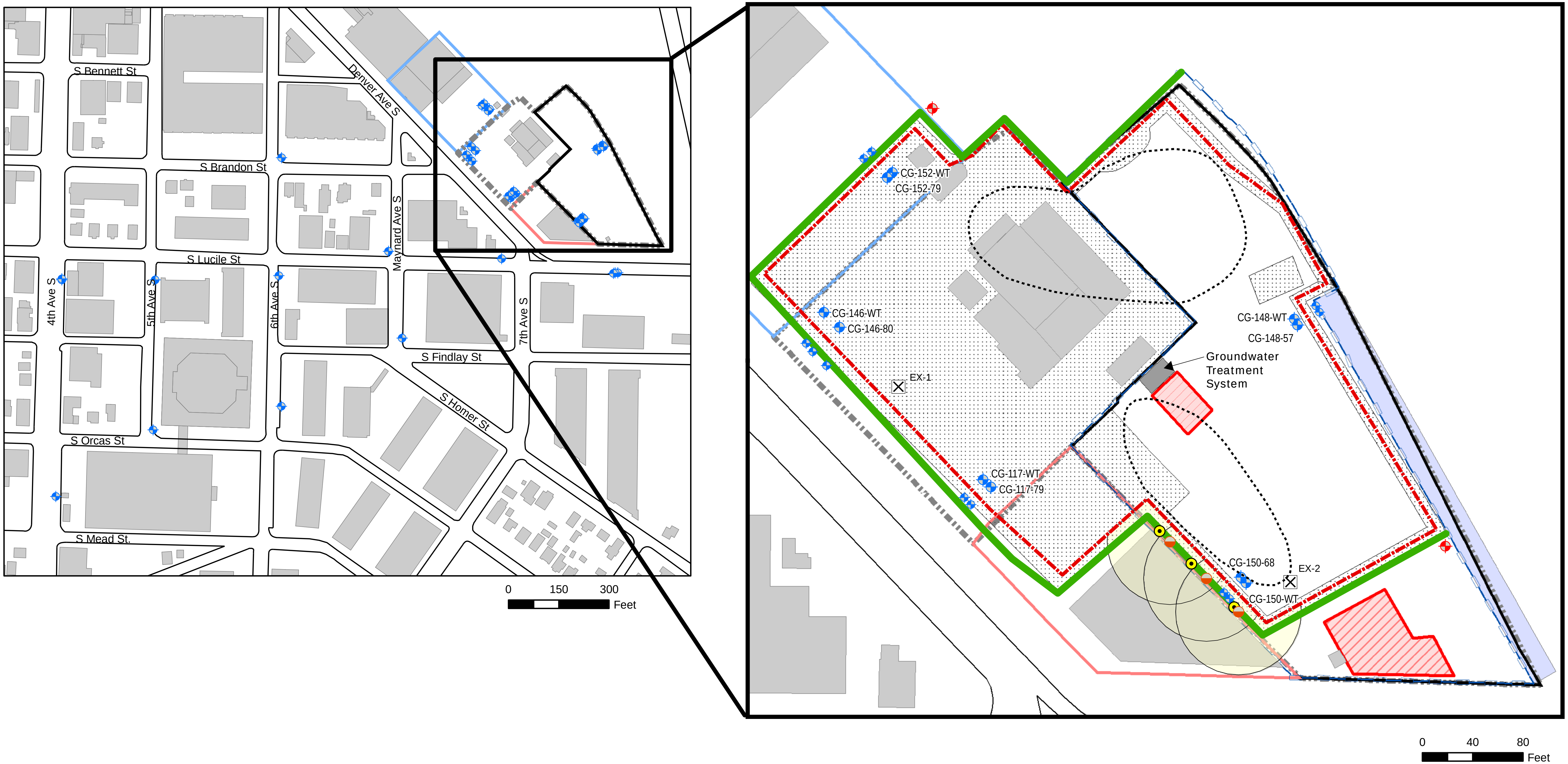
ALTERNATIVE OA-5
EXTENDED MONITORING WELL NETWORK
PSC Georgetown Facility
Seattle, Washington

By: JEM | Date: 04/09/07 | Project No. 8770

Geomatrix

Figure 5-9

S:\8770_2006\011_TechMemo5\Alternative OA-5.mxd



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EXPLANATION

- Existing Groundwater Extraction Well
- Proposed Groundwater Circulation Well
- Proposed Water Table Monitoring Well
- Proposed Soil Vapor Extraction Well
- Anticipated Radius of Influence (50 ft)
- Existing Monitoring Well
- Conditional Point of Compliance
- Fence (from Goldsmith & Associates 3/05 survey)
- HCIM Area
- Suspected DNAPL Area
- PCB Excavation Area
- New Asphalt Cap
- Existing Asphalt
- Stone-Drew / Ashe & Jones, Inc. (SAD) Property
- Aronson Property
- PSC Property
- Facility
- GW Treatment Sys
- Building

N

PREFERRED SITE-WIDE REMEDIATION APPROACH
PSC Georgetown Facility
Seattle, Washington

By: APS	Date: 04/09/07	Project No. 8770
Geomatrix		Figure 6-1

APPENDIX A

Remedial Alternative Cost Estimates

APPENDIX A
REMEDIAL ALTERNATIVE COST ESTIMATES

Technical Memorandum No. 5
PSC Georgetown
Seattle, Washington

The cost estimates for the remedial alternatives were developed based on the conceptual designs for the alternatives described in Sections 4 and 5 of Technical Memorandum No. 5. These cost estimates were prepared in accordance with the methods described in, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA, 2000). Details regarding preparation of these costs estimates are described below.

Cost estimates were prepared for the each of the remedial alternatives described in Sections 4 and 5 of this technical memorandum. Rounding was applied to the total costs only. Net Present Value (NPV) costs were prepared for each alternative, which combine the initial implementation costs as well as the recurring costs for operation, repair and maintenance, monitoring, and future equipment replacement. The initial implementation costs include permitting, engineering design, purchase of facilities and equipment, pilot studies, construction, and construction management costs. Recurring costs include costs that would occur regularly over the life of the remediation due to operation, maintenance, monitoring, property access, purchasing materials, and replacing equipment that may become worn out. For the HCIM Area alternatives, cost sensitivity was assessed by varying costs for those items with uncertain unit costs; the uncertain items were bounded by low and high unit cost estimates. The expected, high, and low NPV costs are summarized for each of the HCIM Area on Table A-1. The estimated NPV costs for the Outside Area alternatives are summarized on Table A-2. Detailed estimates, including costing assumptions and NPV costs, for each of the HCIM Area and Outside Area alternatives are presented in the subsequent tables included in this appendix. The detailed cost estimation tables include the high and low estimates used for the sensitivity analysis. All costs presented in these tables are in 2007 dollars.

The quantities shown in the cost tables were estimated based on the assumed scope of the remedial alternatives and preliminary conceptual designs, as described in Sections 4 and 5. Reasonable assumptions based on professional judgment were made as appropriate to prepare the quantity estimates. The cost estimates based on these quantities are, therefore, preliminary estimates suitable for use in Technical Memorandum No. 5 for comparing the alternatives. These cost estimates are not suitable for final design or for budgeting.

The unit prices for most of the line items presented in the cost estimate tables were taken from the "Building Construction Cost Data" (Means, 2007) and the "Environmental Remediation Cost Data-Unit Price" (Means, 2005); vendor quotes; or based on experience with similar work. Unit prices taken from the Means, 2005 (the most recent Environmental Remediation Cost Data published by Means), were adjusted to 2007 dollars based on the Means Historical Cost Indices (Means, 2007). For Alternatives OA-4 and OA-5, a preliminary engineering estimate for treatment of groundwater contaminated by 1,4-dioxane was prepared by Geomatrix's water treatment specialists based on vendor cost data for similar systems and prior experience; equipment, construction, and operation/maintenance costs were taken from this estimate. A copy of the detailed water treatment estimate is included as Attachment 1.

The estimated cost for thermal treatment for Alternative HA-5 and Alternative HA-6 was based on reported data for pilot scale and full scale implementations of thermally enhanced SVE. Resources evaluated included the Los Alamos National Laboratory ETCAP database (LANL, 2007), the EPA Federal Remediation Roundtable (EPA, 2007), and an EPA Cost and Performance Report (EPA, 2003). Three case studies were obtained from the Federal Remediation Roundtable: a 1997 study at the Missouri Electric Works Superfund Site, a 2002 study conducted at the Rocky Mountain Arsenal, and a 1998 study conducted at the Pinellas Northeast Site in Largo, Florida. Unit costs [per cubic yard (CY)] were calculated for the sites and the costs were converted to 2007 dollars using the Means historical cost indexes (Means, 2007). The unit costs ranged from $21/CY to $760/CY. The low cost was for a site that was an order of magnitude larger than the facility, and the depth of treatment was about half the PSC site. The unit cost used for estimating thermal treatment costs was conservatively set at 60 percent (%) of this range, or $456/CY. It was also assumed that thermal treatment would take 5 years to complete. For calculation of the NPV cost for these two alternatives, the total thermal treatment ost was taken in the second year of the 5-year treatment period.

The following general assumptions were made and may appear as footnotes to the cost estimate tables:

- Production rates and prices would be based on a standard 40-hour work week; no overtime or shift differential was included.
- The personal protective equipment would be Level D, unless otherwise noted.

- Any waste generated would be non-hazardous solid waste, except as otherwise noted.

- Any surface asphalt and concrete removed as part of remediation were assumed to be uncontaminated and were assumed to be recycled.

- No unique or specialty equipment or approaches were considered unless otherwise noted.

- Costs for potable water have not been estimated and have not been included in the remediation cost estimates.

- No security guards would be required.

- Work would be performed without interruptions or multiple mobilizations and setups, unless noted otherwise.

- No prevailing wage or union standby labor costs have been included.

- Costs for legal fees associated with gaining access for remedial construction have not been included.

- For estimating opportunity costs related to delay in property sale or redevelopment, the PSC property (i.e., the facility and the TASCO property) were assumed to be worth $35 per square foot. The opportunity costs were based on the interest that could be earned on this value, based on an annual interest rate of 7%.

Detailed assumptions were made as follows for specific remedial alternatives:

HA-1 ASSUMPTIONS:

- The hydraulic pumping and treatment system that would maintain an active inward hydraulic gradient would be similar to the existing system and costs for operation and maintenance would be similar to current costs.

HA-2 ASSUMPTIONS:

- All assumptions made in HA-1 were also applied to HA-2.

- The ISB system was assumed to included 10 groundwater extraction wells, 22 substrate injection wells, and 4 performance monitoring wells.

- It was assumed that 325 gallons of molasses would need to be injected into each ISB recirculation cell, which makes 3,250 gallons for each event.

- Sampling of extraction wells for the ISB program was assumed to take a similar amount of time as sampling from regular groundwater monitoring wells.

HA-3 ASSUMPTIONS:

- All assumptions made in HA-2 were also applied to HA-3.
- For HA-3, three new groundwater extraction wells would be added for the dewatering system.
- The SVE system would have a total of six SVE wells.
- Annual operation and maintenance costs for the SVE system (electricity, maintenance, labor, etc.) were based on prior experience with SVE at the facility.
- The SVE system would be operational for 4 years.

HA-4 ASSUMPTIONS:

- All assumptions made in HA-3 except those assumptions pertaining to ISB were also made in HA-4.
- The ISCO system was assumed to include 10 groundwater extraction wells, 22 oxidant injection wells, and 4 performance monitoring wells.
- It was assumed that 3,940 lbs of potassium permanganate would be injected into each ISCO recirculation cell, which makes 39,400 lbs per event.
- Sampling of extraction wells for the ISCO program was assumed to take a similar amount of time as sampling from regular groundwater monitoring wells.

HA-5 ASSUMPTIONS:

- All assumptions that were made in HA-3 were also applied to HA-5.
- Two additional SVE wells would be added to the SVE system for the Steam Injection phase of HA-5.
- As discussed above, a unit cost of $456 per CY was assumed for the cost of implementing, and operating a steam injection system on site for a period of 5 years.
- The volume of soil and groundwater to be treated by steam injection was calculated to cover the area of steam injection wells and have a depth of 90 feet bgs. This volume was approximately 62,000 CYs.
- It was assumed that after the steam injection system operations for 5 years it would take the soil and groundwater 2 years to cool to a temperature that would allow implementation of ISB. Preliminary calculations indicate that a period up to 20 years could be required.

HA-6 ASSUMPTIONS:

- All assumptions made in HA-5 were also applied to HA-6.
- The amount of excavated and disposed soil was assumed to be about 2,200 bank CYs, or 3,000 tons, and would cost $163 per ton for disposal.
- All soil would be shipped to a landfill in Arlington, Oregon, for disposal.
- Dewatering annual system operational costs were assumed to be similar to costs for the existing groundwater recovery and treatment that is operating at the facility.

OA-1 ASSUMPTIONS:

- For long-term monitoring, the hydraulic barrier wall would need to be repaired about every 50 years at a cost of approximately $800,000.
- The groundwater monitoring program for all OA alternatives includes 11 CPOC wells, 14 Downgradient wells, and 12 HCIM Area wells (37 wells total).

OA-2 ASSUMPTIONS:

- All assumptions made in OA-1 were also applied to OA-2.
- The amount of excavated and disposed soil was assumed to be about 1,300 bank CYs, or 1,800 tons, and would cost $163 per ton for transportation and landfill disposal in Arlington, Oregon.
- The groundwater recirculation system would have three circulating wells, as described in the 50% design report.
- The SVE system would have three SVE wells.
- 200 gallons of molasses would be injected into each ISB recirculation well, for a total of 600 gallons per event.
- Annual costs for running the SVE system such as electricity, miscellaneous maintenance, annual operational labor, etc., were based on prior SVE experience at the facility.
- The SVE system would be in operation for 1 year.

OA-3 ASSUMPTIONS:

- All assumptions made in OA-2 were also applied to OA-3.

- The amount of excavated and disposed soil was assumed to be about 6,300 bank CYs, or 8,600 tons. For estimating disposal costs, 5,200 tons was assumed to be hazardous and would cost $163 per ton for transportation and disposal; 3,400 tons was assumed to be non-hazardous, with transportation and disposal costs of $34 per ton.

OA-4 ASSUMPTIONS:

- All assumptions made in OA-3 were also applied in OA-4.
- The Hydraulic Control system would include seven groundwater extraction wells in the water table zone, and one groundwater extraction well in the intermediate zone.
- A property purchase was assumed necessary for the Hydraulic Control system. It would be approximately 4,000 square feet and would cost about $35 per square foot, totaling $140,000.

OA-5 ASSUMPTIONS:

- All assumptions made in OA-4 were also applied in OA-5.
- The groundwater recovery system for mass removal would add two groundwater extraction wells in the water table zone, and one groundwater extraction well in the intermediate zone to the hydraulic control system included in OA-4, making a total of nine extraction wells in the water table, and two wells in the intermediate.

The implementation cost estimates include the consultant cost (Professional Technical Services) for individual tasks as a percentage of the remediation construction (see detailed cost estimates for each alternative). The specific line items have been divided into permitting, engineering design, construction management, and project management, as appropriate. The assigned percentages were obtained from EPA guidance (EPA, 2000) and from professional experience.

The estimated recurring costs have also been generalized for simplicity. The unit prices used for recurring cost estimates include the cost of the consultant and contractor costs, as appropriate. Annual project management costs were estimated to range between $10,000 to $25,000 per year for HCIM Area alternatives and $10,000 to $20,000 per year for Outside Area alternatives, depending upon the complexity of each alternative. The estimated duration of the HCIM Area and Outside Area alternatives are presented in Sections 4 and 5 of Technical Memorandum No. 5, respectively.

The NPV costs of the alternatives (Tables A-1 and A-2) were calculated with a net discount (interest) rate of 2.5% based on recommendations provided by the Ecology (EPA guidance recommends a net discount rate of 7%.) Both the initial and recurring cost estimates include a 15 to 25% contingency to address uncertainties and to reflect the preliminary nature of these cost estimates.

A sensitivity analysis (Table A-1) was completed to evaluate the effect of uncertainties associated with the implementation and operation of Alternatives HA-2 through HA-6. Alternative HA-1 and Outside Area alternatives were not included in the analysis because there is a lesser degree of uncertainty associated with these alternatives. Factors that were considered in the sensitivity analysis include:

- The amount of electron donor material required for enhanced anaerobic bioremediation and the associated labor/time required to inject it (Alternatives HA-2, HA-3 and HA-5);
- The amount of potassium permanganate required for in situ chemical oxidation and the labor/time required to inject it (Alternative HA-4);
- The duration of operation of the dewatering and SVE system (Alternatives HA-3 through HA-6);
- Steam injection unit costs (Alternatives HA-5 and HA-6); and
- Excavation and disposal volumes (Alternative HA-6).

Anticipated (baseline), low, and high costs were calculated for each alternative by varying these factors over an estimated range of uncertainty, as shown on Table A-1. Costs differences range from about $100,000 to $29,000,000 and are discussed below:

HA-2. The costs for HA-2 varied by about $100,000 and are attributed only to differences in the amount of electron donor required for enhanced bioremediation and the labor/time required to inject it. This is the smallest total difference and reflects minimal uncertainty in this alternative. A preliminary design has been completed and submitted to Ecology for the key components of this alternative.

HA-3. Costs for HA-3 differed by approximately $2.2 million. This cost estimate varied due to the amount of electron donor estimated for enhanced bioremediation, the labor/time required to inject the electron donor, and the duration of operation of the dewatering and SVE system.

HA-4. HA-4 was varied for the amount of potassium permanganate required for in situ chemical oxidation and the labor/time required to inject the electron donor and the duration of operation of the dewatering and SVE system. These changes account for a cost difference of approximately $2.6 million.

HA-5. The amount of electron donor material required for enhanced anaerobic bioremediation, the associated labor/time required to inject the electron donor and steam injection unit costs were varied for alternative HA-5. The steam injection unit costs varied substantially. The NPV cost difference is $28.3 million between the high and low total cost estimates. While the magnitude of the difference is large, it represents only about 50% of the high estimate. This variance is considered reasonable for the uncertainty associated with the preliminary, conceptual estimate for this type of technology.

HA-6. The duration of operation of the dewatering and SVE system, steam injection unit costs, and excavation and disposal volumes were varied for HA-6. The NPV cost difference for HA-6 is about $29.3 million, and reflects the substantial uncertainty in the design for steam injection. This difference is about 51% of the high NPV estimate.

REFERENCES

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LANL, ETCAP web site, http://www.lanl.gov.orgs/d/d4/enviro/etcap/therm_soil.html, March 2007.

R. S. Means, 2005, Environmental Cost Data-2005, 11th Edition.

R. S. Means, 2007, Building Construction Cost Data, 65th Edition.

Table 1:

Cost Estimate for Groundwater Treatment at PSC

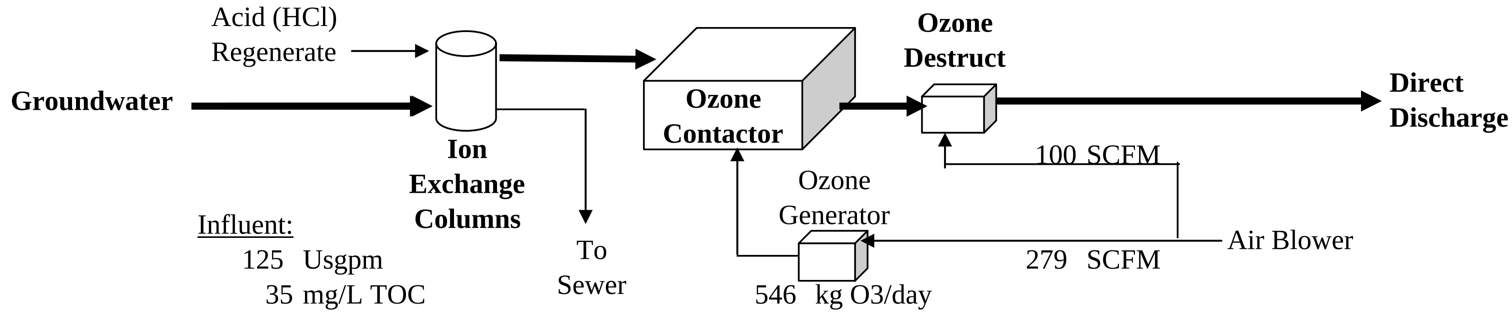
Geomatrix

Client Name: PSC | **Location:**

Description of Works: Ion Exchange System for Cation Removal (Fe, MG, Mn, etc.) Followed by Ozone System for Trace Organic Destruction

Sized for 125 Usgpm

Mass Flow Diagram:



Influent:
125 Usgpm
35 mg/L TOC
41 mg/L Methane
5 mg/L NH3
243 mg/L COD (est.)

Assume:
3.3 kg O3/kg COD
735 cu.ft of air/kg O3

Item Name	Description	Mat'l Quantity	Unit	Unit Price	Install Labour Costs	Total Item Cost
Conveyance Piping to Treatment Plant	200mm HDPE Pipe	100	m	$ 150	$ 75	**$ 22,500**
Ion Exchange System	Package plant c/w Controls & sensors.	1.0	ea	$ 100,000	$ 20,000	**$ 120,000**
Acid Regeneration System	Storage tank, spill containment, level controls,	1.0	ea	$ 25,000	$ 10,000	**$ 35,000**
Caustic Neatralization System for Reject	Storage tank, spill containment, level controls,	1.0	ea	$ 25,000	$ 10,000	**$ 35,000**
Ozone Contactor	7,500 Usgal 304ss Tank w/ antivortex baffles	1.0	ea	$ 25,000	$ 7,500	**$ 32,500**
Oxidation Mixers	Top Mounted 2 hp Mixer w/ 316ss shaft & impeller	3.0	ea	$ 2,500	$ 3,500	**$ 18,000**
Ozone Package Plant	Includes Ozone generator, offgas destruct, and controls. Sized for (in lbs/day) 1,202	1.0	ea	$ 1,040,213	$ 100,000	**$ 1,140,213**
Ozone Destruct Tank	3500	1.0	ea	$ 15,000	$ 7,500	**$ 22,500**
Air Blower	Sized for (scfm) 379	2.0	ea	$ 5,000	$ 2,500	**$ 15,000**
Air Diffuser Grid		2.0	ea	$ 7,500	$ 2,500	**$ 20,000**
Discharge Pump		1.0	ea	$ 7,500	$ 5,000	**$ 12,500**
Discharge Piping	200mm HDPE Pipe	100	m	$ 150	$ 75	**$ 22,500**
Excavation & Backfill		100.0	m^3	$ 20	$ 25	**$ 4,500**
Tank, Building, & Equipment Slab	300mm Reinforced Concrete Slab	30.0	m^3	$ 550	$ 450	**$ 30,000**
Building Allowance	Small building for ozone generator, and controls	50.0	m^2	$ 550	$ 250	**$ 40,000**
Direct Construction Costs (DCC)		**Materials Total =**		**$1,400,600**	**$169,400**	**$1,570,000**
	Indirect Construction Costs (IDCC):		20%	**of DCC**		**$314,000**
	Construction Change Order Allowance:		10%	**of DCC+IDCC**		**$188,400**
	Contingency:		25%	**of DCC+IDCC**		**$471,000**
				Estimated Total Installed Costs (TIC)		**$2,543,000**
	Engineering		8%	**of TIC**		**$203,440**
	Contract Administration		1%	**of TIC**		**$25,430**
	Construction/Installation Supervision		3%	**of TIC**		**$76,290**
	Site Inspection		1%	**of TIC**		**$25,430**
	Commissioning		1%	**of TIC**		**$25,430**
				Total Estimated Capital Costs		**$2,899,000**

Estimated Yearly Operating & Maintenance Costs of the Constructed Works

Item Name	Description	Quantity /year	Unit	Unit Price	Yearly Cost	Present Cost*
Electricity	Oxidation Mixers	43,800	kW hr	$ 0.12	**$ 5,300**	**$ 12,952**
	Blowers and Pumps	219,000	kW hr	$ 0.12	**$ 26,300**	**$ 64,270**
	Ozone units	528,927	kW hr	$ 0.12	**$ 63,500**	**$ 155,176**
Chemicals	Acid for Regen	26,000	kg	$ 1.00	**$ 26,000**	**$ 63,537**
Sewer Fees	Sewerage fees for I/X regen	1,040	m^3	$ 2.50	**$ 2,600**	**$ 6,354**
Manpower (included benefits, payroll, taxes, etc)	supervisor (0.1 hr/day)	37	hours	$ 38.00	**$ 1,400**	**$ 3,421**
	operator (2.0 hr/day)	730	hours	$ 32.00	**$ 23,400**	**$ 57,183**
Maintenance	Percent of capital costs (TIC)/yr	3%	per year		**$ 76,300**	**$ 186,455**
* Performs a present value calc. over 3 yrs at an interest of		11%		**O&M Costs**	**$ 224,800**	**$ 549,347**
				Total Present Value Cost of Alternative*		**$ 3,448,347**

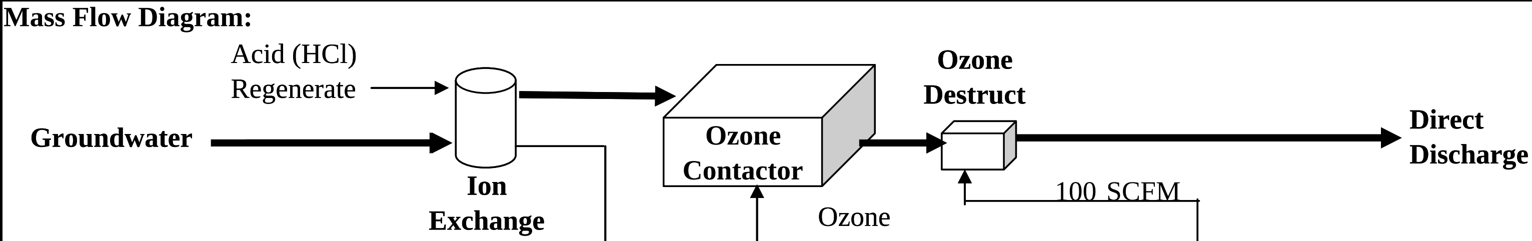
Table 2:

Cost Estimate for Groundwater Treatment at PSC

Geomatrix

Client Name:	**PSC**	**Location:**	
Description of Works:	**Ion Exchange System for Cation Removal (Fe, MG, Mn, etc.) Followed by Ozone System for Trace Organic Destruction Sized for 160 Usgpm**		

Mass Flow Diagram:



Influent:
160 Usgpm
35 mg/L TOC
41 mg/L Methane
5 mg/L NH3
243 mg/L COD (est.)

Assume:
3.3 kg O3/kg COD
735 cu.ft of air/kg O3

Item Name	Description	Mat'l Quantity	Unit	Unit Price	Install Labour Costs	Total Item Cost
Conveyance Piping to Treatment Plant	200mm HDPE Pipe	100	m	$ 150	$ 75	**$ 22,500**
Ion Exchange System	Package plant c/w Controls & sensors.	1.0	ea	$ 100,000	$ 20,000	**$ 120,000**
Acid Regeneration System	Storage tank, spill containment, level controls,	1.0	ea	$ 25,000	$ 10,000	**$ 35,000**
Caustic Neatralization System for Reject	Storage tank, spill containment, level controls,	1.0	ea	$ 25,000	$ 10,000	**$ 35,000**
Ozone Contactor	7,500 Usgal 304ss Tank w/ antivortex baffles	1.0	ea	$ 25,000	$ 7,500	**$ 32,500**
Oxidation Mixers	Top Mounted 2 hp Mixer w/ 316ss shaft & impeller	3.0	ea	$ 2,500	$ 3,500	**$ 18,000**
Ozone Package Plant	Includes Ozone generator, offgas destruct, and controls. Sized for (in lbs/day) 1,538	1.0	ea	$ 1,206,281	$ 100,000	**$ 1,306,281**
Ozone Destruct Tank	3500	1.0	ea	$ 15,000	$ 7,500	**$ 22,500**
Air Blower	Sized for (scfm) 457	2.0	ea	$ 5,000	$ 2,500	**$ 15,000**
Air Diffuser Grid		2.0	ea	$ 7,500	$ 2,500	**$ 20,000**
Discharge Pump		1.0	ea	$ 7,500	$ 5,000	**$ 12,500**
Discharge Piping	200mm HDPE Pipe	100	m	$ 150	$ 75	**$ 22,500**
Excavation & Backfill		100.0	m^3	$ 20	$ 25	**$ 4,500**
Tank, Building, & Equipment Slab	300mm Reinforced Concrete Slab	30.0	m^3	$ 550	$ 450	**$ 30,000**
Building Allowance	Small building for ozone generator, and controls	50.0	m^2	$ 550	$ 250	**$ 40,000**
Direct Construction Costs (DCC)		**Materials Total =**		**$1,566,600**	**$169,400**	**$1,736,000**
	Indirect Construction Costs (IDCC):		20%	**of DCC**		**$347,200**
	Construction Change Order Allowance:		10%	**of DCC+IDCC**		**$208,300**
	Contingency:		25%	**of DCC+IDCC**		**$520,800**
				Estimated Total Installed Costs (TIC)		**$2,812,000**
	Engineering		8%	**of TIC**		**$224,960**
	Contract Administration		1%	**of TIC**		**$28,120**
	Construction/Installation Supervision		3%	**of TIC**		**$84,360**
	Site Inspection		1%	**of TIC**		**$28,120**
	Commissioning		1%	**of TIC**		**$28,120**
				Total Estimated Capital Costs		**$3,206,000**

Estimated Yearly Operating & Maintenance Costs of the Constructed Works

Item Name	Description	Quantity /year	Unit	Unit Price	Yearly Cost	Present Cost*
Electricity	Oxidation Mixers	43,800	kW hr	$ 0.12	**$ 5,300**	**$ 12,952**
	Blowers and Pumps	219,000	kW hr	$ 0.12	**$ 26,300**	**$ 64,270**
	Ozone units	677,027	kW hr	$ 0.12	**$ 81,200**	**$ 198,430**
Chemicals	Acid for Regen	26,000	kg	$ 1.00	**$ 26,000**	**$ 63,537**
Sewer Fees	Sewerage fees for I/X regen	1,040	m^3	$ 2.50	**$ 2,600**	**$ 6,354**
Manpower (included benefits, payroll, taxes, etc)	supervisor (0.1 hr/day)	37	hours	$ 38.00	**$ 1,400**	**$ 3,421**
	operator (2.0 hr/day)	730	hours	$ 32.00	**$ 23,400**	**$ 57,183**
Maintenance	Percent of capital costs (TIC)/yr	3%	per year		**$ 84,400**	**$ 206,250**
* Performs a present value calc. over 3 yrs at an interest of		11%		**O&M Costs**	**$ 250,600**	**$ 612,395**
				Total Present Value Cost of Alternative*		**$ 3,818,395**

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TABLE A-1

HCIM AREA REMEDIAL ALTERNATIVES COST SUMMARY

PSC Georgetown Facility
Seattle, Washington

Alternatives	Net Present Value Cost	Net Present Value Cost (High)	Net Present Value Cost (Low)
HA-1: Active Hydraulic Containment	$7,211,300	NA	NA
HA-2: Enhanced Anaerobic Bioremediation	$9,249,800	$9,303,000	$9,202,100
HA-3: Enhanced Anaerobic Bioremediation/Dewatering/SVE	$14,283,300	$15,411,400	$13,101,700
HA-4: ISCO/Dewatering/SVE	$15,278,400	$16,870,900	$13,575,500
HA-5: Steam Stripping/Enhanced Anaerobic Bioremediation/Dewatering/SVE	$45,040,900	$56,111,400	$27,757,500
HA-6: Steam Stripping/Dewatering/SVE/Excavation	$45,827,200	$57,177,400	$27,853,600

Notes:
NA - Not Applicable
1. All costs are in 2007 dollars.
2. No sensitivity analysis was done for HA-1
3. For HA-2 through -6, the implementation and operational period varied by 2 years
4. For HA-2 the cost of bioremediation was varied by 25%
5. HA-3 had the all variations of HA-2, and the SVE system operational period varied from 2 to 6 years
6. HA-4 had the same SVE system operational period variation, and the ISCO costs varied by 50%
7. HA-5 had the same SVE system operational period variation, and the cost of steam injection ranged from $200/cubic yard to $650/cubic yard
8. HA-6 had the same variations as HA-5, and had the Excavation and Disposal Volumes varied by 50%

Geomatrix

TABLE A-2

OUTSIDE AREA REMEDIAL ALTERNATIVES COST SUMMARY

PSC Georgetown

Seattle, Washington

Outside Area Remedial Alternatives	Net Present Value Cost
OA-1: Monitored Natural Attenuation and IPIM	$4,912,900
OA-2: Enhanced Anaerobic Bioremediation, PCB Excavation, SVE, Surface Cover, and IPIM	$5,594,900
OA-3: Enhanced Anaerobic Bioremediation, PCB & Hot Spot Excavation, SVE, Surface Cover, & IPIM	$7,117,600
OA-4: Enhanced Anaerobic Bioremediation, Hydrolic Control, Hot Spot, Excavation, SVE, Surface Cover, and IPIM	$14,000,600
OA-5: Enhanced Bioremediation, Groundwater Recovery and Treatment, Hot Spot Excavation, SVE, Hydraulic Control/Mass Removal and IPIM	$16,426,800

Notes:

1. All costs are in 2007 dollars.

Geomatrix

TABLE A-3

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-1

PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **CAP CONSTRUCTION**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction Cost Data p. 24; 02 21 13.09 0020
Subtotal				**$5,100**	
Professional Technical Services					
Permitting	%	7%	$5,100	$400	Geomatrix standard rate
Engineering Design Costs	%	20%	$5,100	$1,000	from EPA, 2000, Exh. 5-8
Construction Management	%	15%	$5,100	$800	from EPA, 2000, Exh. 5-8
Project Management	%	10%	$5,100	$500	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$2,700	
TOTAL INITIAL IMPLEMENTATION COST				**$7,800**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

Geomatrix

TABLE A-4

RECURRING COSTS FOR ALTERNATIVE HA-1
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
3	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$31	13	$400	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$2,970**	
4	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-5

Geomatrix

NET PRESENT VALUE FOR ALTERNATIVE HA-1
PSC Georgetown Facility
Seattle, Washington

Year	Imp. Cost	Inspection & PM	Treatment System O&M	Annual Replacement Costs	15% Contingency	Yearly Total
0	$7,800				$1,170	$9,000
1		$10,550	$162,200	$2,970	$26,358	$202,100
2		$10,550	$162,200	$2,970	$26,358	$202,100
3		$10,550	$162,200	$2,970	$26,358	$202,100
4		$10,550	$162,200	$2,970	$26,358	$202,100
5		$10,550	$162,200	$2,970	$26,358	$202,100
6		$10,550	$162,200	$2,970	$26,358	$202,100
7		$10,550	$162,200	$2,970	$26,358	$202,100
8		$10,550	$162,200	$2,970	$26,358	$202,100
9		$10,550	$162,200	$2,970	$26,358	$202,100
10		$10,550	$162,200	$2,970	$26,358	$202,100
11		$10,550	$162,200	$2,970	$26,358	$202,100
12		$10,550	$162,200	$2,970	$26,358	$202,100
13		$10,550	$162,200	$2,970	$26,358	$202,100
14		$10,550	$162,200	$2,970	$26,358	$202,100
15		$10,550	$162,200	$2,970	$26,358	$202,100
16		$10,550	$162,200	$2,970	$26,358	$202,100
17		$10,550	$162,200	$2,970	$26,358	$202,100
18		$10,550	$162,200	$2,970	$26,358	$202,100
19		$10,550	$162,200	$2,970	$26,358	$202,100
20		$10,550	$162,200	$2,970	$26,358	$202,100
21		$10,550	$162,200	$2,970	$26,358	$202,100
22		$10,550	$162,200	$2,970	$26,358	$202,100
23		$10,550	$162,200	$2,970	$26,358	$202,100
24		$10,550	$162,200	$2,970	$26,358	$202,100
25		$10,550	$162,200	$2,970	$26,358	$202,100
26		$10,550	$162,200	$2,970	$26,358	$202,100
27		$10,550	$162,200	$2,970	$26,358	$202,100
28		$10,550	$162,200	$2,970	$26,358	$202,100
29		$10,550	$162,200	$2,970	$26,358	$202,100
30		$10,550	$162,200	$2,970	$26,358	$202,100
31		$10,550	$162,200	$2,970	$26,358	$202,100
32		$10,550	$162,200	$2,970	$26,358	$202,100
33		$10,550	$162,200	$2,970	$26,358	$202,100
34		$10,550	$162,200	$2,970	$26,358	$202,100
35		$10,550	$162,200	$2,970	$26,358	$202,100
36		$10,550	$162,200	$2,970	$26,358	$202,100
37		$10,550	$162,200	$2,970	$26,358	$202,100
38		$10,550	$162,200	$2,970	$26,358	$202,100
39		$10,550	$162,200	$2,970	$26,358	$202,100
40		$10,550	$162,200	$2,970	$26,358	$202,100
41		$10,550	$162,200	$2,970	$26,358	$202,100
42		$10,550	$162,200	$2,970	$26,358	$202,100
43		$10,550	$162,200	$2,970	$26,358	$202,100
44		$10,550	$162,200	$2,970	$26,358	$202,100
45		$10,550	$162,200	$2,970	$26,358	$202,100
46		$10,550	$162,200	$2,970	$26,358	$202,100
47		$10,550	$162,200	$2,970	$26,358	$202,100
48		$10,550	$162,200	$2,970	$26,358	$202,100
49		$10,550	$162,200	$2,970	$26,358	$202,100
50		$10,550	$162,200	$2,970	$26,358	$202,100
51		$10,550	$162,200	$2,970	$26,358	$202,100
52		$10,550	$162,200	$2,970	$26,358	$202,100
53		$10,550	$162,200	$2,970	$26,358	$202,100
54		$10,550	$162,200	$2,970	$26,358	$202,100
55		$10,550	$162,200	$2,970	$26,358	$202,100
56		$10,550	$162,200	$2,970	$26,358	$202,100
57		$10,550	$162,200	$2,970	$26,358	$202,100
58		$10,550	$162,200	$2,970	$26,358	$202,100
59		$10,550	$162,200	$2,970	$26,358	$202,100
60		$10,550	$162,200	$2,970	$26,358	$202,100
61		$10,550	$162,200	$2,970	$26,358	$202,100
62		$10,550	$162,200	$2,970	$26,358	$202,100
63		$10,550	$162,200	$2,970	$26,358	$202,100
64		$10,550	$162,200	$2,970	$26,358	$202,100
65		$10,550	$162,200	$2,970	$26,358	$202,100
66		$10,550	$162,200	$2,970	$26,358	$202,100
67		$10,550	$162,200	$2,970	$26,358	$202,100
68		$10,550	$162,200	$2,970	$26,358	$202,100
69		$10,550	$162,200	$2,970	$26,358	$202,100
70		$10,550	$162,200	$2,970	$26,358	$202,100
71		$10,550	$162,200	$2,970	$26,358	$202,100
72		$10,550	$162,200	$2,970	$26,358	$202,100
73		$10,550	$162,200	$2,970	$26,358	$202,100
74		$10,550	$162,200	$2,970	$26,358	$202,100
75		$10,550	$162,200	$2,970	$26,358	$202,100
76		$10,550	$162,200	$2,970	$26,358	$202,100
77		$10,550	$162,200	$2,970	$26,358	$202,100
78		$10,550	$162,200	$2,970	$26,358	$202,100
79		$10,550	$162,200	$2,970	$26,358	$202,100
80		$10,550	$162,200	$2,970	$26,358	$202,100
81		$10,550	$162,200	$2,970	$26,358	$202,100
82		$10,550	$162,200	$2,970	$26,358	$202,100
83		$10,550	$162,200	$2,970	$26,358	$202,100
84		$10,550	$162,200	$2,970	$26,358	$202,100
85		$10,550	$162,200	$2,970	$26,358	$202,100
86		$10,550	$162,200	$2,970	$26,358	$202,100
87		$10,550	$162,200	$2,970	$26,358	$202,100
88		$10,550	$162,200	$2,970	$26,358	$202,100
89		$10,550	$162,200	$2,970	$26,358	$202,100
90		$10,550	$162,200	$2,970	$26,358	$202,100
91		$10,550	$162,200	$2,970	$26,358	$202,100
92		$10,550	$162,200	$2,970	$26,358	$202,100
93		$10,550	$162,200	$2,970	$26,358	$202,100
94		$10,550	$162,200	$2,970	$26,358	$202,100
95		$10,550	$162,200	$2,970	$26,358	$202,100
96		$10,550	$162,200	$2,970	$26,358	$202,100
97		$10,550	$162,200	$2,970	$26,358	$202,100
98		$10,550	$162,200	$2,970	$26,358	$202,100
99		$10,550	$162,200	$2,970	$26,358	$202,100
TOTAL	$7,800	$1,044,500	$16,057,800	$294,000	$2,610,600	$20,016,900

Net Discount rate: 2.5% **NPV** **$7,211,300**

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TABLE A-6
IMPLEMENTATION COSTS FOR ALTERNATIVE HA-2
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 4 Wells, 2 at 30' bgs, 2 at 50' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 **Pilot Study**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	3	$2,400	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,950	$2,000	Price from similar job
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 3 Total				**$54,200**	
4 **Full-Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 4 Total				**$137,600**	
Subtotal				$209,400	
Professional Technical Services					
Permitting	%	7%	$209,400	$14,700	Geomatrix standard rate
Engineering Design Costs	%	12%	$209,400	$25,100	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$209,400	$16,800	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$209,400	$12,600	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$69,200	
TOTAL INITIAL IMPLEMENTATION COST				**$278,600**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

TABLE A-7

RECURRING COSTS FOR ALTERNATIVE HA-2
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
3	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
4	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Molassess	lbs	$1	39000	$39,000	Price from similar job
	Recirculation/Injection Labor	day	$1,600	10	$16,000	2 engineers/scientists, $100/hour
	Subtotal				**$55,000**	
6	**SEMI ANNUAL ISB MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
7	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	per year	$15,000	1	$15,000	Price from similar job
	Subtotal				**$15,000**	
8	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
9	**PROPERTY OPPORTUNITY COST (5 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-8

NET PRESENT VALUE FOR ALTERNATIVE HA-2
PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Semi-Annual Injection	Semi-Annual ISB Monitoring	Inspection & Project Management	System Annual Costs Including O&M	Annual Replacement Costs	Property Opportunity Cost	25% Contingency	Yearly Total
0	$278,600					$367,500	$161,525	$646,100
1	$55,000	$26,620	$15,550	$162,200	$3,290	$367,500	$157,540	$630,200
2	$55,000	$26,620	$15,550	$162,200	$3,290	$367,500	$157,540	$630,200
3	$55,000	$26,620	$15,550	$162,200	$3,290	$367,500	$157,540	$630,200
4	$55,000	$26,620	$15,550	$162,200	$3,290	$367,500	$157,540	$630,200
5		$26,620	$15,550	$162,200	$3,290	$367,500	$143,790	$575,200
6		$26,620	$15,550	$162,200	$3,290	$367,500	$143,790	$575,200
7			$10,550	$162,200	$3,290		$44,010	$176,000
8			$10,550	$162,200	$3,290		$44,010	$176,000
9			$10,550	$162,200	$3,290		$44,010	$176,000
10			$10,550	$162,200	$3,290		$44,010	$176,000
11			$10,550	$162,200	$3,290		$44,010	$176,000
12			$10,550	$162,200	$3,290		$44,010	$176,000
13			$10,550	$162,200	$3,290		$44,010	$176,000
14			$10,550	$162,200	$3,290		$44,010	$176,000
15			$10,550	$162,200	$3,290		$44,010	$176,000
16			$10,550	$162,200	$3,290		$44,010	$176,000
17			$10,550	$162,200	$3,290		$44,010	$176,000
18			$10,550	$162,200	$3,290		$44,010	$176,000
19			$10,550	$162,200	$3,290		$44,010	$176,000
20			$10,550	$162,200	$3,290		$44,010	$176,000
21			$10,550	$162,200	$3,290		$44,010	$176,000
22			$10,550	$162,200	$3,290		$44,010	$176,000
23			$10,550	$162,200	$3,290		$44,010	$176,000
24			$10,550	$162,200	$3,290		$44,010	$176,000
25			$10,550	$162,200	$3,290		$44,010	$176,000
26			$10,550	$162,200	$3,290		$44,010	$176,000
27			$10,550	$162,200	$3,290		$44,010	$176,000
28			$10,550	$162,200	$3,290		$44,010	$176,000
29			$10,550	$162,200	$3,290		$44,010	$176,000
30			$10,550	$162,200	$3,290		$44,010	$176,000
31			$10,550	$162,200	$3,290		$44,010	$176,000
32			$10,550	$162,200	$3,290		$44,010	$176,000
33			$10,550	$162,200	$3,290		$44,010	$176,000
34			$10,550	$162,200	$3,290		$44,010	$176,000
35			$10,550	$162,200	$3,290		$44,010	$176,000
36			$10,550	$162,200	$3,290		$44,010	$176,000
37			$10,550	$162,200	$3,290		$44,010	$176,000
38			$10,550	$162,200	$3,290		$44,010	$176,000
39			$10,550	$162,200	$3,290		$44,010	$176,000
40			$10,550	$162,200	$3,290		$44,010	$176,000
41			$10,550	$162,200	$3,290		$44,010	$176,000
42			$10,550	$162,200	$3,290		$44,010	$176,000
43			$10,550	$162,200	$3,290		$44,010	$176,000
44			$10,550	$162,200	$3,290		$44,010	$176,000
45			$10,550	$162,200	$3,290		$44,010	$176,000
46			$10,550	$162,200	$3,290		$44,010	$176,000
47			$10,550	$162,200	$3,290		$44,010	$176,000
48			$10,550	$162,200	$3,290		$44,010	$176,000
49			$10,550	$162,200	$3,290		$44,010	$176,000
50			$10,550	$162,200	$3,290		$44,010	$176,000
51			$10,550	$162,200	$3,290		$44,010	$176,000
52			$10,550	$162,200	$3,290		$44,010	$176,000
53			$10,550	$162,200	$3,290		$44,010	$176,000
54			$10,550	$162,200	$3,290		$44,010	$176,000
55			$10,550	$162,200	$3,290		$44,010	$176,000
56			$10,550	$162,200	$3,290		$44,010	$176,000
57			$10,550	$162,200	$3,290		$44,010	$176,000
58			$10,550	$162,200	$3,290		$44,010	$176,000
59			$10,550	$162,200	$3,290		$44,010	$176,000
60			$10,550	$162,200	$3,290		$44,010	$176,000
61			$10,550	$162,200	$3,290		$44,010	$176,000
62			$10,550	$162,200	$3,290		$44,010	$176,000
63			$10,550	$162,200	$3,290		$44,010	$176,000
64			$10,550	$162,200	$3,290		$44,010	$176,000
65			$10,550	$162,200	$3,290		$44,010	$176,000
66			$10,550	$162,200	$3,290		$44,010	$176,000
67			$10,550	$162,200	$3,290		$44,010	$176,000
68			$10,550	$162,200	$3,290		$44,010	$176,000
69			$10,550	$162,200	$3,290		$44,010	$176,000
70			$10,550	$162,200	$3,290		$44,010	$176,000
71			$10,550	$162,200	$3,290		$44,010	$176,000
72			$10,550	$162,200	$3,290		$44,010	$176,000
73			$10,550	$162,200	$3,290		$44,010	$176,000
74			$10,550	$162,200	$3,290		$44,010	$176,000
75			$10,550	$162,200	$3,290		$44,010	$176,000
76			$10,550	$162,200	$3,290		$44,010	$176,000
77			$10,550	$162,200	$3,290		$44,010	$176,000
78			$10,550	$162,200	$3,290		$44,010	$176,000
79			$10,550	$162,200	$3,290		$44,010	$176,000
80			$10,550	$162,200	$3,290		$44,010	$176,000
81			$10,550	$162,200	$3,290		$44,010	$176,000
82			$10,550	$162,200	$3,290		$44,010	$176,000
83			$10,550	$162,200	$3,290		$44,010	$176,000
84			$10,550	$162,200	$3,290		$44,010	$176,000
85			$10,550	$162,200	$3,290		$44,010	$176,000
86			$10,550	$162,200	$3,290		$44,010	$176,000
87			$10,550	$162,200	$3,290		$44,010	$176,000
88			$10,550	$162,200	$3,290		$44,010	$176,000
89			$10,550	$162,200	$3,290		$44,010	$176,000
90			$10,550	$162,200	$3,290		$44,010	$176,000
91			$10,550	$162,200	$3,290		$44,010	$176,000
92			$10,550	$162,200	$3,290		$44,010	$176,000
93			$10,550	$162,200	$3,290		$44,010	$176,000
94			$10,550	$162,200	$3,290		$44,010	$176,000
95			$10,550	$162,200	$3,290		$44,010	$176,000
96			$10,550	$162,200	$3,290		$44,010	$176,000
97			$10,550	$162,200	$3,290		$44,010	$176,000
98			$10,550	$162,200	$3,290		$44,010	$176,000
99			$10,550	$162,200	$3,290		$44,010	$176,000
TOTAL	$498,600	$159,700	$1,074,500	$16,057,800	$325,700	$2,572,500	$5,172,200	$20,685,300

Net Discount rate: 2.5% **NPV $9,249,800**

Geomatrix

TABLE A-9

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-3
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 Cap Construction					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 Performance Monitoring Well Installation					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 4 Wells, 2 at 30' bgs, 2 at 50' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 Dewatering and Soil Vapor Extraction System					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
30 HP, 580 SCFM Vapor Extraction Blower	EA	$11,523	1	$11,500	2005 RSMeans Environmental p 9-153; 33 13 2342
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Permanent	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	150	$5,900	2005 RSMeans Environmental p. 9-236; 33 23 1101; 6 SVE wells at 25' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	30	$700	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 6 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	120	$4,300	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 6 wells
4" Well, Grout (Annular Seal)	LF	$128.04	6	$800	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	6	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1702
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$232,800**	
4 Pilot Study					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	3	$2,400	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,950	$2,000	Price from similar job
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 4 Total				**$54,200**	
5 ISB Full-Scale Installation					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p. 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p. 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p. 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 5 Total				**$137,600**	
Subtotal				$442,200	
Professional Technical Services					
Permitting	%	7%	$442,200	$31,000	Geomatrix standard rate
Engineering Design Costs	%	12%	$442,200	$53,100	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$442,200	$35,400	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$442,200	$26,500	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$146,000	
TOTAL INITIAL IMPLEMENTATION COST				**$588,200**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

TABLE A-10

RECURRING COSTS FOR ALTERNATIVE HA-3

PSC Georgetown Facility

Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
5	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Molassess	lbs	$1	39000	$39,000	Price from similar job
	Recirculation/Injection Labor	day	$1,600	10	$16,000	2 engineers/scientists, $100/hour
	Subtotal				**$55,000**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
8	**SEMI ANNUAL ISB MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
9	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	per year	$20,000	1	$20,000	Price from similar job
	Subtotal				**$20,000**	
10	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
11	**PROPERTY OPPORTUNITY COST (9 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:

1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

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TABLE A-11

NET PRESENT VALUE FOR ALTERNATIVE HA-3

PSC Georgetown Facility

Seattle, Washington

Year	Implementation & Injection Costs	Semi-Annual ISB Monitoring	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	SVE / Dewatering System Monitoring	Property Opportunity Cost	25% Contingency	Yearly Total
0	$588,200							$367,500	$238,925	$1,194,600
1			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
2			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
3			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
4			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
5	$55,000	$26,620	$20,550	$162,200	$3,290			$367,500	$158,790	$794,000
6	$55,000	$26,620	$20,550	$162,200	$3,290			$367,500	$158,790	$794,000
7	$55,000	$26,620	$20,550	$162,200	$3,290			$367,500	$158,790	$794,000
8	$55,000	$26,620	$20,550	$162,200	$3,290			$367,500	$158,790	$794,000
9		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
10		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
11			$10,550	$162,200	$3,290				$44,010	$220,100
12			$10,550	$162,200	$3,290				$44,010	$220,100
13			$10,550	$162,200	$3,290				$44,010	$220,100
14			$10,550	$162,200	$3,290				$44,010	$220,100
15			$10,550	$162,200	$3,290				$44,010	$220,100
16			$10,550	$162,200	$3,290				$44,010	$220,100
17			$10,550	$162,200	$3,290				$44,010	$220,100
18			$10,550	$162,200	$3,290				$44,010	$220,100
19			$10,550	$162,200	$3,290				$44,010	$220,100
20			$10,550	$162,200	$3,290				$44,010	$220,100
21			$10,550	$162,200	$3,290				$44,010	$220,100
22			$10,550	$162,200	$3,290				$44,010	$220,100
23			$10,550	$162,200	$3,290				$44,010	$220,100
24			$10,550	$162,200	$3,290				$44,010	$220,100
25			$10,550	$162,200	$3,290				$44,010	$220,100
26			$10,550	$162,200	$3,290				$44,010	$220,100
27			$10,550	$162,200	$3,290				$44,010	$220,100
28			$10,550	$162,200	$3,290				$44,010	$220,100
29			$10,550	$162,200	$3,290				$44,010	$220,100
30			$10,550	$162,200	$3,290				$44,010	$220,100
31			$10,550	$162,200	$3,290				$44,010	$220,100
32			$10,550	$162,200	$3,290				$44,010	$220,100
33			$10,550	$162,200	$3,290				$44,010	$220,100
34			$10,550	$162,200	$3,290				$44,010	$220,100
35			$10,550	$162,200	$3,290				$44,010	$220,100
36			$10,550	$162,200	$3,290				$44,010	$220,100
37			$10,550	$162,200	$3,290				$44,010	$220,100
38			$10,550	$162,200	$3,290				$44,010	$220,100
39			$10,550	$162,200	$3,290				$44,010	$220,100
40			$10,550	$162,200	$3,290				$44,010	$220,100
41			$10,550	$162,200	$3,290				$44,010	$220,100
42			$10,550	$162,200	$3,290				$44,010	$220,100
43			$10,550	$162,200	$3,290				$44,010	$220,100
44			$10,550	$162,200	$3,290				$44,010	$220,100
45			$10,550	$162,200	$3,290				$44,010	$220,100
46			$10,550	$162,200	$3,290				$44,010	$220,100
47			$10,550	$162,200	$3,290				$44,010	$220,100
48			$10,550	$162,200	$3,290				$44,010	$220,100
49			$10,550	$162,200	$3,290				$44,010	$220,100
50			$10,550	$162,200	$3,290				$44,010	$220,100
51			$10,550	$162,200	$3,290				$44,010	$220,100
52			$10,550	$162,200	$3,290				$44,010	$220,100
53			$10,550	$162,200	$3,290				$44,010	$220,100
54			$10,550	$162,200	$3,290				$44,010	$220,100
55			$10,550	$162,200	$3,290				$44,010	$220,100
56			$10,550	$162,200	$3,290				$44,010	$220,100
57			$10,550	$162,200	$3,290				$44,010	$220,100
58			$10,550	$162,200	$3,290				$44,010	$220,100
59			$10,550	$162,200	$3,290				$44,010	$220,100
60			$10,550	$162,200	$3,290				$44,010	$220,100
61			$10,550	$162,200	$3,290				$44,010	$220,100
62			$10,550	$162,200	$3,290				$44,010	$220,100
63			$10,550	$162,200	$3,290				$44,010	$220,100
64			$10,550	$162,200	$3,290				$44,010	$220,100
65			$10,550	$162,200	$3,290				$44,010	$220,100
66			$10,550	$162,200	$3,290				$44,010	$220,100
67			$10,550	$162,200	$3,290				$44,010	$220,100
68			$10,550	$162,200	$3,290				$44,010	$220,100
69			$10,550	$162,200	$3,290				$44,010	$220,100
70			$10,550	$162,200	$3,290				$44,010	$220,100
71			$10,550	$162,200	$3,290				$44,010	$220,100
72			$10,550	$162,200	$3,290				$44,010	$220,100
73			$10,550	$162,200	$3,290				$44,010	$220,100
74			$10,550	$162,200	$3,290				$44,010	$220,100
75			$10,550	$162,200	$3,290				$44,010	$220,100
76			$10,550	$162,200	$3,290				$44,010	$220,100
77			$10,550	$162,200	$3,290				$44,010	$220,100
78			$10,550	$162,200	$3,290				$44,010	$220,100
79			$10,550	$162,200	$3,290				$44,010	$220,100
80			$10,550	$162,200	$3,290				$44,010	$220,100
81			$10,550	$162,200	$3,290				$44,010	$220,100
82			$10,550	$162,200	$3,290				$44,010	$220,100
83			$10,550	$162,200	$3,290				$44,010	$220,100
84			$10,550	$162,200	$3,290				$44,010	$220,100
85			$10,550	$162,200	$3,290				$44,010	$220,100
86			$10,550	$162,200	$3,290				$44,010	$220,100
87			$10,550	$162,200	$3,290				$44,010	$220,100
88			$10,550	$162,200	$3,290				$44,010	$220,100
89			$10,550	$162,200	$3,290				$44,010	$220,100
90			$10,550	$162,200	$3,290				$44,010	$220,100
91			$10,550	$162,200	$3,290				$44,010	$220,100
92			$10,550	$162,200	$3,290				$44,010	$220,100
93			$10,550	$162,200	$3,290				$44,010	$220,100
94			$10,550	$162,200	$3,290				$44,010	$220,100
95			$10,550	$162,200	$3,290				$44,010	$220,100
96			$10,550	$162,200	$3,290				$44,010	$220,100
97			$10,550	$162,200	$3,290				$44,010	$220,100
98			$10,550	$162,200	$3,290				$44,010	$220,100
99			$10,550	$162,200	$3,290				$44,010	$220,100
TOTAL	$808,200	$159,700	$1,144,500	$16,057,800	$325,700	$677,600	$67,200	$4,042,500	$5,820,800	$29,108,700

Net Discount rate: 2.5%

NPV **$14,283,300**

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TABLE A-12

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-4
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 4 Wells, 2 at 30' bgs, 2 at 50' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 **Dewatering and Soil Vapor Extraction System**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
30 HP, 580 SCFM Vapor Extraction Blower	EA	$11,523	1	$11,500	2005 RSMeans Environmental p 9-153; 33 13 2342
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Permanent	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	150	$5,900	2005 RSMeans Environmental p. 9-236; 33 23 1101; 6 SVE wells at 25' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	30	$700	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 6 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	120	$4,300	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 6 wells
4" Well, Grout (Annular Seal)	LF	$128.04	6	$800	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	6	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1702
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$232,800**	
4 **ISCO Pilot Study**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Soil Sampling	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Potassium Permanganate ($KMNO_4$)	lbs	$2	3,940	$6,400	Estimate of required substrate per recirculation cell, Geomatrix past experience
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 4 Total				**$65,000**	
5 **ISCO Full-Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p. 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	20	$16,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 5 Total				**$145,600**	
Subtotal				$461,000	
Professional Technical Services					
Permitting	%	7%	$461,000	$32,300	Geomatrix standard rate
Engineering Design Costs	%	12%	$461,000	$55,300	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$461,000	$36,900	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$461,000	$27,700	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$152,200	
TOTAL INITIAL IMPLEMENTATION COST				**$613,200**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

TABLE A-13

RECURRING COSTS FOR ALTERNATIVE HA-4

PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
5	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Potassium Permanganate ($KMNO_4$)	lbs	$2	157500	$255,150	Carcus Chemical Company
	Recirculation/Injection Labor	day	$1,600	20	$32,000	2 engineers/scientists, $100/hour
	Subtotal				**$287,150**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
8	**SEMI ANNUAL ISCO MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
9	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	per year	$20,000	1	$20,000	Price from similar job
	Subtotal				**$20,000**	
10	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
11	**PROPERTY OPPORTUNITY COST (9 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-14

NET PRESENT VALUE FOR ALTERNATIVE HA-4
PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Injection Costs	Semi-Annual ISCO Monitoring	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	Dewatering System Monitoring	Property Opportunity Cost	25% Contingency	Yearly Total
0	$613,200							$367,500	$245,175	$1,225,900
1			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
2			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
3			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
4			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
5	$287,150	$26,620	$20,550	$162,200	$3,290			$367,500	$216,828	$1,084,100
6	$287,150	$26,620	$20,550	$162,200	$3,290			$367,500	$216,828	$1,084,100
7	$287,150	$26,620	$20,550	$162,200	$3,290			$367,500	$216,828	$1,084,100
8	$287,150	$26,620	$20,550	$162,200	$3,290			$367,500	$216,828	$1,084,100
9		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
10		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
11			$10,550	$162,200	$3,290				$44,010	$220,100
12			$10,550	$162,200	$3,290				$44,010	$220,100
13			$10,550	$162,200	$3,290				$44,010	$220,100
14			$10,550	$162,200	$3,290				$44,010	$220,100
15			$10,550	$162,200	$3,290				$44,010	$220,100
16			$10,550	$162,200	$3,290				$44,010	$220,100
17			$10,550	$162,200	$3,290				$44,010	$220,100
18			$10,550	$162,200	$3,290				$44,010	$220,100
19			$10,550	$162,200	$3,290				$44,010	$220,100
20			$10,550	$162,200	$3,290				$44,010	$220,100
21			$10,550	$162,200	$3,290				$44,010	$220,100
22			$10,550	$162,200	$3,290				$44,010	$220,100
23			$10,550	$162,200	$3,290				$44,010	$220,100
24			$10,550	$162,200	$3,290				$44,010	$220,100
25			$10,550	$162,200	$3,290				$44,010	$220,100
26			$10,550	$162,200	$3,290				$44,010	$220,100
27			$10,550	$162,200	$3,290				$44,010	$220,100
28			$10,550	$162,200	$3,290				$44,010	$220,100
29			$10,550	$162,200	$3,290				$44,010	$220,100
30			$10,550	$162,200	$3,290				$44,010	$220,100
31			$10,550	$162,200	$3,290				$44,010	$220,100
32			$10,550	$162,200	$3,290				$44,010	$220,100
33			$10,550	$162,200	$3,290				$44,010	$220,100
34			$10,550	$162,200	$3,290				$44,010	$220,100
35			$10,550	$162,200	$3,290				$44,010	$220,100
36			$10,550	$162,200	$3,290				$44,010	$220,100
37			$10,550	$162,200	$3,290				$44,010	$220,100
38			$10,550	$162,200	$3,290				$44,010	$220,100
39			$10,550	$162,200	$3,290				$44,010	$220,100
40			$10,550	$162,200	$3,290				$44,010	$220,100
41			$10,550	$162,200	$3,290				$44,010	$220,100
42			$10,550	$162,200	$3,290				$44,010	$220,100
43			$10,550	$162,200	$3,290				$44,010	$220,100
44			$10,550	$162,200	$3,290				$44,010	$220,100
45			$10,550	$162,200	$3,290				$44,010	$220,100
46			$10,550	$162,200	$3,290				$44,010	$220,100
47			$10,550	$162,200	$3,290				$44,010	$220,100
48			$10,550	$162,200	$3,290				$44,010	$220,100
49			$10,550	$162,200	$3,290				$44,010	$220,100
50			$10,550	$162,200	$3,290				$44,010	$220,100
51			$10,550	$162,200	$3,290				$44,010	$220,100
52			$10,550	$162,200	$3,290				$44,010	$220,100
53			$10,550	$162,200	$3,290				$44,010	$220,100
54			$10,550	$162,200	$3,290				$44,010	$220,100
55			$10,550	$162,200	$3,290				$44,010	$220,100
56			$10,550	$162,200	$3,290				$44,010	$220,100
57			$10,550	$162,200	$3,290				$44,010	$220,100
58			$10,550	$162,200	$3,290				$44,010	$220,100
59			$10,550	$162,200	$3,290				$44,010	$220,100
60			$10,550	$162,200	$3,290				$44,010	$220,100
61			$10,550	$162,200	$3,290				$44,010	$220,100
62			$10,550	$162,200	$3,290				$44,010	$220,100
63			$10,550	$162,200	$3,290				$44,010	$220,100
64			$10,550	$162,200	$3,290				$44,010	$220,100
65			$10,550	$162,200	$3,290				$44,010	$220,100
66			$10,550	$162,200	$3,290				$44,010	$220,100
67			$10,550	$162,200	$3,290				$44,010	$220,100
68			$10,550	$162,200	$3,290				$44,010	$220,100
69			$10,550	$162,200	$3,290				$44,010	$220,100
70			$10,550	$162,200	$3,290				$44,010	$220,100
71			$10,550	$162,200	$3,290				$44,010	$220,100
72			$10,550	$162,200	$3,290				$44,010	$220,100
73			$10,550	$162,200	$3,290				$44,010	$220,100
74			$10,550	$162,200	$3,290				$44,010	$220,100
75			$10,550	$162,200	$3,290				$44,010	$220,100
76			$10,550	$162,200	$3,290				$44,010	$220,100
77			$10,550	$162,200	$3,290				$44,010	$220,100
78			$10,550	$162,200	$3,290				$44,010	$220,100
79			$10,550	$162,200	$3,290				$44,010	$220,100
80			$10,550	$162,200	$3,290				$44,010	$220,100
81			$10,550	$162,200	$3,290				$44,010	$220,100
82			$10,550	$162,200	$3,290				$44,010	$220,100
83			$10,550	$162,200	$3,290				$44,010	$220,100
84			$10,550	$162,200	$3,290				$44,010	$220,100
85			$10,550	$162,200	$3,290				$44,010	$220,100
86			$10,550	$162,200	$3,290				$44,010	$220,100
87			$10,550	$162,200	$3,290				$44,010	$220,100
88			$10,550	$162,200	$3,290				$44,010	$220,100
89			$10,550	$162,200	$3,290				$44,010	$220,100
90			$10,550	$162,200	$3,290				$44,010	$220,100
91			$10,550	$162,200	$3,290				$44,010	$220,100
92			$10,550	$162,200	$3,290				$44,010	$220,100
93			$10,550	$162,200	$3,290				$44,010	$220,100
94			$10,550	$162,200	$3,290				$44,010	$220,100
95			$10,550	$162,200	$3,290				$44,010	$220,100
96			$10,550	$162,200	$3,290				$44,010	$220,100
97			$10,550	$162,200	$3,290				$44,010	$220,100
98			$10,550	$162,200	$3,290				$44,010	$220,100
99			$10,550	$162,200	$3,290				$44,010	$220,100
TOTAL	$1,761,800	$159,700	$1,144,500	$16,057,800	$325,700	$677,600	$67,200	$4,042,500	$6,059,200	$30,300,400

Net Discount rate: 2.5%

NPV $15,278,400

Geomatrix

TABLE A-15

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-5

PSC Georgetown Facility

Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 Cap Construction					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 Performance Monitoring Well Installation					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 4 Wells, 2 at 30' bgs, 2 at 50' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 Dewatering and Soil Vapor Extraction System (3 extra ext. wells)					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower, 50 gpm	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
1000 SCFM, Vapor Recovery System	EA	$27,034	1	$27,000	2005 RSMeans Environmental p 9-154; 33 13 2361
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Carbon Assorption	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	140	$5,500	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 SVE wells at 25' bgs, 4 SVE wells at 10' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	40	$1,000	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 8 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	100	$3,600	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 4 wells, 5' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	8	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	8	$1,400	2005 RSMeans Environmental p 9-246; 33 23 1702
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$248,100**	
4 Steam Injection					
Similar Case Study Overall Costs	CY	$456	61,834	$28,196,304	Based on reported range of costs for published applications
Task 4 Total				**NA**	
5 ISB Pilot Study					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	3	$2,400	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Emulsified Vegetable Oil	lbs	$1	1,950	$2,000	Price from similar job
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 5 Total				**$54,200**	
6 ISB Full-Scale Installation					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p. 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 6 Total				**$137,600**	
Subtotal				$457,500	
Professional Technical Services					
Permitting	%	7%	$457,500	$32,000	Geomatrix standard rate
Engineering Design Costs	%	12%	$457,500	$54,900	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$457,500	$36,600	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$457,500	$27,500	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$151,000	
TOTAL INITIAL IMPLEMENTATION COST				**$608,500**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

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TABLE A-16

RECURRING COSTS FOR ALTERNATIVE HA-5
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (12 TOTAL YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**ANNUAL REPLACEMENT COSTS (12 TOTAL YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
5	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Molasses	lbs	$1	39000	$39,000	Price from similar job
	Recirculation/Injection Labor	day	$1,600	10	$16,000	2 engineers/scientists, $100/hour
	Subtotal				**$55,000**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
8	**SEMI ANNUAL ISB MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
9	**PROJECT MANAGEMENT (12 TOTAL YEARS)**					
	Project Management	per year	$20,000	1	$20,000	Price from similar job
	Subtotal				**$20,000**	
10	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
11	**PROPERTY OPPORTUNITY COST (19 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-17

NET PRESENT VALUE FOR ALTERNATIVE HA-5

PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Injection Costs	Semi-Annual ISB Monitoring	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	SVE / Dewatering System Monitoring	Property Opportunity Cost	25% Contingency	Yearly Total
0	$608,500							$367,500	$244,000	$1,220,000
1			$20,550	$162,200	$3,290			$367,500	$138,385	$691,900
2			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
3			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
4			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
5			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
6			$550	$162,200	$3,290			$367,500	$133,385	$666,900
7	$28,196,300		$550	$162,200	$3,290			$367,500	$7,182,460	$35,912,300
8			$550	$162,200	$3,290			$367,500	$133,385	$666,900
9			$550	$162,200	$3,290			$367,500	$133,385	$666,900
10			$550	$162,200	$3,290			$367,500	$133,385	$666,900
11			$20,550	$162,200	$3,290			$367,500	$138,385	$691,900
12			$20,550	$162,200	$3,290			$367,500	$138,385	$691,900
13	$55,000	$26,620	$20,550	$162,200	$3,290			$367,500	$158,790	$794,000
14	$55,000	$26,620	$20,550	$162,200	$3,290			$367,500	$158,790	$794,000
15	$55,000	$26,620	$20,550	$162,200	$3,290			$367,500	$158,790	$794,000
16	$55,000	$26,620	$20,550	$162,200	$3,290			$367,500	$158,790	$794,000
17		$26,620	$20,550	$162,200	$3,290				$53,165	$265,800
18		$26,620	$20,550	$162,200	$3,290				$53,165	$265,800
19			$10,550	$162,200	$3,290				$44,010	$220,100
20			$10,550	$162,200	$3,290				$44,010	$220,100
21			$10,550	$162,200	$3,290				$44,010	$220,100
22			$10,550	$162,200	$3,290				$44,010	$220,100
23			$10,550	$162,200	$3,290				$44,010	$220,100
24			$10,550	$162,200	$3,290				$44,010	$220,100
25			$10,550	$162,200	$3,290				$44,010	$220,100
26			$10,550	$162,200	$3,290				$44,010	$220,100
27			$10,550	$162,200	$3,290				$44,010	$220,100
28			$10,550	$162,200	$3,290				$44,010	$220,100
29			$10,550	$162,200	$3,290				$44,010	$220,100
30			$10,550	$162,200	$3,290				$44,010	$220,100
31			$10,550	$162,200	$3,290				$44,010	$220,100
32			$10,550	$162,200	$3,290				$44,010	$220,100
33			$10,550	$162,200	$3,290				$44,010	$220,100
34			$10,550	$162,200	$3,290				$44,010	$220,100
35			$10,550	$162,200	$3,290				$44,010	$220,100
36			$10,550	$162,200	$3,290				$44,010	$220,100
37			$10,550	$162,200	$3,290				$44,010	$220,100
38			$10,550	$162,200	$3,290				$44,010	$220,100
39			$10,550	$162,200	$3,290				$44,010	$220,100
40			$10,550	$162,200	$3,290				$44,010	$220,100
41			$10,550	$162,200	$3,290				$44,010	$220,100
42			$10,550	$162,200	$3,290				$44,010	$220,100
43			$10,550	$162,200	$3,290				$44,010	$220,100
44			$10,550	$162,200	$3,290				$44,010	$220,100
45			$10,550	$162,200	$3,290				$44,010	$220,100
46			$10,550	$162,200	$3,290				$44,010	$220,100
47			$10,550	$162,200	$3,290				$44,010	$220,100
48			$10,550	$162,200	$3,290				$44,010	$220,100
49			$10,550	$162,200	$3,290				$44,010	$220,100
50			$10,550	$162,200	$3,290				$44,010	$220,100
51			$10,550	$162,200	$3,290				$44,010	$220,100
52			$10,550	$162,200	$3,290				$44,010	$220,100
53			$10,550	$162,200	$3,290				$44,010	$220,100
54			$10,550	$162,200	$3,290				$44,010	$220,100
55			$10,550	$162,200	$3,290				$44,010	$220,100
56			$10,550	$162,200	$3,290				$44,010	$220,100
57			$10,550	$162,200	$3,290				$44,010	$220,100
58			$10,550	$162,200	$3,290				$44,010	$220,100
59			$10,550	$162,200	$3,290				$44,010	$220,100
60			$10,550	$162,200	$3,290				$44,010	$220,100
61			$10,550	$162,200	$3,290				$44,010	$220,100
62			$10,550	$162,200	$3,290				$44,010	$220,100
63			$10,550	$162,200	$3,290				$44,010	$220,100
64			$10,550	$162,200	$3,290				$44,010	$220,100
65			$10,550	$162,200	$3,290				$44,010	$220,100
66			$10,550	$162,200	$3,290				$44,010	$220,100
67			$10,550	$162,200	$3,290				$44,010	$220,100
68			$10,550	$162,200	$3,290				$44,010	$220,100
69			$10,550	$162,200	$3,290				$44,010	$220,100
70			$10,550	$162,200	$3,290				$44,010	$220,100
71			$10,550	$162,200	$3,290				$44,010	$220,100
72			$10,550	$162,200	$3,290				$44,010	$220,100
73			$10,550	$162,200	$3,290				$44,010	$220,100
74			$10,550	$162,200	$3,290				$44,010	$220,100
75			$10,550	$162,200	$3,290				$44,010	$220,100
76			$10,550	$162,200	$3,290				$44,010	$220,100
77			$10,550	$162,200	$3,290				$44,010	$220,100
78			$10,550	$162,200	$3,290				$44,010	$220,100
79			$10,550	$162,200	$3,290				$44,010	$220,100
80			$10,550	$162,200	$3,290				$44,010	$220,100
81			$10,550	$162,200	$3,290				$44,010	$220,100
82			$10,550	$162,200	$3,290				$44,010	$220,100
83			$10,550	$162,200	$3,290				$44,010	$220,100
84			$10,550	$162,200	$3,290				$44,010	$220,100
85			$10,550	$162,200	$3,290				$44,010	$220,100
86			$10,550	$162,200	$3,290				$44,010	$220,100
87			$10,550	$162,200	$3,290				$44,010	$220,100
88			$10,550	$162,200	$3,290				$44,010	$220,100
89			$10,550	$162,200	$3,290				$44,010	$220,100
90			$10,550	$162,200	$3,290				$44,010	$220,100
91			$10,550	$162,200	$3,290				$44,010	$220,100
92			$10,550	$162,200	$3,290				$44,010	$220,100
93			$10,550	$162,200	$3,290				$44,010	$220,100
94			$10,550	$162,200	$3,290				$44,010	$220,100
95			$10,550	$162,200	$3,290				$44,010	$220,100
96			$10,550	$162,200	$3,290				$44,010	$220,100
97			$10,550	$162,200	$3,290				$44,010	$220,100
98			$10,550	$162,200	$3,290				$44,010	$220,100
99			$10,550	$162,200	$3,290				$44,010	$220,100
TOTAL	$29,024,800	$159,700	$1,124,500	$16,057,800	$325,700	$677,600	$67,200	$6,247,500	$13,421,200	$67,110,100

Net Discount rate: 2.5%

NPV $45,040,900

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TABLE A-18

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-6
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 4 Wells, 2 at 30' bgs, 2 at 50' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 **Dewatering and Soil Vapor Extraction System (3 extra ext. wells)**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower, 50 gpm	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
1000 SCFM, Vapor Recovery System	EA	$27,034	1	$27,000	2005 RSMeans Environmental p 9-154; 33 13 2361
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Carbon Assorption	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	140	$5,500	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 SVE wells at 25' bgs, 4 SVE wells at 10' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	40	$1,000	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 8 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	100	$3,600	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 4 wells, 5' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	8	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	8	$1,400	2005 RSMeans Environmental p 9-246; 33 23 1702
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$248,100**	
4 **Steam Injection**					
Similar Case Study Overall Costs	CY	$456	61,834	$28,196,300	Based on reported range of costs for published applications.
Task 4 Total				**NA**	
5 **Excavation and Disposal**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
Track Mounted Excavator, 1 C.Y. bucket, +15% for loading onto trucks	BCY	$3	2,200	$6,300	2007 RSMeans Building Construction p. 528; 31 23 16.42 0200
Tanker Trailer Transport, Hazardous Waste	MI	$3	47,000	$141,000	2005 RSMeans Environmental p. 9-178; 33 190254; 3000 tons, 16.5 tons/truck, 260 miles to Arlington, OR
Landfill Hazardous Solid Bulk Waste	TON	$163	3,000	$488,400	2005 RSMeans Environmental p. 9-204; 33 19 72641
Confirmation Soil Sampling	day	$800	2	$1,600	1 engineer/scientist, Geomatrix standard rate
Analytical on Soil Samples	Lump Sum	$2,000	1	$2,000	Price from similar job
Clean Fill, Delivered	TON	$15	3,750	$56,300	Price from similar job
Dozer Backfilling, compacting in 6" to 12" lifts with Vibratory Compactor	ECY	$3	2,200	$5,800	2007 RSMeans Building Construction p. 532; 31 23 23.13 1600
Asphalt Paving	SY	$10	658	$6,600	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 5 Total				**$726,000**	
Subtotal				$991,700	
Professional Technical Services					
Permitting	%	7%	$991,700	$69,400	Geomatrix standard rate
Engineering Design Costs	%	12%	$991,700	$119,000	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$991,700	$79,300	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$991,700	$59,500	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$327,200	
TOTAL INITIAL IMPLEMENTATION COST (w/o steam injection)				**$1,318,900**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

TABLE A-19

RECURRING COSTS FOR ALTERNATIVE HA-6
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**DEWATERING ANNUAL COSTS INCLUDING O&M (5 YEARS AFTER STEAM)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$36,000	1	$36,000	Current System Costs x 3 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$186,200**	
5	**ANNUAL REPLACEMENT COSTS**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
7	**SEMI-ANNUAL MONITORING (15 YEARS DURING GW EXTRACTION/REINJECTION)**					
	Sampling Labor	day	$1,600	4	$6,400	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	32	$9,120	ARI
	Analysis - Metals	per well	$290	32	$9,280	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$44,800**	
8	**PROJECT MANAGEMENT**					
	Project Management	per year	$25,000	1	$25,000	Price from similar job
	Subtotal				**$25,000**	
9	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
10	**PROPERTY OPPORTUNITY COST (16 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-20

NET PRESENT VALUE FOR ALTERNATIVE HA-6

PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Injection Costs	Inspection & Project Management	Treatment System Annual Costs	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	SVE / Dewatering System	Pump & Treat Semi-Annual Monitoring	Property Opportunity Cost	25% Contingency	Yearly Total
0	$592,900							$367,500	$240,100	$1,200,500
1		$25,550	$186,200	$3,290			$44,800	$367,500	$156,800	$784,100
2		$25,550	$186,200	$3,290	$169,400	$16,800	$44,800	$367,500	$203,400	$1,016,900
3		$25,550	$186,200	$3,290	$169,400	$16,800	$44,800	$367,500	$203,400	$1,016,900
4		$25,550	$186,200	$3,290	$169,400	$16,800	$44,800	$367,500	$203,400	$1,016,900
5		$25,550	$186,200	$3,290	$169,400	$16,800	$44,800	$367,500	$203,400	$1,016,900
6		$550	$186,200	$3,290			$44,800	$367,500	$150,600	$752,900
7	$28,196,300	$550	$186,200	$3,290			$44,800	$367,500	$7,199,700	$35,998,300
8		$550	$186,200	$3,290			$44,800	$367,500	$150,600	$752,900
9		$550	$186,200	$3,290			$44,800	$367,500	$150,600	$752,900
10		$550	$186,200	$3,290			$44,800	$367,500	$150,600	$752,900
11	$726,000	$25,550	$186,200	$3,290			$44,800	$367,500	$338,300	$1,691,600
12		$25,550	$186,200	$3,290			$44,800	$367,500	$156,800	$784,100
13		$25,550	$186,200	$3,290			$44,800	$367,500	$156,800	$784,100
14		$25,550	$186,200	$3,290			$44,800	$367,500	$156,800	$784,100
15		$25,550	$186,200	$3,290			$44,800		$65,000	$324,800
16		$10,550	$162,200	$3,290					$44,000	$220,000
17		$10,550	$162,200	$3,290					$44,000	$220,000
18		$10,550	$162,200	$3,290					$44,000	$220,000
19		$10,550	$162,200	$3,290					$44,000	$220,000
20		$10,550	$162,200	$3,290					$44,000	$220,000
21		$10,550	$162,200	$3,290					$44,000	$220,000
22		$10,550	$162,200	$3,290					$44,000	$220,000
23		$10,550	$162,200	$3,290					$44,000	$220,000
24		$10,550	$162,200	$3,290					$44,000	$220,000
25		$10,550	$162,200	$3,290					$44,000	$220,000
26		$10,550	$162,200	$3,290					$44,000	$220,000
27		$10,550	$162,200	$3,290					$44,000	$220,000
28		$10,550	$162,200	$3,290					$44,000	$220,000
29		$10,550	$162,200	$3,290					$44,000	$220,000
30		$10,550	$162,200	$3,290					$44,000	$220,000
31		$10,550	$162,200	$3,290					$44,000	$220,000
32		$10,550	$162,200	$3,290					$44,000	$220,000
33		$10,550	$162,200	$3,290					$44,000	$220,000
34		$10,550	$162,200	$3,290					$44,000	$220,000
35		$10,550	$162,200	$3,290					$44,000	$220,000
36		$10,550	$162,200	$3,290					$44,000	$220,000
37		$10,550	$162,200	$3,290					$44,000	$220,000
38		$10,550	$162,200	$3,290					$44,000	$220,000
39		$10,550	$162,200	$3,290					$44,000	$220,000
40		$10,550	$162,200	$3,290					$44,000	$220,000
41		$10,550	$162,200	$3,290					$44,000	$220,000
42		$10,550	$162,200	$3,290					$44,000	$220,000
43		$10,550	$162,200	$3,290					$44,000	$220,000
44		$10,550	$162,200	$3,290					$44,000	$220,000
45		$10,550	$162,200	$3,290					$44,000	$220,000
46		$10,550	$162,200	$3,290					$44,000	$220,000
47		$10,550	$162,200	$3,290					$44,000	$220,000
48		$10,550	$162,200	$3,290					$44,000	$220,000
49		$10,550	$162,200	$3,290					$44,000	$220,000
50		$10,550	$162,200	$3,290					$44,000	$220,000
51		$10,550	$162,200	$3,290					$44,000	$220,000
52		$10,550	$162,200	$3,290					$44,000	$220,000
53		$10,550	$162,200	$3,290					$44,000	$220,000
54		$10,550	$162,200	$3,290					$44,000	$220,000
55		$10,550	$162,200	$3,290					$44,000	$220,000
56		$10,550	$162,200	$3,290					$44,000	$220,000
57		$10,550	$162,200	$3,290					$44,000	$220,000
58		$10,550	$162,200	$3,290					$44,000	$220,000
59		$10,550	$162,200	$3,290					$44,000	$220,000
60		$10,550	$162,200	$3,290					$44,000	$220,000
61		$10,550	$162,200	$3,290					$44,000	$220,000
62		$10,550	$162,200	$3,290					$44,000	$220,000
63		$10,550	$162,200	$3,290					$44,000	$220,000
64		$10,550	$162,200	$3,290					$44,000	$220,000
65		$10,550	$162,200	$3,290					$44,000	$220,000
66		$10,550	$162,200	$3,290					$44,000	$220,000
67		$10,550	$162,200	$3,290					$44,000	$220,000
68		$10,550	$162,200	$3,290					$44,000	$220,000
69		$10,550	$162,200	$3,290					$44,000	$220,000
70		$10,550	$162,200	$3,290					$44,000	$220,000
71		$10,550	$162,200	$3,290					$44,000	$220,000
72		$10,550	$162,200	$3,290					$44,000	$220,000
73		$10,550	$162,200	$3,290					$44,000	$220,000
74		$10,550	$162,200	$3,290					$44,000	$220,000
75		$10,550	$162,200	$3,290					$44,000	$220,000
76		$10,550	$162,200	$3,290					$44,000	$220,000
77		$10,550	$162,200	$3,290					$44,000	$220,000
78		$10,550	$162,200	$3,290					$44,000	$220,000
79		$10,550	$162,200	$3,290					$44,000	$220,000
80		$10,550	$162,200	$3,290					$44,000	$220,000
81		$10,550	$162,200	$3,290					$44,000	$220,000
82		$10,550	$162,200	$3,290					$44,000	$220,000
83		$10,550	$162,200	$3,290					$44,000	$220,000
84		$10,550	$162,200	$3,290					$44,000	$220,000
85		$10,550	$162,200	$3,290					$44,000	$220,000
86		$10,550	$162,200	$3,290					$44,000	$220,000
87		$10,550	$162,200	$3,290					$44,000	$220,000
88		$10,550	$162,200	$3,290					$44,000	$220,000
89		$10,550	$162,200	$3,290					$44,000	$220,000
90		$10,550	$162,200	$3,290					$44,000	$220,000
91		$10,550	$162,200	$3,290					$44,000	$220,000
92		$10,550	$162,200	$3,290					$44,000	$220,000
93		$10,550	$162,200	$3,290					$44,000	$220,000
94		$10,550	$162,200	$3,290					$44,000	$220,000
95		$10,550	$162,200	$3,290					$44,000	$220,000
96		$10,550	$162,200	$3,290					$44,000	$220,000
97		$10,550	$162,200	$3,290					$44,000	$220,000
98		$10,550	$162,200	$3,290					$44,000	$220,000
99		$10,550	$162,200	$3,290					$44,000	$220,000
TOTAL	$29,515,200	$1,144,500	$16,417,800	$325,700	$677,600	$67,200	$672,000	$5,512,500	$13,582,300	$67,910,800

Net Discount rate: 2.5% **NPV** **$45,827,200**

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TABLE A-21

IMPLEMENTATION COSTS FOR ALTERNATIVE OA-1

PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 2 Total				**$4,600**	
2 **Traffic Control**					
Barricade (Barrels with flashers)	each weekly	$20	20	$400	RSMeans Building Construction p. 23; 1590 400 1620
Labor (2 flaggers)	day	$690	1	$690	RSMeans Building Construction p. 631
Task 2 Total				**$1,100**	
Subtotal				**$5,700**	
Professional Technical Services					
Permitting	%	7%	$5,700	$399	Geomatrix standard rate
Engineering Design Costs	%	20%	$5,700	$1,140	from EPA, 2000, Exh. 5-8
Construction Management	%	15%	$5,700	$855	from EPA, 2000, Exh. 5-8
Project Management	%	10%	$5,700	$570	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				**$2,964**	
TOTAL INITIAL REMEDIATION COST				**$8,700**	

Notes:
1. 2005 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

Geomatrix

TABLE A-22

RECURRING COSTS FOR ALTERNATIVE OA-1
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**ANNUAL REPLACEMENT COSTS**					
	Well Maintenance	per well	$5,000	4	$20,000	Est. 10% of wells need maintence
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$21,190**	
3	**HCIM QUARTERLY WATER LEVEL MONITORING (5 YEARS)**					
	Water Level Monitoring Labor	day	$1,600	4	$6,400	2 engineers/scientists, $100/hour
	Subtotal				**$6,400**	
4	**CPOC QUARTERLY MONITORING (5 YEARS)**					
	Sampling Labor	day	$1,600	12	$19,200	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	48	$14,160	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	48	$13,680	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	48	$9,360	ARI, 10% QA samples
	Analysis - Metals	per well	$290	48	$13,920	ARI, 10% QA samples
	Reporting	per round	$10,000	4	$40,000	Price from similar job
	Subtotal				**$110,320**	
5	**DOWNGRADIENT SEMI-ANNUAL MONITORING (5 YEARS)**					
	Sampling Labor	day	$1,600	6	$9,600	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	31	$9,150	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	31	$8,840	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	31	$6,050	ARI, 10% QA samples
	Analysis - Metals	per well	$290	31	$8,990	ARI, 10% QA samples
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$62,630**	
6	**HCIM ANNUAL WATER QUALITY MONITORING (5 YEARS)**					
	Sampling	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	13	$3,840	ARI, 10% QA samples
	Analysis - VOCs, Ethenes, Metals, 1,4-Dioxane)	per well	$770	13	$10,010	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$27,050**	
7	**HCIM MONITORING (ANNUAL TO 30 YR, BIANNUAL AFTER 30 YR)**					
	Sampling	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	13	$3,840	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	13	$3,710	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	13	$2,540	ARI, 10% QA samples
	Analysis - Metals	per well	$290	13	$3,770	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$27,060**	
8	**CPOC MONITORING (ANNUAL 5 YR TO 31 YR, BIANNUAL AFTER 31 YR)**					
	Sampling	day	$1,600	3	$4,800	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	12	$3,540	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	12	$2,340	ARI, 10% QA samples
	Analysis - Metals	per well	$290	12	$3,480	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$27,580**	
9	**DOWNGRADIENT ANNUAL MONITORING (6 - 31 YEARS)**					
	Sampling Labor	day	$1,600	3	$4,800	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	15	$4,430	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	15	$4,280	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	15	$2,930	ARI, 10% QA samples
	Analysis - Metals	per well	$290	15	$4,350	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$30,790**	
10	**IPIM (29 YEARS)**					
	Investigation (Annualized, $100,000 every 5 years)	Lump sum	$ 20,000	1	$20,000	
	Maintenance	Lump sum	$ 5,000	1	$5,000	
	Subtotal				**$25,000**	
11	**BARRIER WALL REPAIRS (EVERY 50 YEARS)**					
	Repairs	Lump sum	$800,000	1	$800,000	Estimated using price from wall installation
	Subtotal				**$800,000**	
12	**PROJECT MANAGEMENT**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-23

NET PRESENT VALUE FOR ALTERNATIVE OA-1
PSC Georgetown Facililty
Seaattle, Washington

Year	Imp. Costs	Inspection & PM	Replacement Costs	IPIM Costs	HCIM WQ/WL Monitoring	CPOC Monitoring	OA Monitoring	15% Contingency	Yearly Total
0	$8,700							$1,300	$10,000
1		$10,550	$21,190	$25,000	$33,450	$110,320	$62,630	$39,500	$302,600
2		$10,550	$21,190	$25,000	$33,450	$110,320	$62,630	$39,500	$302,600
3		$10,550	$21,190	$25,000	$33,450	$110,320	$62,630	$39,500	$302,600
4		$10,550	$21,190	$25,000	$33,450	$110,320	$62,630	$39,500	$302,600
5		$10,550	$21,190	$25,000	$33,450	$110,320	$62,630	$39,500	$302,600
6		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
7		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
8		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
9		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
10		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
11		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
12		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
13		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
14		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
15		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
16		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
17		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
18		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
19		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
20		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
21		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
22		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
23		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
24		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
25		$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$21,300	$163,500
26		$10,550	$21,190		$27,060	$27,580	$30,790	$17,600	$134,800
27		$10,550	$21,190		$27,060	$27,580	$30,790	$17,600	$134,800
28		$10,550	$21,190		$27,060	$27,580	$30,790	$17,600	$134,800
29		$10,550	$21,190		$27,060	$27,580	$30,790	$17,600	$134,800
30		$10,550	$21,190		$27,060	$27,580	$30,790	$17,600	$134,800
31		$10,550	$21,190		$27,060	$27,580	$30,790	$17,600	$134,800
32		$10,550						$1,600	$12,200
33		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
34		$10,550						$1,600	$12,200
35		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
36		$10,550						$1,600	$12,200
37		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
38		$10,550						$1,600	$12,200
39		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
40		$10,550						$1,600	$12,200
41		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
42		$10,550						$1,600	$12,200
43		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
44		$10,550						$1,600	$12,200
45		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
46		$10,550						$1,600	$12,200
47		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
48		$10,550						$1,600	$12,200
49	$800,000	$10,550	$21,190		$27,060	$27,580		$133,000	$1,019,400
50		$10,550						$1,600	$12,200
51		$10,550						$1,600	$12,200
52		$10,550						$1,600	$12,200
53		$10,550						$1,600	$12,200
54		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
55		$10,550						$1,600	$12,200
56		$10,550						$1,600	$12,200
57		$10,550						$1,600	$12,200
58		$10,550						$1,600	$12,200
59		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
60		$10,550						$1,600	$12,200
61		$10,550						$1,600	$12,200
62		$10,550						$1,600	$12,200
63		$10,550						$1,600	$12,200
64		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
65		$10,550						$1,600	$12,200
66		$10,550						$1,600	$12,200
67		$10,550						$1,600	$12,200
68		$10,550						$1,600	$12,200
69		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
70		$10,550						$1,600	$12,200
71		$10,550						$1,600	$12,200
72		$10,550						$1,600	$12,200
73		$10,550						$1,600	$12,200
74		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
75		$10,550						$1,600	$12,200
76		$10,550						$1,600	$12,200
77		$10,550						$1,600	$12,200
78		$10,550						$1,600	$12,200
79		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
80		$10,550						$1,600	$12,200
81		$10,550						$1,600	$12,200
82		$10,550						$1,600	$12,200
83		$10,550						$1,600	$12,200
84		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
85		$10,550						$1,600	$12,200
86		$10,550						$1,600	$12,200
87		$10,550						$1,600	$12,200
88		$10,550						$1,600	$12,200
89		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
90		$10,550						$1,600	$12,200
91		$10,550						$1,600	$12,200
92		$10,550						$1,600	$12,200
93		$10,550						$1,600	$12,200
94		$10,550	$21,190		$27,060	$27,580		$13,000	$99,400
95		$10,550						$1,600	$12,200
96		$10,550						$1,600	$12,200
97		$10,550						$1,600	$12,200
98		$10,550						$1,600	$12,200
99	$800,000	$10,550	$21,190		$27,060	$27,580		$133,000	$1,019,400
TOTAL	$1,608,700	$1,044,500	$1,059,500	$625,000	$1,385,000	$1,792,700	$1,113,700	$1,295,800	$9,928,200

Net Discount rate: 2.5% **NPV** **$4,912,900**

Geomatrix

TABLE A-24

IMPLEMENTATION COSTS FOR ALTERNATIVE OA-2
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	140	$4,400	2005 RSMeans Environmental p. 9-253; 33 23 2504; 2 Wells, 1 at 50' bgs, 1 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Barricade (Barrels with flashers)	each weekly	$20	20	$400	RSMeans Building Construction p. 23; 1590 400 1620
Labor (2 flaggers)	day	$690	1	$690	RSMeans Building Construction p. 631
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$10,300**	
3 **Excavation and Disposal**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
Track Mounted Excavator, 1 C.Y. bucket, +15% for loading onto trucks	BCY	$3	1,300	$3,700	2007 RSMeans Building Construction p. 528; 31 23 16.42 0200
Tanker Trailer Transport, Hazardous Waste	MI	$3	29,250	$87,800	2005 RSMeans Environmental p. 9-178; 33 190254; 1800 tons, 16 tons/truck, 260 miles to Arlington, OR
Landfill Hazardous Solid Bulk Waste	TON	$163	1,800	$293,000	2005 RSMeans Environmental p. 9-204; 33 19 72641
Confirmation Soil Sampling	day	$800	2	$1,600	1 engineer/scientist, Geomatrix standard rate
Analytical on Soil Samples	Lump Sum	$2,000	1	$2,000	Price from similar job
Clean Fill, Delivered	TON	$15	2,200	$33,000	Price from similar job
Dozer Backfilling, compacting in 6" to 12" lifts with Vibratory Compactor	ECY	$3	2,200	$5,800	2007 RSMeans Building Construction p. 532; 31 23 23.13 1600
3" Asphalt Paving	SY	$10	150	$1,500	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$446,400**	
4 **Soil Vapor Extraction System**					
Mobilization/Demobilization	Lump Sum	$5,000	1	$5,000	Price from similar job
500 CFM, 1,200 LB Fill, Closed Upflow, Activated Carbon Unit	EA	$5,391	2	$10,800	2005 RSMeans Environmental p. 9-143; 33 13 1909
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
30 HP, 580 SCFM Vapor Extraction Blower	EA	$11,523	1	$11,500	2005 RSMeans Environmental p 9-153; 33 13 2342
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	30	$1,800	2005 RSMeans Environmental p. 9-236; 33 23 33 23 1105; 3 SVE wells at 10' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	15	$400	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 3 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	15	$400	2005 RSMeans Environmental p 9-215; 33 23 0202; 5' of screen for 3 wells
4" Well, Grout (Annular Seal)	LF	$128.04	3	$400	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	3	$500	2005 RSMeans Environmental p 9-246; 33 23 1702
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Task 4 Total				**$127,200**	
5 **Enhanced Bioremediation Pilot Test**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	30	$1,800	2005 RSMeans Environmental p. 9-236; 33 23 1105; 1 Groundwater Circulation Well (GCW) at 30' bgs
8" PVC, Schedule 80, Well Casing	LF	$61	15	$900	2005 RSMeans Environmental p. 2-212; 33 23 0115
8" Stainless Steel Well Screen, 5' Sec, Flush Threaded	LF	$438.77	15	$6,600	2005 RSMeans Environmental p. 2-216; 33 23 0225
8" Well, Grout (Annular Seal)	LF	$251.59	1	$300	2005 RSMeans Environmental p. 2-246; 33 23 1804
Precast Concrete Vaults for GCW	EA	$722	1	$700	2005 RSMeans Environmental p 9-248; 33 23 2201
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Pump Assembly Tubing	Lump Sum	$2,000.00	1	$2,000	Price from similar job
40" Packer Tube	EA	$6,000.00	1	$6,000	Price from similar job
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526
4" PVC, Schedule 40, Connection Piping	LF	$8	10	$100	2005 RSMeans Environmental p. 9-257; 33 26 0415
Recirculation Device Assembly	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	2	$3,200	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,200	$1,200	Price from similar job
Task 5 Total				**$30,400**	
6 **Enhanced Bioremediation Full Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	60	$3,700	2005 RSMeans Environmental p. 9-236; 33 23 1105; 2 GCW's at 30' bgs
8" PVC, Schedule 80, Well Casing	LF	$61	30	$1,800	2005 RSMeans Environmental p. 2-212; 33 23 0115
8" Stainless Steel Well Screen, 5' Sec, Flush Threaded	LF	$438.77	30	$13,200	2005 RSMeans Environmental p. 2-216; 33 23 0225
8" Well, Grout (Annular Seal)	LF	$251.59	2	$500	2005 RSMeans Environmental p. 2-246; 33 23 1804
Precast Concrete Vaults for GCW	EA	$722	2	$1,400	2005 RSMeans Environmental p 9-248; 33 23 2201
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Task 6 Total				**$24,400**	
7 **Confirmation Soil Borings**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling	LF	$61.26	60	$3,700	2005 RSMeans Environmental p. 9-236; 33 23 1105; 4 borings at 15' bgs
Confirmation Soil Sampling	day	$800	2	$1,600	1 engineer/scientist, Geomatrix standard rate
Analytical on Soil Samples	Lump Sum	$2,000	1	$2,000	Price from similar job
Equipment	day	$100	2	$200	PID rental, Geomatrix standard rate
Task 7 Total				**$10,500**	
Subtotal				**$653,800**	
Professional Technical Services					
Permitting	%	7%	$653,800	$45,766	Geomatrix standard rate
Engineering Design Costs	%	12%	$653,800	$78,456	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$653,800	$52,304	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$653,800	$39,228	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				**$215,754**	
TOTAL INITIAL REMEDIATION COST				**$869,600**	

Notes:
1. 2005 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt.

TABLE A-25

RECURRING COSTS FOR ALTERNATIVE OA-2
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**ANNUAL REPLACEMENT COSTS (ANNUAL 18 YR, BIANNUAL AFTER 18 YR)**					
	Well Maintenance	per well	$5,000	4	$20,000	Est. 10% of wells need maintence
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$21,190**	
3	**SVE SYSTEM ANNUAL COSTS INCLUDING O&M (1 YEAR)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	lump sum	$6,000	1	$6,000	Current System Costs
	Misc. Maintenance	lump sum	$12,000	1	$12,000	Current System Costs
	Subtotal				**$59,600**	
4	**HCIM QUARTERLY WATER LEVEL MONITORING (5 YEARS)**					
	Water Level Monitoring Labor	day	$1,600	4	$6,400	2 engineers/scientists, $100/hour
	Subtotal				**$6,400**	
5	**SEMI-ANNUAL INJECTION (2 YEARS)**					
	Molasses	lbs	$1	1800	$1,800	Price from similar job
	Recirculation/Injection Labor	day	$1,600	9	$14,400	2 engineers/scientists, $100/hour
	Subtotal				**$16,200**	
6	**CPOC QUARTERLY MONITORING (5 YEARS)**					
	Sampling Labor	day	$1,600	12	$19,200	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	48	$14,160	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	48	$13,680	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	48	$9,360	ARI, 10% QA samples
	Analysis - Metals	per well	$290	48	$13,920	ARI, 10% QA samples
	Reporting	per round	$10,000	4	$40,000	Price from similar job
	Subtotal				**$110,320**	
7	**DOWNGRADIENT SEMI-ANNUAL MONITORING (5 YEARS)**					
	Sampling Labor	day	$1,600	6	$9,600	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	31	$9,150	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	31	$8,840	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	31	$6,050	ARI, 10% QA samples
	Analysis - Metals	per well	$290	31	$8,990	ARI, 10% QA samples
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$62,630**	
8	**HCIM MONITORING (ANNUAL TO 18 YR, BIANNUAL AFTER 18 YR)**					
	Sampling	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	13	$3,840	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	13	$3,710	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	13	$2,540	ARI, 10% QA samples
	Analysis - Metals	per well	$290	13	$3,770	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$27,060**	
9	**CPOC MONITORING (ANNUAL 5 YR TO 18 YR, BIANNUAL AFTER 18 YR)**					
	Sampling	day	$1,600	3	$4,800	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	12	$3,540	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	12	$2,340	ARI, 10% QA samples
	Analysis - Metals	per well	$290	12	$3,480	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$27,580**	
10	**DOWNGRADIENT MONITORING (ANNUAL 5 YR TO 18 YR)**					
	Sampling	day	$1,600	3	$4,800	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	15	$4,430	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	15	$4,280	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	15	$2,930	ARI, 10% QA samples
	Analysis - Metals	per well	$290	15	$4,350	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$30,790**	
11	**IPIM (14 YEARS)**					
	Investigation (Annualized, $100,000 every 5 years)	Lump sum	$ 20,000	1	$20,000	
	Maintenance	Lump sum	$ 5,000	1	$5,000	
	Subtotal				**$25,000**	
12	**LOW PERMEABILITY WALL REPAIRS (EVERY 50 YEARS)**					
	Repairs	Lump sum	$800,000	1	$800,000	Estimated using price from wall installation
	Subtotal				**$800,000**	
13	**PROJECT MANAGEMENT (5 YEARS)**					
	Project Management	per year	$15,000	1	$15,000	Price from similar job
	Subtotal				**$15,000**	
14	**PROJECT MANAGEMENT (AFTER 5 YR)**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-26

NET PRESENT VALUE FOR ALTERNATIVE OA-2
PSC Georgetown Facility
Seattle, Washington

Year	Imp. & Inj. Costs	Inspection & Project Management	Replacement Costs	IPIM Costs	SVE System Costs	HCIM WQ/WL Monitoring	CPOC Monitoring	Outside Area Monitoring	25% Contingency	Yearly Total
0	$869,600								$217,400	$1,087,000
1		$15,550	$21,190	$25,000	$59,600	$33,460	$110,320	$62,630	$81,900	$409,700
2	$16,200	$15,550	$21,190	$25,000		$33,460	$110,320	$62,630	$71,100	$355,500
3	$16,200	$15,550	$21,190	$25,000		$33,460	$110,320	$62,630	$71,100	$355,500
4		$15,550	$21,190	$25,000		$33,460	$110,320	$62,630	$67,000	$335,200
5		$15,550	$21,190	$25,000		$33,460	$110,320	$62,630	$67,000	$335,200
6		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
7		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
8		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
9		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
10		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
11		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
12		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
13		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
14		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
15		$10,550	$21,190			$27,060	$27,580	$30,790	$29,300	$146,500
16		$10,550	$21,190			$27,060	$27,580	$30,790	$29,300	$146,500
17		$10,550	$21,190			$27,060	$27,580	$30,790	$29,300	$146,500
18		$10,550	$21,190			$27,060	$27,580	$30,790	$29,300	$146,500
19		$10,550							$2,600	$13,200
20		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
21		$10,550							$2,600	$13,200
22		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
23		$10,550							$2,600	$13,200
24		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
25		$10,550							$2,600	$13,200
26		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
27		$10,550							$2,600	$13,200
28		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
29		$10,550							$2,600	$13,200
30		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
31		$10,550							$2,600	$13,200
32		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
33		$10,550							$2,600	$13,200
34		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
35		$10,550							$2,600	$13,200
36		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
37		$10,550							$2,600	$13,200
38		$10,550							$2,600	$13,200
39		$10,550							$2,600	$13,200
40		$10,550							$2,600	$13,200
41		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
42		$10,550							$2,600	$13,200
43		$10,550							$2,600	$13,200
44		$10,550							$2,600	$13,200
45		$10,550							$2,600	$13,200
46		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
47		$10,550							$2,600	$13,200
48		$10,550							$2,600	$13,200
49	$800,000	$10,550							$202,600	$1,013,200
50		$10,550							$2,600	$13,200
51		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
52		$10,550							$2,600	$13,200
53		$10,550							$2,600	$13,200
54		$10,550							$2,600	$13,200
55		$10,550							$2,600	$13,200
56		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
57		$10,550							$2,600	$13,200
58		$10,550							$2,600	$13,200
59		$10,550							$2,600	$13,200
60		$10,550							$2,600	$13,200
61		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
62		$10,550							$2,600	$13,200
63		$10,550							$2,600	$13,200
64		$10,550							$2,600	$13,200
65		$10,550							$2,600	$13,200
66		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
67		$10,550							$2,600	$13,200
68		$10,550							$2,600	$13,200
69		$10,550							$2,600	$13,200
70		$10,550							$2,600	$13,200
71		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
72		$10,550							$2,600	$13,200
73		$10,550							$2,600	$13,200
74		$10,550							$2,600	$13,200
75		$10,550							$2,600	$13,200
76		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
77		$10,550							$2,600	$13,200
78		$10,550							$2,600	$13,200
79		$10,550							$2,600	$13,200
80		$10,550							$2,600	$13,200
81		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
82		$10,550							$2,600	$13,200
83		$10,550							$2,600	$13,200
84		$10,550							$2,600	$13,200
85		$10,550							$2,600	$13,200
86		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
87		$10,550							$2,600	$13,200
88		$10,550							$2,600	$13,200
89		$10,550							$2,600	$13,200
90		$10,550							$2,600	$13,200
91		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
92		$10,550							$2,600	$13,200
93		$10,550							$2,600	$13,200
94		$10,550							$2,600	$13,200
95		$10,550							$2,600	$13,200
96		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
97		$10,550							$2,600	$13,200
98		$10,550							$2,600	$13,200
99	$800,000	$10,550							$202,600	$1,013,200
TOTAL	$2,502,000	$1,069,500	$826,400	$350,000	$59,600	$1,087,300	$1,489,300	$713,400	$2,021,800	$10,123,400

Net Discount rate: 2.5% **NPV** **$5,594,900**

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TABLE A-27

IMPLEMENTATION COSTS FOR ALTERNATIVE OA-3
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	140	$4,400	2005 RSMeans Environmental p. 9-253; 33 23 2504; 2 Wells, 1 at 50' bgs, 1 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Barricade (Barrels with flashers)	each weekly	$20	20	$400	RSMeans Building Construction p. 23; 1590 400 1620
Labor (2 flaggers)	day	$690	1	$690	RSMeans Building Construction p. 631
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$10,300**	
3 **Excavation and Disposal**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
Track Mounted Excavator, 1 C.Y. bucket, +15% for loading onto trucks	BCY	$3	6,300	$18,100	2007 RSMeans Building Construction p. 528; 31 23 16.42 0200
Tanker Trailer Transport, Hazardous Waste, Arlington	MI	$3	85,000	$255,000	2005 RSMeans Environmental p. 9-178; 33 190254; 5200 tons, 16 tons/truck, 260 miles to Arlington, OR
Landfill Hazardous Solid Bulk Waste	TON	$163	5,200	$846,600	2005 RSMeans Environmental p. 9-204; 33 19 72641
Landfill Non-Hazardous Solid Bulk Waste, w/ Transportation	TON	$34	3,400	$116,600	Geomatrix past experience
Confirmation Soil Sampling	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Analytical on Soil Samples	Lump Sum	$5,000	1	$5,000	Price from similar job
Clean Fill, Delivered	TON	$15	10,700	$160,500	Price from similar job
Dozer Backfilling, compacting in 6" to 12" lifts with Vibratory Compactor	ECY	$3	10,700	$28,200	2007 RSMeans Building Construction p. 532; 31 23 23.13 1600
3" Asphalt Paving	SY	$10	700	$7,000	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	20	$16,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$1,467,000**	
4 **Soil Vapor Extraction System**					
Mobilization/Demobilization	Lump Sum	$5,000	1	$5,000	Price from similar job
500 CFM, 1,200 LB Fill, Closed Upflow, Activated Carbon Unit	EA	$5,391	2	$10,800	2005 RSMeans Environmental p. 9-143; 33 13 1909
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
30 HP, 580 SCFM Vapor Extraction Blower	EA	$11,523	1	$11,500	2005 RSMeans Environmental p 9-153; 33 13 2342
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	30	$1,800	2005 RSMeans Environmental p. 9-236; 33 23 33 23 1105; 3 SVE wells at 10' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	15	$400	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 3 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	15	$400	2005 RSMeans Environmental p 9-215; 33 23 0202; 5' of screen for 3 wells
4" Well, Grout (Annular Seal)	LF	$128.04	3	$400	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	3	$500	2005 RSMeans Environmental p 9-246; 33 23 1702
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Task 4 Total				**$127,200**	
5 **Enhanced Bioremediation Pilot Test**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	30	$1,800	2005 RSMeans Environmental p. 9-236; 33 23 1105; 1 Groundwater Circulation Well (GCW) at 30' bgs
8" PVC, Schedule 80, Well Casing	LF	$61	15	$900	2005 RSMeans Environmental p. 2-212; 33 23 0115
8" Stainless Steel Well Screen, 5' Sec, Flush Threaded	LF	$438.77	15	$6,600	2005 RSMeans Environmental p. 2-216; 33 23 0225
8" Well, Grout (Annular Seal)	LF	$251.59	1	$300	2005 RSMeans Environmental p. 2-246; 33 23 1804
Precast Concrete Vaults for GCW	EA	$722	1	$700	2005 RSMeans Environmental p 9-248; 33 23 2201
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Pump Assembly Tubing	Lump Sum	$2,000.00	1	$2,000	Price from similar job
40" Packer Tube	EA	$6,000.00	1	$6,000	Price from similar job
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526
4" PVC, Schedule 40, Connection Piping	LF	$8	10	$100	2005 RSMeans Environmental p. 9-257; 33 26 0415
Recirculation Device Assembly	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	2	$3,200	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,200	$1,200	Price from similar job
Task 5 Total				**$30,400**	
6 **Enhanced Bioremediation Full Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	60	$3,700	2005 RSMeans Environmental p. 9-236; 33 23 1105; 2 GCW's at 30' bgs
8" PVC, Schedule 80, Well Casing	LF	$61	30	$1,800	2005 RSMeans Environmental p. 2-212; 33 23 0115
8" Stainless Steel Well Screen, 5' Sec, Flush Threaded	LF	$438.77	30	$13,200	2005 RSMeans Environmental p. 2-216; 33 23 0225
8" Well, Grout (Annular Seal)	LF	$251.59	2	$500	2005 RSMeans Environmental p. 2-246; 33 23 1804
Precast Concrete Vaults for GCW	EA	$722	2	$1,400	2005 RSMeans Environmental p 9-248; 33 23 2201
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Task 6 Total				**$24,400**	
7 **Confirmation Soil Borings**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling	LF	$61.26	60	$3,700	2005 RSMeans Environmental p. 9-236; 33 23 1105; 4 borings at 15' bgs
Confirmation Soil Sampling	day	$800	2	$1,600	1 engineer/scientist, Geomatrix standard rate
Analytical on Soil Samples	Lump Sum	$2,000	1	$2,000	Price from similar job
Equipment	day	$100	2	$200	PID rental, Geomatrix standard rate
Task 7 Total				**$10,500**	
Subtotal				**$1,674,400**	
Professional Technical Services					
Permitting	%	7%	$1,674,400	$117,208	Geomatrix standard rate
Engineering Design Costs	%	8%	$1,674,400	$133,952	from EPA, 2000, Exh. 5-8
Construction Management	%	6%	$1,674,400	$100,464	from EPA, 2000, Exh. 5-8
Project Management	%	5%	$1,674,400	$83,720	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				**$435,344**	
TOTAL INITIAL REMEDIATION COST				**$2,109,800**	

Notes:
1. 2005 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt.

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TABLE A-28

RECURRING COSTS FOR ALTERNATIVE OA-3

PSC Georgetown Facility
Seattle, Washington

	ITEM	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**ANNUAL REPLACEMENT COSTS (ANNUAL 18 YR, BIANNUAL AFTER 18 YR)**					
	Well Maintenance	per well	$5,000	4	$20,000	Est. 10% of wells need maintence
	Surface Cover Maintenance	per year	$400	1	$400	Geomatrix past experience
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$21,190**	
3	**SVE SYSTEM ANNUAL COSTS INCLUDING O&M (1 YEAR)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	lump sum	$6,000	1	$6,000	Current System Costs
	Misc. Maintenance	lump sum	$12,000	1	$12,000	Current System Costs
	Subtotal				**$59,600**	
4	**SEMI-ANNUAL INJECTION (2 YEARS)**					
	Molasses	lbs	$1	1800	$1,800	Price from similar job
	Recirculation/Injection Labor	day	$1,600	9	$14,400	2 engineers/scientists, $100/hour
	Subtotal				**$16,200**	
5	**HCIM QUARTERLY WATER LEVEL MONITORING (5 YEARS)**					
	Water Level Monitoring Labor	day	$1,600	4	$6,400	2 engineers/scientists, $100/hour
	Subtotal				**$6,400**	
6	**CPOC QUARTERLY MONITORING (5 YEARS)**					
	Sampling Labor	day	$1,600	12	$19,200	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	48	$14,160	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	48	$13,680	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	48	$9,360	ARI, 10% QA samples
	Analysis - Metals	per well	$290	48	$13,920	ARI, 10% QA samples
	Reporting	per round	$10,000	4	$40,000	Price from similar job
	Subtotal				**$110,320**	
7	**DOWNGRADIENT SEMI-ANNUAL MONITORING (5 YEARS)**					
	Sampling Labor	day	$1,600	6	$9,600	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	31	$9,150	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	31	$8,840	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	31	$6,050	ARI, 10% QA samples
	Analysis - Metals	per well	$290	31	$8,990	ARI, 10% QA samples
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$62,630**	
8	**HCIM MONITORING (ANNUAL TO 18 YR, BIANNUAL AFTER 18 YR)**					
	Sampling	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	13	$3,840	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	13	$3,710	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	13	$2,540	ARI, 10% QA samples
	Analysis - Metals	per well	$290	13	$3,770	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$27,060**	
9	**CPOC MONITORING (ANNUAL 5 YR TO 18 YR, BIANNUAL AFTER 18 YR)**					
	Sampling	day	$1,600	3	$4,800	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	12	$3,540	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	12	$2,340	ARI, 10% QA samples
	Analysis - Metals	per well	$290	12	$3,480	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$27,580**	
10	**DOWNGRADIENT MONITORING (ANNUAL 5 YR TO 18 YR)**					
	Sampling	day	$1,600	3	$4,800	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	15	$4,430	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	15	$4,280	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	15	$2,930	ARI, 10% QA samples
	Analysis - Metals	per well	$290	15	$4,350	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$30,790**	
11	**IPIM (14 YEARS)**					
	Investigation (Annualized, $100,000 every 5 years)	Lump sum	$ 20,000	1	$20,000	
	Maintenance	Lump sum	$ 5,000	1	$5,000	
	Subtotal				**$25,000**	
12	**LOW PERMEABILITY WALL REPAIRS (EVERY 50 YEARS)**					
	Repairs	Lump sum	$800,000	1	$800,000	Estimated using price from wall installation
	Subtotal				**$800,000**	
13	**PROJECT MANAGEMENT (5 YR)**					
	Project Management	per year	$15,000	1	$15,000	Price from similar job
	Subtotal				**$15,000**	
14	**PROJECT MANAGEMENT (AFTER 5 YR)**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	

Notes:

1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-29

NET PRESENT VALUE FOR ALTERNATIVE OA-3
PSC Georgetown Facility
Seattle, Washington

Year	Imp. & Inj. Costs	Inspection & PM	Replacement Costs	IPIM Costs	SVE Costs	HCIM WQ/WL Monitoring	CPOC Monitoring	Outside Area Monitoring	25% Contingency	Yearly Total
0	$2,109,800								$527,500	$2,637,300
1		$15,550	$21,190	$25,000	$59,600	$33,460	$110,320	$62,630	$81,900	$409,700
2	$16,200	$15,550	$21,190	$25,000		$33,460	$110,320	$62,630	$71,100	$355,500
3	$16,200	$15,550	$21,190	$25,000		$33,460	$110,320	$62,630	$71,100	$355,500
4		$10,550	$21,190	$25,000		$33,460	$110,320	$62,630	$65,800	$329,000
5		$10,550	$21,190	$25,000		$33,460	$110,320	$62,630	$65,800	$329,000
6		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
7		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
8		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
9		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
10		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
11		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
12		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
13		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
14		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
15		$10,550	$21,190	$25,000		$27,060	$27,580	$30,790	$35,500	$177,700
16		$10,550	$21,190			$27,060	$27,580	$30,790	$29,300	$146,500
17		$10,550	$21,190			$27,060	$27,580	$30,790	$29,300	$146,500
18		$10,550	$21,190			$27,060	$27,580	$30,790	$29,300	$146,500
19		$10,550							$2,600	$13,200
20		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
21		$10,550							$2,600	$13,200
22		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
23		$10,550							$2,600	$13,200
24		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
25		$10,550							$2,600	$13,200
26		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
27		$10,550							$2,600	$13,200
28		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
29		$10,550							$2,600	$13,200
30		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
31		$10,550							$2,600	$13,200
32		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
33		$10,550							$2,600	$13,200
34		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
35		$10,550							$2,600	$13,200
36		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
37		$10,550							$2,600	$13,200
38		$10,550							$2,600	$13,200
39		$10,550							$2,600	$13,200
40		$10,550							$2,600	$13,200
41		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
42		$10,550							$2,600	$13,200
43		$10,550							$2,600	$13,200
44		$10,550							$2,600	$13,200
45		$10,550							$2,600	$13,200
46		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
47		$10,550							$2,600	$13,200
48		$10,550							$2,600	$13,200
49	$800,000	$10,550							$202,600	$1,013,200
50		$10,550							$2,600	$13,200
51		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
52		$10,550							$2,600	$13,200
53		$10,550							$2,600	$13,200
54		$10,550							$2,600	$13,200
55		$10,550							$2,600	$13,200
56		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
57		$10,550							$2,600	$13,200
58		$10,550							$2,600	$13,200
59		$10,550							$2,600	$13,200
60		$10,550							$2,600	$13,200
61		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
62		$10,550							$2,600	$13,200
63		$10,550							$2,600	$13,200
64		$10,550							$2,600	$13,200
65		$10,550							$2,600	$13,200
66		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
67		$10,550							$2,600	$13,200
68		$10,550							$2,600	$13,200
69		$10,550							$2,600	$13,200
70		$10,550							$2,600	$13,200
71		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
72		$10,550							$2,600	$13,200
73		$10,550							$2,600	$13,200
74		$10,550							$2,600	$13,200
75		$10,550							$2,600	$13,200
76		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
77		$10,550							$2,600	$13,200
78		$10,550							$2,600	$13,200
79		$10,550							$2,600	$13,200
80		$10,550							$2,600	$13,200
81		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
82		$10,550							$2,600	$13,200
83		$10,550							$2,600	$13,200
84		$10,550							$2,600	$13,200
85		$10,550							$2,600	$13,200
86		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
87		$10,550							$2,600	$13,200
88		$10,550							$2,600	$13,200
89		$10,550							$2,600	$13,200
90		$10,550							$2,600	$13,200
91		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
92		$10,550							$2,600	$13,200
93		$10,550							$2,600	$13,200
94		$10,550							$2,600	$13,200
95		$10,550							$2,600	$13,200
96		$10,550	$21,190			$27,060	$27,580		$21,600	$108,000
97		$10,550							$2,600	$13,200
98		$10,550							$2,600	$13,200
99	$800,000	$10,550							$202,600	$1,013,200
TOTAL	$3,742,200	$1,059,500	$826,400	$375,000	$59,600	$1,087,300	$1,489,300	$713,400	$2,335,700	$11,692,500

Net Discount rate: 2.5% **NPV** **$7,117,600**

TABLE A-30

IMPLEMENTATION COSTS FOR ALTERNATIVE OA-4
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	140	$4,400	2005 RSMeans Environmental p. 9-253; 33 23 2504; 2 Wells, 1 at 50' bgs, 1 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Barricade (Barrels with flashers)	each weekly	$20	20	$400	RSMeans Building Construction p. 23; 1590 400 1620
Labor (2 flaggers)	day	$690	1	$690	RSMeans Building Construction p. 631
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$10,300**	
3 **Excavation and Disposal**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
Track Mounted Excavator, 1 C.Y. bucket, +15% for loading onto trucks	BCY	$3	6,300	$18,100	2007 RSMeans Building Construction p. 528; 31 23 16.42 0200
Tanker Trailer Transport, Hazardous Waste, Arlington	MI	$3	85,000	$255,000	2005 RSMeans Environmental p. 9-178; 33 190254; 5200 tons, 16 tons/truck, 260 miles to Arlington, OR
Landfill Hazardous Solid Bulk Waste	TON	$163	5,200	$846,600	2005 RSMeans Environmental p. 9-204; 33 19 72641
Landfill Non-Hazardous Solid Buld Waste, w/ Transportation	TON	$34	3,400	$116,600	Price from similar job
Confirmation Soil Sampling	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Analytical on Soil Samples	Lump Sum	$5,000	1	$5,000	Price from similar job
Clean Fill, Delivered	TON	$15	10,700	$160,500	Price from similar job
Dozer Backfilling, compacting in 6" to 12" lifts with Vibratory Compactor	ECY	$3	10,700	$28,200	2007 RSMeans Building Construction p. 532; 31 23 23.13 1600
3" Asphalt Paving	SY	$10	700	$7,000	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	20	$16,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$1,467,000**	
4 **Soil Vapor Extraction System**					
Mobilization/Demobilization	Lump Sum	$5,000	1	$5,000	Price from similar job
500 CFM, 1,200 LB Fill, Closed Upflow, Activated Carbon Unit	EA	$5,391	2	$10,800	2005 RSMeans Environmental p. 9-143; 33 13 1909
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
30 HP, 580 SCFM Vapor Extraction Blower	EA	$11,523	1	$11,500	2005 RSMeans Environmental p 9-153; 33 13 2342
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	30	$1,800	2005 RSMeans Environmental p. 9-236; 33 23 33 23 1105; 3 SVE wells at 10' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	15	$400	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 3 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	15	$400	2005 RSMeans Environmental p 9-215; 33 23 0202; 5' of screen for 3 wells
4" Well, Grout (Annular Seal)	LF	$128.04	3	$400	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	3	$500	2005 RSMeans Environmental p 9-246; 33 23 1702
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Task 4 Total				**$127,200**	
5 **Enhanced Bioremediation Pilot Test**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	30	$1,800	2005 RSMeans Environmental p. 9-236; 33 23 1105; 1 Groundwater Circulation Well (GCW) at 30' bgs
8" PVC, Schedule 80, Well Casing	LF	$61	15	$900	2005 RSMeans Environmental p. 2-212; 33 23 0115
8" Stainless Steel Well Screen, 5' Sec, Flush Threaded	LF	$438.77	15	$6,600	2005 RSMeans Environmental p. 2-216; 33 23 0225
8" Well, Grout (Annular Seal)	LF	$251.59	1	$300	2005 RSMeans Environmental p. 2-246; 33 23 1804
Precast Concrete Vaults for GCW	EA	$722	1	$700	2005 RSMeans Environmental p 9-248; 33 23 2201
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Pump Assembly Tubing	Lump Sum	$2,000.00	1	$2,000	Price from similar job
40" Packer Tube	EA	$6,000.00	1	$6,000	Price from similar job
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526
4" PVC, Schedule 40, Connection Piping	LF	$8	10	$100	2005 RSMeans Environmental p. 9-257; 33 26 0415
Recirculation Device Assembly	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	2	$3,200	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,200	$1,200	Price from similar job
Task 5 Total				**$30,400**	
6 **Enhanced Bioremediation Full Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	60	$3,700	2005 RSMeans Environmental p. 9-236; 33 23 1105; 2 GCW's at 30' bgs
8" PVC, Schedule 80, Well Casing	LF	$61	30	$1,800	2005 RSMeans Environmental p. 2-212; 33 23 0115
8" Stainless Steel Well Screen, 5' Sec, Flush Threaded	LF	$438.77	30	$13,200	2005 RSMeans Environmental p. 2-216; 33 23 0225
8" Well, Grout (Annular Seal)	LF	$251.59	2	$500	2005 RSMeans Environmental p. 2-246; 33 23 1804
Precast Concrete Vaults for GCW	EA	$722	2	$1,400	2005 RSMeans Environmental p 9-248; 33 23 2201
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Task 6 Total				**$24,400**	
7 **Confirmation Soil Borings**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling	LF	$61.26	60	$3,700	2005 RSMeans Environmental p. 9-236; 33 23 1105; 4 borings at 15' bgs
Confirmation Soil Sampling	day	$800	2	$1,600	1 engineer/scientist, Geomatrix standard rate
Analytical on Soil Samples	Lump Sum	$2,000	1	$2,000	Price from similar job
Equipment	day	$100	2	$200	PID rental, Geomatrix standard rate
Task 7 Total				**$10,500**	
8 **Outside Area Hydraulic Containment**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
Traffic Control Labor	day	$355	60	$21,300	RSMeans Building Construction p. 613; 30 days with crew of 2
Traffic Control Vehical	day	$97	30	$2,900	RSMeans Building Construction p. 608; 01 54 33 7100
8" dia. Water Supply, PVC pipe, AWWA C905, PR 100, DR 41	LF	$21	6,600	$138,600	RSMeans Building Construction p. 571; 33 11 13.25 2210
Pavement removal, bituminous roads, 4" to 6" thick	SY	$7	1,467	$10,500	RSMeans Building Construction p. 25; 02 41 13.17 5050
Excavating, Trench, 1' to 4' deep, 3/8 C.Y. excavator	CY	$7	1,956	$14,200	RSMeans Building Consturction p. 523; 31 23 16.13 0020
Crushed 3/4" stone base, compacted, 6" deep	SY	$8	1,467	$11,500	RSMeans Building Consturction p. 547; 32 11 23.23 0100
Plant-Mix Asphalt Paving, 4" thick	SY	$13	1,467	$19,300	RSMeans Building Consturction p. 547; 32 12 16.13 0200
4" Submersible Pump, 15-20 gpm, 601'< Head <=1000', 5 hp, w/ controls	EA	$5,482	8	$43,900	2005 RSMeans Environmental p. 9-225; 33 23 0539; 8 extraction wells
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	340	$13,300	2005 RSMeans Environmental p. 9-236; 33 23 1101; 8 extraction wells, 7 at 40' bgs and 1 at 60' bgs
6" PVC, Schedule 80, Well Casing	LF	$46	220	$10,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 25' of casing for 7 wells, 45' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	120	$5,900	2005 RSMeans Environmental p 9-215; 33 23 0203; 15' of screen for 8 wells
6" Well, Grout (Annular Seal)	LF	$189	8	$1,500	2005 RSMeans Environmental p 9-215; 33 23 0203
6" Well, Locking Cap	EA	$208	8	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1703
250 gpm UV Reactor, Ozone and Peroxide Capital Equipment	EA	$318,240	1	$318,200	2005 RSMeans Environmental p. 9-117; 33 12 0836
Groundwater Treatment System, 120 gpm	Lump Sum	$2,899,000	1	$2,899,000	Detailed cost estimation done by Geomatrix
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	20	$16,000	1 engineer/scientist, Geomatrix standard rate
Task 8 Total				**$3,540,100**	
9 **Treatment System Property Purchase**					
Property Purchase	SF	$35	4,000	$140,000	
Task 9 Total				**$140,000**	
Subtotal				**$5,354,500**	
Professional Technical Services					
Permitting	%	7%	$5,354,500	$374,800	Geomatrix standard rate
Engineering Design Costs	%	8%	$5,354,500	$428,400	from EPA, 2000, Exh. 5-8
Construction Management	%	6%	$5,354,500	$321,300	from EPA, 2000, Exh. 5-8
Project Management	%	5%	$5,354,500	$267,700	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$1,392,200	
TOTAL INITIAL IMPLEMENTATION COST				**$6,746,700**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 RSMeans Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

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TABLE A-31

RECURRING COSTS FOR ALTERNATIVE OA-4
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**ANNUAL REPLACEMENT COSTS (ANNUAL 18 YR, BIANNUAL AFTER 18 YR)**					
	Well Maintenance	per well	$5,000	4	$20,000	Est. 10% of wells need maintence
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$21,190**	
3	**OA HYDRAULIC CONTROL SYSTEM ANNUAL COSTS INCLUDING O&M (10 YEARS)**					
	Annual operation labor	year	$24,800	1	$24,800	2 hr/d, 350 d/yr + supv., PSC employees
	Electricity	lump sum	$95,100	1	$95,100	$0.12/KWH, est. power usage
	Misc. Maintenance	lump sum	$76,300	1	$76,300	3% of equipment costs
	Treatment chemicals (acid regenerant)	lump sum	$26,000	1	$26,000	Est., $0.45/lb
	Sewer fees (apent regenerant)	lump sum	$2,600	1	$2,600	Est., $0.95/gal
	Subtotal				**$222,200**	
4	**SVE SYSTEM ANNUAL COSTS INCLUDING O&M (1 YEAR)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	lump sum	$6,000	1	$6,000	Prior System Costs
	Misc. Maintenance	lump sum	$12,000	1	$12,000	Prior System Costs
	Subtotal				**$59,600**	
5	**SEMI-ANNUAL INJECTION (2 YEARS)**					
	Molasses	lbs	$1	1800	$1,800	Price from similar job
	Recirculation/Injection Labor	day	$1,600	9	$14,400	2 engineers/scientists, $100/hour
	Subtotal				**$16,200**	
6	**HCIM QUARTERLY WATER LEVEL MONITORING (5 YEARS)**					
	Water Level Monitoring Labor	day	$1,600	4	$6,400	2 engineers/scientists, $100/hour
	Subtotal				**$6,400**	
7	**CPOC QUARTERLY MONITORING (5 YEARS)**					
	Sampling Labor	day	$1,600	12	$19,200	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	48	$14,160	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	48	$13,680	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	48	$9,360	ARI, 10% QA samples
	Analysis - Metals	per well	$290	48	$13,920	ARI, 10% QA samples
	Reporting	per round	$10,000	4	$40,000	Price from similar job
	Subtotal				**$110,320**	
8	**SEMI-ANNUAL OA HYDRAULIC CONTAINMENT MONITORING (10 YEARS)**					
	Sampling Labor	day	$1,600	4	$6,400	2 engineers/scientists, $100/hour
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	15	$2,930	ARI, 10% QA samples
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$29,330**	
9	**DOWNGRADIENT SEMI-ANNUAL MONITORING (5 YEARS)**					
	Sampling Labor	day	$1,600	6	$9,600	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	31	$9,150	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	31	$8,840	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	31	$6,050	ARI, 10% QA samples
	Analysis - Metals	per well	$290	31	$8,990	ARI, 10% QA samples
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$62,630**	
10	**HCIM MONITORING (ANNUAL TO 18 YR, BIANNUAL AFTER 18 YR)**					
	Sampling	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	13	$3,840	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	13	$3,710	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	13	$2,540	ARI, 10% QA samples
	Analysis - Metals	per well	$290	13	$3,770	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$27,060**	
11	**CPOC MONITORING (ANNUAL 5 YR TO 18 YR, BIANNUAL AFTER 18 YR)**					
	Sampling	day	$1,600	3	$4,800	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	12	$3,540	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	12	$2,340	ARI, 10% QA samples
	Analysis - Metals	per well	$290	12	$3,480	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$27,580**	
12	**DOWNGRADIENT MONITORING (ANNUAL 5 YR TO 18 YR)**					
	Sampling	day	$1,600	3	$4,800	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	15	$4,430	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	15	$4,280	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	15	$2,930	ARI, 10% QA samples
	Analysis - Metals	per well	$290	15	$4,350	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$30,790**	
13	**IPIM (15 YEARS)**					
	Investigation (Annualized, $100,000 every 5 years)	Lump sum	$ 20,000	1	$20,000	
	Maintenance	Lump sum	$ 5,000	1	$5,000	
	Subtotal				**$25,000**	
14	**LOW PERMEABILITY WALL REPAIRS (EVERY 50 YEARS)**					
	Repairs	Lump sum	$800,000	1	$800,000	Estimated using price from wall installation
	Subtotal				**$800,000**	
15	**PROJECT MANAGEMENT (10 YEARS)**					
	Project Management	per year	$20,000	1	$20,000	Price from similar job
	Subtotal				**$20,000**	
16	**PROJECT MANAGEMENT (AFTER 10 YR)**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-32
NET PRESENT VALUE FOR ALTERNATIVE OA-4
PSC Georgetown Facility
Seattle, Washington

Year	Implementation Costs	O&M Costs	Inspection & PM	Replacement Costs	IPIM Costs	HCIM WQ/WL Monitoring	CPOC Monitoring	Outside Area Monitoring	25% Contingency	Yearly Total
0	$6,746,700								$1,686,700	$8,433,400
1		$281,800	$20,550	$21,190	$25,000	$33,460	$110,320	$62,630	$138,700	$693,700
2	$16,200	$222,200	$20,550	$21,190	$25,000	$33,460	$110,320	$62,630	$127,900	$639,500
3	$16,200	$222,200	$20,550	$21,190	$25,000	$33,460	$110,320	$62,630	$127,900	$639,500
4		$222,200	$20,550	$21,190	$25,000	$33,460	$110,320	$62,630	$123,800	$619,200
5		$222,200	$20,550	$21,190	$25,000	$33,460	$110,320	$62,630	$123,800	$619,200
6		$222,200	$20,550	$21,190	$25,000	$27,060	$27,580	$30,790	$93,600	$468,000
7		$222,200	$20,550	$21,190	$25,000	$27,060	$27,580	$30,790	$93,600	$468,000
8		$222,200	$20,550	$21,190	$25,000	$27,060	$27,580	$30,790	$93,600	$468,000
9		$222,200	$20,550	$21,190	$25,000	$27,060	$27,580	$30,790	$93,600	$468,000
10		$222,200	$20,550	$21,190	$25,000	$27,060	$27,580	$30,790	$93,600	$468,000
11			$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$35,500	$177,700
12			$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$35,500	$177,700
13			$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$35,500	$177,700
14			$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$35,500	$177,700
15			$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$35,500	$177,700
16			$10,550	$21,190		$27,060	$27,580	$30,790	$29,300	$146,500
17			$10,550	$21,190		$27,060	$27,580	$30,790	$29,300	$146,500
18			$10,550	$21,190		$27,060	$27,580	$30,790	$29,300	$146,500
19			$10,550						$2,600	$13,200
20			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
21			$10,550						$2,600	$13,200
22			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
23			$10,550						$2,600	$13,200
24			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
25			$10,550						$2,600	$13,200
26			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
27			$10,550						$2,600	$13,200
28			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
29			$10,550						$2,600	$13,200
30			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
31			$10,550						$2,600	$13,200
32			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
33			$10,550						$2,600	$13,200
34			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
35			$10,550						$2,600	$13,200
36			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
37			$10,550						$2,600	$13,200
38			$10,550						$2,600	$13,200
39			$10,550						$2,600	$13,200
40			$10,550						$2,600	$13,200
41			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
42			$10,550						$2,600	$13,200
43			$10,550						$2,600	$13,200
44			$10,550						$2,600	$13,200
45			$10,550						$2,600	$13,200
46			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
47			$10,550						$2,600	$13,200
48			$10,550						$2,600	$13,200
49	$800,000		$10,550						$202,600	$1,013,200
50			$10,550						$2,600	$13,200
51			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
52			$10,550						$2,600	$13,200
53			$10,550						$2,600	$13,200
54			$10,550						$2,600	$13,200
55			$10,550						$2,600	$13,200
56			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
57			$10,550						$2,600	$13,200
58			$10,550						$2,600	$13,200
59			$10,550						$2,600	$13,200
60			$10,550						$2,600	$13,200
61			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
62			$10,550						$2,600	$13,200
63			$10,550						$2,600	$13,200
64			$10,550						$2,600	$13,200
65			$10,550						$2,600	$13,200
66			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
67			$10,550						$2,600	$13,200
68			$10,550						$2,600	$13,200
69			$10,550						$2,600	$13,200
70			$10,550						$2,600	$13,200
71			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
72			$10,550						$2,600	$13,200
73			$10,550						$2,600	$13,200
74			$10,550						$2,600	$13,200
75			$10,550						$2,600	$13,200
76			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
77			$10,550						$2,600	$13,200
78			$10,550						$2,600	$13,200
79			$10,550						$2,600	$13,200
80			$10,550						$2,600	$13,200
81			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
82			$10,550						$2,600	$13,200
83			$10,550						$2,600	$13,200
84			$10,550						$2,600	$13,200
85			$10,550						$2,600	$13,200
86			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
87			$10,550						$2,600	$13,200
88			$10,550						$2,600	$13,200
89			$10,550						$2,600	$13,200
90			$10,550						$2,600	$13,200
91			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
92			$10,550						$2,600	$13,200
93			$10,550						$2,600	$13,200
94			$10,550						$2,600	$13,200
95			$10,550						$2,600	$13,200
96			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
97			$10,550						$2,600	$13,200
98			$10,550						$2,600	$13,200
99	$800,000		$10,550						$202,600	$1,013,200
TOTAL	$6,779,100	$2,281,600	$311,000	$402,600	$375,000	$519,100	$910,100	$713,400	$3,086,400	$15,433,700

Net Discount rate: 2.5% **NPV** **$14,000,600**

TABLE A-33
IMPLEMENTATION COSTS FOR ALTERNATIVE OA-5
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	140	$4,400	2005 RSMeans Environmental p. 9-253; 33 23 2504; 2 Wells, 1 at 50' bgs, 1 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversite	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Barricade (Barrels with flashers)	each weekly	$20	20	$400	RSMeans Building Construction p. 23; 1590 400 1620
Labor (2 flaggers)	day	$690	1	$690	RSMeans Building Construction p. 631
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$10,300**	
3 **Excavation and Disposal**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
Track Mounted Excavator, 1 C.Y. bucket, +15% for loading onto trucks	BCY	$3	6,300	$18,100	2007 RSMeans Building Construction p. 528; 31 23 16.42 0200
Tanker Trailer Transport, Hazardous Waste, Arlington	MI	$3	85,000	$255,000	2005 RSMeans Environmental p. 9-178; 33 190254; 5200 tons, 16 tons/truck, 260 miles to Arlington, OR
Landfill Hazardous Solid Bulk Waste	TON	$163	5,200	$846,600	2005 RSMeans Environmental p. 9-204; 33 19 72641
Landfill Non-Hazardous Solid Buld Waste, w/ Transportation	TON	$34	3,400	$116,600	Price from similar job
Confirmation Soil Sampling	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Analytical on Soil Samples	Lump Sum	$5,000	1	$5,000	Price from similar job
Clean Fill, Delivered	TON	$15	10,700	$160,500	Price from similar job
Dozer Backfilling, compacting in 6" to 12" lifts with Vibratory Compactor	ECY	$3	10,700	$28,200	2007 RSMeans Building Construction p. 532; 31 23 23.13 1600
3" Asphalt Paving	SY	$10	700	$7,000	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	20	$16,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$1,467,000**	
4 **Soil Vapor Extraction System**					
Mobilization/Demobilization	Lump Sum	$5,000	1	$5,000	Price from similar job
500 CFM, 1,200 LB Fill, Closed Upflow, Activated Carbon Unit	EA	$5,391	2	$10,800	2005 RSMeans Environmental p. 9-143; 33 13 1909
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
30 HP, 580 SCFM Vapor Extraction Blower	EA	$11,523	1	$11,500	2005 RSMeans Environmental p 9-153; 33 13 2342
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	30	$1,800	2005 RSMeans Environmental p. 9-236; 33 23 33 23 1105; 3 SVE wells at 10' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	15	$400	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 3 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	15	$400	2005 RSMeans Environmental p 9-215; 33 23 0202; 5' of screen for 3 wells
4" Well, Grout (Annular Seal)	LF	$128.04	3	$400	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	3	$500	2005 RSMeans Environmental p 9-246; 33 23 1702
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Task 4 Total				**$127,200**	
5 **Enhanced Bioremediation Pilot Test**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	30	$1,800	2005 RSMeans Environmental p. 9-236; 33 23 1105; 1 Groundwater Circulation Well (GCW) at 30' bgs
8" PVC, Schedule 80, Well Casing	LF	$61	15	$900	2005 RSMeans Environmental p. 2-212; 33 23 0115
8" Stainless Steel Well Screen, 5' Sec, Flush Threaded	LF	$438.77	15	$6,600	2005 RSMeans Environmental p. 2-216; 33 23 0225
8" Well, Grout (Annular Seal)	LF	$251.59	1	$300	2005 RSMeans Environmental p. 2-246; 33 23 1804
Precast Concrete Vaults for GCW	EA	$722	1	$700	2005 RSMeans Environmental p 9-248; 33 23 2201
Construction Oversite	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Pump Assembly Tubing	Lump Sum	$2,000.00	1	$2,000	Price from similar job
40" Packer Tube	EA	$6,000.00	1	$6,000	Price from similar job
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526
4" PVC, Schedule 40, Connection Piping	LF	$8	10	$100	2005 RSMeans Environmental p. 9-257; 33 26 0415
Recirculation Device Assembly	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	2	$3,200	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,200	$1,200	Price from similar job
Task 5 Total				**$30,400**	
6 **Enhanced Bioremediation Full Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$61.26	60	$3,700	2005 RSMeans Environmental p. 9-236; 33 23 1105; 2 GCW's at 30' bgs
8" PVC, Schedule 80, Well Casing	LF	$61	30	$1,800	2005 RSMeans Environmental p. 2-212; 33 23 0115
8" Stainless Steel Well Screen, 5' Sec, Flush Threaded	LF	$438.77	30	$13,200	2005 RSMeans Environmental p. 2-216; 33 23 0225
8" Well, Grout (Annular Seal)	LF	$251.59	2	$500	2005 RSMeans Environmental p. 2-246; 33 23 1804
Precast Concrete Vaults for GCW	EA	$722	2	$1,400	2005 RSMeans Environmental p 9-248; 33 23 2201
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Task 6 Total				**$24,400**	
7 **Confirmation Soil Borings**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	Price from similar job
14" dia. Hollow Stem Auger Drilling	LF	$61.26	60	$3,700	2005 RSMeans Environmental p. 9-236; 33 23 1105; 4 borings at 15' bgs
Confirmation Soil Sampling	day	$800	2	$1,600	1 engineer/scientist, Geomatrix standard rate
Analytical on Soil Samples	Lump Sum	$2,000	1	$2,000	Price from similar job
Equipment	day	$100	2	$200	PID rental, Geomatrix standard rate
Task 7 Total				**$10,500**	
8 **Outside Area Hydraulic Containment and Mass Removal**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
Traffic Control Labor	day	$355	60	$21,300	RSMeans Building Construction p. 613; 30 days with crew of 2
Traffic Control Vehical	day	$97	30	$2,900	RSMeans Building Construction p. 608; 01 54 33 7100
8" dia. Water Supply, PVC pipe, AWWA C905, PR 100, DR 41	LF	$21	6,600	$138,600	RSMeans Building Construction p. 571; 33 11 13.25 2210
Pavement removal, bituminous roads, 4" to 6" thick	SY	$7	1,467	$10,500	RSMeans Building Construction p. 25; 02 41 13.17 5050
Excavating, Trench, 1' to 4' deep, 3/8 C.Y. excavator	CY	$7	1,956	$14,200	RSMeans Building Consturction p. 523; 31 23 16.13 0020
Crushed 3/4" stone base, compacted, 6" deep	SY	$8	1,467	$11,500	RSMeans Building Construction p. 547; 32 11 23.23 0100
Plant-Mix Asphalt Paving, 4" thick	SY	$13	1,467	$19,300	RSMeans Building Consturction p. 547; 32 12 16.13 0200
4" Submersible Pump, 15-20 gpm, 601'< Head <=1000', 5 hp, w/ controls	EA	$5,482	11	$60,300	2005 RSMeans Environmental p. 9-225; 33 23 0539; 11 extraction wells
6" Groundwater Extraction Well Drilling (Mud Drilling)	LF	$51	480	$24,700	2005 RSMeans Environmental p. 9-236; 33 23 1111; 11 extraction wells, 9 at 40' bgs and 2 at 60' bgs
6" PVC, Schedule 80, Well Casing	LF	$46	305	$14,000	2005 RSMeans Environmental p. 9-211; 33 23 0103; 25' of casing for 9 wells, 45' of casing for 2 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	165	$8,100	2005 RSMeans Environmental p 9-215; 33 23 0203; 15' of screen for 11 wells
6" Well, Grout (Annular Seal)	LF	$189	11	$2,100	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208	11	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1703
250 gpm UV Reactor, Ozone and Peroxide Capital Equipment	EA	$318,240	1	$318,200	2005 RSMeans Environmental p. 9-117; 33 12 0836
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
200 gpm, 6,000 lb fill Carbon Adsorption tank	EA	$16,290	2	$32,600	2005 RSMeans Environmental p. 9-148; 33 13 2024
Foranger Type MTU Granules	CF	$575	86	$49,500	Quote from Foranger
Groundwater Treatment System, 165 gpm	Lump Sum	$3,206,000	1	$3,206,000	Detailed cost estimation done by Geomatrix
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	20	$16,000	1 engineer/scientist, Geomatrix standard rate
Task 8 Total				**$3,965,300**	
9 **Treatment System Property Purchase**					
Property Purchase	SF	$35	4,000	$140,000	
Task 9 Total				**$140,000**	
Subtotal				**$5,779,700**	
Professional Technical Services					
Permitting	%	7%	$5,779,700	$404,600	Geomatrix standard rate
Engineering Design Costs	%	8%	$5,779,700	$462,400	from EPA, 2000, Exh. 5-8
Construction Management	%	6%	$5,779,700	$346,800	from EPA, 2000, Exh. 5-8
Project Management	%	5%	$5,779,700	$289,000	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$1,502,800	
TOTAL INITIAL IMPLEMENTATION COST				**$7,282,500**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 RSMeans Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

Geomatrix

TABLE A-34

RECURRING COSTS FOR ALTERNATIVE OA-5

PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**ANNUAL REPLACEMENT COSTS (ANNUAL 18 YR, BIANNUAL AFTER 18 YR)**					
	Well Maintenance	per well	$5,000	4	$20,000	Est. 10% of wells need maintence
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$21,190**	
3	**OA HYD. CONTROL/MASS REM. O&M COSTS (10 YEARS)**					
	Annual operation labor	year	$24,800	1	$24,800	2 hr/d, 350 d/yr + supv., PSC employees
	Electricity	lump sum	$112,800	1	$112,800	$0.12/KWH, est. power usage
	Misc. Maintenance	lump sum	$84,400	1	$84,400	3% of equipment costs
	Treatment chemicals (acid regenerant)	lump sum	$26,000	1	$26,000	Est., $0.45/lb
	Sewer fees (apent regenerant)	lump sum	$2,600	1	$2,600	Est., $0.95/gal
	Subtotal				**$250,600**	
4	**SVE SYSTEM O&M COSTS (1 YEAR)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	lump sum	$6,000	1	$6,000	Prior System Costs
	Misc. Maintenance	lump sum	$12,000	1	$12,000	Prior System Costs
	Subtotal				**$59,600**	
5	**SEMI-ANNUAL INJECTION (2 YEARS)**					
	Molasses	lbs	$1	1800	$1,800	Price from similar job
	Recirculation/Injection Labor	day	$1,600	9	$14,400	2 engineers/scientists, $100/hour
	Subtotal				**$16,200**	
6	**HCIM QUARTERLY WATER LEVEL MONITORING (5 YEARS)**					
	Water Level Monitoring Labor	day	$1,600	3	$4,800	2 engineers/scientists, $100/hour
	Subtotal				**$4,800**	
7	**CPOC QUARTERLY MONITORING (5 YEARS)**					
	Sampling Labor	day	$1,600	12	$19,200	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	48	$14,160	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	48	$13,680	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	48	$9,360	ARI, 10% QA samples
	Analysis - Metals	per well	$290	48	$13,920	ARI, 10% QA samples
	Reporting	per round	$10,000	4	$40,000	Price from similar job
	Subtotal				**$110,320**	
8	**SEMI-ANNUAL OA PUMP & TREAT MONITORING (10 YEARS)**					
	Sampling Labor	day	$1,600	4	$6,400	2 engineers/scientists, $100/hour
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	24	$4,680	ARI, 10% QA samples
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$31,080**	
9	**DOWNGRADIENT SEMI-ANNUAL MONITORING (5 YEARS)**					
	Sampling Labor	day	$1,600	6	$9,600	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	31	$9,150	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	31	$8,840	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	31	$6,050	ARI, 10% QA samples
	Analysis - Metals	per well	$290	31	$8,990	ARI, 10% QA samples
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$62,630**	
10	**HCIM MONITORING (ANNUAL TO 18 YR, BIANNUAL AFTER 18 YR)**					
	Sampling	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	13	$3,840	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	13	$3,710	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	13	$2,540	ARI, 10% QA samples
	Analysis - Metals	per well	$290	13	$3,770	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$27,060**	
11	**CPOC MONITORING (ANNUAL 5 YR TO 18 YR, BIANNUAL AFTER 18 YR)**					
	Sampling	day	$1,600	3	$4,800	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	12	$3,540	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	12	$2,340	ARI, 10% QA samples
	Analysis - Metals	per well	$290	12	$3,480	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$27,580**	
12	**DOWNGRADIENT MONITORING (ANNUAL 5 YR TO 18 YR)**					
	Sampling	day	$1,600	3	$4,800	2 engineers/scientists, $100/hour
	Analysis - SVOCs	per well	$295	15	$4,430	ARI, 10% QA samples
	Analysis - VOCs, Ethenes	per well	$285	15	$4,280	ARI, 10% QA samples
	Analysis - Alkalinity, 1,4-Dioxane	per well	$195	15	$2,930	ARI, 10% QA samples
	Analysis - Metals	per well	$290	15	$4,350	ARI, 10% QA samples
	Reporting	per round	$10,000	1	$10,000	Price from similar job
	Subtotal				**$30,790**	
13	**IPIM (15 YEARS)**					
	Investigation (Annualized, $100,000 every 5 years)	Lump sum	$ 20,000	1	$20,000	
	Maintenance	Lump sum	$ 5,000	1	$5,000	
	Subtotal				**$25,000**	
14	**LOW PERMEABILITY WALL REPAIRS (EVERY 50 YEARS)**					
	Repairs	Lump sum	$800,000	1	$800,000	Estimated using price from wall installation
	Subtotal				**$800,000**	
15	**PROJECT MANAGEMENT (10 YEARS)**					
	Project Management	per year	$20,000	1	$20,000	Price from similar job
	Subtotal				**$20,000**	
16	**PROJECT MANAGEMENT (AFTER 10 YR)**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-35

NET PRESENT VALUE FOR ALTERNATIVE OA-5

PSC Georgetown Facility
Seattle, Washington

Year	Implementation Costs	O&M Costs	Inspection & PM	Replacement Costs	IPIM Costs	HCIM WQ/WL Monitoring	CPOC Monitoring	Outside Area Monitoring	25% Contingency	Yearly Total
0	$7,282,500								$1,820,600	$9,103,100
1		$330,750	$20,550	$21,190	$25,000	$31,860	$115,120	$62,630	$151,800	$758,900
2	$16,200	$271,150	$20,550	$21,190	$25,000	$31,860	$115,120	$62,630	$140,900	$704,600
3	$16,200	$271,150	$20,550	$21,190	$25,000	$31,860	$115,120	$62,630	$140,900	$704,600
4		$271,150	$20,550	$21,190	$25,000	$31,860	$115,120	$62,630	$136,900	$684,400
5		$271,150	$20,550	$21,190	$25,000	$31,860	$115,120	$62,630	$136,900	$684,400
6		$271,150	$20,550	$21,190	$25,000	$27,060	$27,580	$30,790	$105,800	$529,100
7		$271,150	$20,550	$21,190	$25,000	$27,060	$27,580	$30,790	$105,800	$529,100
8		$271,150	$20,550	$21,190	$25,000	$27,060	$27,580	$30,790	$105,800	$529,100
9		$271,150	$20,550	$21,190	$25,000	$27,060	$27,580	$30,790	$105,800	$529,100
10		$271,150	$20,550	$21,190	$25,000	$27,060	$27,580	$30,790	$105,800	$529,100
11			$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$35,500	$177,700
12			$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$35,500	$177,700
13			$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$35,500	$177,700
14			$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$35,500	$177,700
15			$10,550	$21,190	$25,000	$27,060	$27,580	$30,790	$35,500	$177,700
16			$10,550	$21,190		$27,060	$27,580	$30,790	$29,300	$146,500
17			$10,550	$21,190		$27,060	$27,580	$30,790	$29,300	$146,500
18			$10,550	$21,190		$27,060	$27,580	$30,790	$29,300	$146,500
19			$10,550						$2,600	$13,200
20			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
21			$10,550						$2,600	$13,200
22			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
23			$10,550						$2,600	$13,200
24			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
25			$10,550						$2,600	$13,200
26			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
27			$10,550						$2,600	$13,200
28			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
29			$10,550						$2,600	$13,200
30			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
31			$10,550						$2,600	$13,200
32			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
33			$10,550						$2,600	$13,200
34			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
35			$10,550						$2,600	$13,200
36			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
37			$10,550						$2,600	$13,200
38			$10,550						$2,600	$13,200
39			$10,550						$2,600	$13,200
40			$10,550						$2,600	$13,200
41			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
42			$10,550						$2,600	$13,200
43			$10,550						$2,600	$13,200
44			$10,550						$2,600	$13,200
45			$10,550						$2,600	$13,200
46			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
47			$10,550						$2,600	$13,200
48			$10,550						$2,600	$13,200
49	$800,000		$10,550						$202,600	$1,013,200
50			$10,550						$2,600	$13,200
51			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
52			$10,550						$2,600	$13,200
53			$10,550						$2,600	$13,200
54			$10,550						$2,600	$13,200
55			$10,550						$2,600	$13,200
56			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
57			$10,550						$2,600	$13,200
58			$10,550						$2,600	$13,200
59			$10,550						$2,600	$13,200
60			$10,550						$2,600	$13,200
61			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
62			$10,550						$2,600	$13,200
63			$10,550						$2,600	$13,200
64			$10,550						$2,600	$13,200
65			$10,550						$2,600	$13,200
66			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
67			$10,550						$2,600	$13,200
68			$10,550						$2,600	$13,200
69			$10,550						$2,600	$13,200
70			$10,550						$2,600	$13,200
71			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
72			$10,550						$2,600	$13,200
73			$10,550						$2,600	$13,200
74			$10,550						$2,600	$13,200
75			$10,550						$2,600	$13,200
76			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
77			$10,550						$2,600	$13,200
78			$10,550						$2,600	$13,200
79			$10,550						$2,600	$13,200
80			$10,550						$2,600	$13,200
81			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
82			$10,550						$2,600	$13,200
83			$10,550						$2,600	$13,200
84			$10,550						$2,600	$13,200
85			$10,550						$2,600	$13,200
86			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
87			$10,550						$2,600	$13,200
88			$10,550						$2,600	$13,200
89			$10,550						$2,600	$13,200
90			$10,550						$2,600	$13,200
91			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
92			$10,550						$2,600	$13,200
93			$10,550						$2,600	$13,200
94			$10,550						$2,600	$13,200
95			$10,550						$2,600	$13,200
96			$10,550	$21,190		$27,060	$27,580		$21,600	$108,000
97			$10,550						$2,600	$13,200
98			$10,550						$2,600	$13,200
99	$800,000		$10,550						$202,600	$1,013,200
TOTAL	$8,914,900	$2,771,100	$1,144,500	$826,400	$375,000	$1,079,300	$1,513,300	$713,400	$4,332,000	$21,673,500

Net Discount rate: 2.5%

NPV **$16,426,800**

Geomatrix

TABLE A-36

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-1 (HIGH)

PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 CAP CONSTRUCTION					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction Cost Data p. 24; 02 21 13.09 0020
Subtotal				**$5,100**	
Professional Technical Services					
Permitting	%	7%	$5,100	$400	Geomatrix standard rate
Engineering Design Costs	%	20%	$5,100	$1,000	from EPA, 2000, Exh. 5-8
Construction Management	%	15%	$5,100	$800	from EPA, 2000, Exh. 5-8
Project Management	%	10%	$5,100	$500	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$2,700	
TOTAL INITIAL IMPLEMENTATION COST				**$7,800**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

Geomatrix

TABLE A-37

RECURRING COSTS FOR ALTERNATIVE HA-1 (HIGH)

PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
3	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$31	13	$400	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$2,970**	
4	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	

Notes:

1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-38

NET PRESENT VALUE FOR ALTERNATIVE HA-1 (HIGH)

PSC Georgetown Facility

Seattle, Washington

Year	Implementation Cost	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	15% Contingency	Yearly Total
0	$7,800				$1,170	$9,000
1		$10,550	$162,200	$2,970	$26,358	$202,100
2		$10,550	$162,200	$2,970	$26,358	$202,100
3		$10,550	$162,200	$2,970	$26,358	$202,100
4		$10,550	$162,200	$2,970	$26,358	$202,100
5		$10,550	$162,200	$2,970	$26,358	$202,100
6		$10,550	$162,200	$2,970	$26,358	$202,100
7		$10,550	$162,200	$2,970	$26,358	$202,100
8		$10,550	$162,200	$2,970	$26,358	$202,100
9		$10,550	$162,200	$2,970	$26,358	$202,100
10		$10,550	$162,200	$2,970	$26,358	$202,100
11		$10,550	$162,200	$2,970	$26,358	$202,100
12		$10,550	$162,200	$2,970	$26,358	$202,100
13		$10,550	$162,200	$2,970	$26,358	$202,100
14		$10,550	$162,200	$2,970	$26,358	$202,100
15		$10,550	$162,200	$2,970	$26,358	$202,100
16		$10,550	$162,200	$2,970	$26,358	$202,100
17		$10,550	$162,200	$2,970	$26,358	$202,100
18		$10,550	$162,200	$2,970	$26,358	$202,100
19		$10,550	$162,200	$2,970	$26,358	$202,100
20		$10,550	$162,200	$2,970	$26,358	$202,100
21		$10,550	$162,200	$2,970	$26,358	$202,100
22		$10,550	$162,200	$2,970	$26,358	$202,100
23		$10,550	$162,200	$2,970	$26,358	$202,100
24		$10,550	$162,200	$2,970	$26,358	$202,100
25		$10,550	$162,200	$2,970	$26,358	$202,100
26		$10,550	$162,200	$2,970	$26,358	$202,100
27		$10,550	$162,200	$2,970	$26,358	$202,100
28		$10,550	$162,200	$2,970	$26,358	$202,100
29		$10,550	$162,200	$2,970	$26,358	$202,100
30		$10,550	$162,200	$2,970	$26,358	$202,100
31		$10,550	$162,200	$2,970	$26,358	$202,100
32		$10,550	$162,200	$2,970	$26,358	$202,100
33		$10,550	$162,200	$2,970	$26,358	$202,100
34		$10,550	$162,200	$2,970	$26,358	$202,100
35		$10,550	$162,200	$2,970	$26,358	$202,100
36		$10,550	$162,200	$2,970	$26,358	$202,100
37		$10,550	$162,200	$2,970	$26,358	$202,100
38		$10,550	$162,200	$2,970	$26,358	$202,100
39		$10,550	$162,200	$2,970	$26,358	$202,100
40		$10,550	$162,200	$2,970	$26,358	$202,100
41		$10,550	$162,200	$2,970	$26,358	$202,100
42		$10,550	$162,200	$2,970	$26,358	$202,100
43		$10,550	$162,200	$2,970	$26,358	$202,100
44		$10,550	$162,200	$2,970	$26,358	$202,100
45		$10,550	$162,200	$2,970	$26,358	$202,100
46		$10,550	$162,200	$2,970	$26,358	$202,100
47		$10,550	$162,200	$2,970	$26,358	$202,100
48		$10,550	$162,200	$2,970	$26,358	$202,100
49		$10,550	$162,200	$2,970	$26,358	$202,100
50		$10,550	$162,200	$2,970	$26,358	$202,100
51		$10,550	$162,200	$2,970	$26,358	$202,100
52		$10,550	$162,200	$2,970	$26,358	$202,100
53		$10,550	$162,200	$2,970	$26,358	$202,100
54		$10,550	$162,200	$2,970	$26,358	$202,100
55		$10,550	$162,200	$2,970	$26,358	$202,100
56		$10,550	$162,200	$2,970	$26,358	$202,100
57		$10,550	$162,200	$2,970	$26,358	$202,100
58		$10,550	$162,200	$2,970	$26,358	$202,100
59		$10,550	$162,200	$2,970	$26,358	$202,100
60		$10,550	$162,200	$2,970	$26,358	$202,100
61		$10,550	$162,200	$2,970	$26,358	$202,100
62		$10,550	$162,200	$2,970	$26,358	$202,100
63		$10,550	$162,200	$2,970	$26,358	$202,100
64		$10,550	$162,200	$2,970	$26,358	$202,100
65		$10,550	$162,200	$2,970	$26,358	$202,100
66		$10,550	$162,200	$2,970	$26,358	$202,100
67		$10,550	$162,200	$2,970	$26,358	$202,100
68		$10,550	$162,200	$2,970	$26,358	$202,100
69		$10,550	$162,200	$2,970	$26,358	$202,100
70		$10,550	$162,200	$2,970	$26,358	$202,100
71		$10,550	$162,200	$2,970	$26,358	$202,100
72		$10,550	$162,200	$2,970	$26,358	$202,100
73		$10,550	$162,200	$2,970	$26,358	$202,100
74		$10,550	$162,200	$2,970	$26,358	$202,100
75		$10,550	$162,200	$2,970	$26,358	$202,100
76		$10,550	$162,200	$2,970	$26,358	$202,100
77		$10,550	$162,200	$2,970	$26,358	$202,100
78		$10,550	$162,200	$2,970	$26,358	$202,100
79		$10,550	$162,200	$2,970	$26,358	$202,100
80		$10,550	$162,200	$2,970	$26,358	$202,100
81		$10,550	$162,200	$2,970	$26,358	$202,100
82		$10,550	$162,200	$2,970	$26,358	$202,100
83		$10,550	$162,200	$2,970	$26,358	$202,100
84		$10,550	$162,200	$2,970	$26,358	$202,100
85		$10,550	$162,200	$2,970	$26,358	$202,100
86		$10,550	$162,200	$2,970	$26,358	$202,100
87		$10,550	$162,200	$2,970	$26,358	$202,100
88		$10,550	$162,200	$2,970	$26,358	$202,100
89		$10,550	$162,200	$2,970	$26,358	$202,100
90		$10,550	$162,200	$2,970	$26,358	$202,100
91		$10,550	$162,200	$2,970	$26,358	$202,100
92		$10,550	$162,200	$2,970	$26,358	$202,100
93		$10,550	$162,200	$2,970	$26,358	$202,100
94		$10,550	$162,200	$2,970	$26,358	$202,100
95		$10,550	$162,200	$2,970	$26,358	$202,100
96		$10,550	$162,200	$2,970	$26,358	$202,100
97		$10,550	$162,200	$2,970	$26,358	$202,100
98		$10,550	$162,200	$2,970	$26,358	$202,100
99		$10,550	$162,200	$2,970	$26,358	$202,100
TOTAL	$7,800	$1,044,500	$16,057,800	$294,000	$2,610,600	$20,016,900

Net Discount rate: 2.5% **NPV** **$7,211,300**

TABLE A-39

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-2 (HIGH)
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 4 Wells, 2 at 30' bgs, 2 at 50' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 **Pilot Study**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	3	$2,400	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,950	$2,000	Price from similar job
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 3 Total				**$54,200**	
4 **Full-Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 4 Total				**$137,600**	
Subtotal				$209,400	
Professional Technical Services					
Permitting	%	7%	$209,400	$14,700	Geomatrix standard rate
Engineering Design Costs	%	12%	$209,400	$25,100	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$209,400	$16,800	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$209,400	$12,600	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$69,200	
TOTAL INITIAL IMPLEMENTATION COST				**$278,600**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

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TABLE A-40

RECURRING COSTS FOR ALTERNATIVE HA-2 (HIGH)

PSC Georgetown Facility
Seattle, Washington

	ITEM	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
3	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
4	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Molassess	lbs	$1	48750	$48,750	Price from similar job
	Recirculation/Injection Labor	day	$1,600	13	$20,800	2 engineers/scientists, $100/hour
	Subtotal				**$69,550**	
6	**SEMI ANNUAL ISB MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
7	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	per year	$15,000	1	$15,000	Price from similar job
	Subtotal				**$15,000**	
8	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
9	**PROPERTY OPPORTUNITY COST (5 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-41

NET PRESENT VALUE FOR ALTERNATIVE HA-2 (HIGH)

PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Semi-Annual Injection	Semi-Annual ISB Monitoring	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	Property Opportunity Cost	25% Contingency	Yearly Total
0	$278,600					$367,500	$161,525	$646,100
1	$69,550	$26,620	$15,550	$162,200	$3,290	$367,500	$161,178	$644,700
2	$69,550	$26,620	$15,550	$162,200	$3,290	$367,500	$161,178	$644,700
3	$69,550	$26,620	$15,550	$162,200	$3,290	$367,500	$161,178	$644,700
4	$69,550	$26,620	$15,550	$162,200	$3,290	$367,500	$161,178	$644,700
5		$26,620	$15,550	$162,200	$3,290	$367,500	$143,790	$575,200
6		$26,620	$15,550	$162,200	$3,290	$367,500	$143,790	$575,200
7			$10,550	$162,200	$3,290		$44,010	$176,000
8			$10,550	$162,200	$3,290		$44,010	$176,000
9			$10,550	$162,200	$3,290		$44,010	$176,000
10			$10,550	$162,200	$3,290		$44,010	$176,000
11			$10,550	$162,200	$3,290		$44,010	$176,000
12			$10,550	$162,200	$3,290		$44,010	$176,000
13			$10,550	$162,200	$3,290		$44,010	$176,000
14			$10,550	$162,200	$3,290		$44,010	$176,000
15			$10,550	$162,200	$3,290		$44,010	$176,000
16			$10,550	$162,200	$3,290		$44,010	$176,000
17			$10,550	$162,200	$3,290		$44,010	$176,000
18			$10,550	$162,200	$3,290		$44,010	$176,000
19			$10,550	$162,200	$3,290		$44,010	$176,000
20			$10,550	$162,200	$3,290		$44,010	$176,000
21			$10,550	$162,200	$3,290		$44,010	$176,000
22			$10,550	$162,200	$3,290		$44,010	$176,000
23			$10,550	$162,200	$3,290		$44,010	$176,000
24			$10,550	$162,200	$3,290		$44,010	$176,000
25			$10,550	$162,200	$3,290		$44,010	$176,000
26			$10,550	$162,200	$3,290		$44,010	$176,000
27			$10,550	$162,200	$3,290		$44,010	$176,000
28			$10,550	$162,200	$3,290		$44,010	$176,000
29			$10,550	$162,200	$3,290		$44,010	$176,000
30			$10,550	$162,200	$3,290		$44,010	$176,000
31			$10,550	$162,200	$3,290		$44,010	$176,000
32			$10,550	$162,200	$3,290		$44,010	$176,000
33			$10,550	$162,200	$3,290		$44,010	$176,000
34			$10,550	$162,200	$3,290		$44,010	$176,000
35			$10,550	$162,200	$3,290		$44,010	$176,000
36			$10,550	$162,200	$3,290		$44,010	$176,000
37			$10,550	$162,200	$3,290		$44,010	$176,000
38			$10,550	$162,200	$3,290		$44,010	$176,000
39			$10,550	$162,200	$3,290		$44,010	$176,000
40			$10,550	$162,200	$3,290		$44,010	$176,000
41			$10,550	$162,200	$3,290		$44,010	$176,000
42			$10,550	$162,200	$3,290		$44,010	$176,000
43			$10,550	$162,200	$3,290		$44,010	$176,000
44			$10,550	$162,200	$3,290		$44,010	$176,000
45			$10,550	$162,200	$3,290		$44,010	$176,000
46			$10,550	$162,200	$3,290		$44,010	$176,000
47			$10,550	$162,200	$3,290		$44,010	$176,000
48			$10,550	$162,200	$3,290		$44,010	$176,000
49			$10,550	$162,200	$3,290		$44,010	$176,000
50			$10,550	$162,200	$3,290		$44,010	$176,000
51			$10,550	$162,200	$3,290		$44,010	$176,000
52			$10,550	$162,200	$3,290		$44,010	$176,000
53			$10,550	$162,200	$3,290		$44,010	$176,000
54			$10,550	$162,200	$3,290		$44,010	$176,000
55			$10,550	$162,200	$3,290		$44,010	$176,000
56			$10,550	$162,200	$3,290		$44,010	$176,000
57			$10,550	$162,200	$3,290		$44,010	$176,000
58			$10,550	$162,200	$3,290		$44,010	$176,000
59			$10,550	$162,200	$3,290		$44,010	$176,000
60			$10,550	$162,200	$3,290		$44,010	$176,000
61			$10,550	$162,200	$3,290		$44,010	$176,000
62			$10,550	$162,200	$3,290		$44,010	$176,000
63			$10,550	$162,200	$3,290		$44,010	$176,000
64			$10,550	$162,200	$3,290		$44,010	$176,000
65			$10,550	$162,200	$3,290		$44,010	$176,000
66			$10,550	$162,200	$3,290		$44,010	$176,000
67			$10,550	$162,200	$3,290		$44,010	$176,000
68			$10,550	$162,200	$3,290		$44,010	$176,000
69			$10,550	$162,200	$3,290		$44,010	$176,000
70			$10,550	$162,200	$3,290		$44,010	$176,000
71			$10,550	$162,200	$3,290		$44,010	$176,000
72			$10,550	$162,200	$3,290		$44,010	$176,000
73			$10,550	$162,200	$3,290		$44,010	$176,000
74			$10,550	$162,200	$3,290		$44,010	$176,000
75			$10,550	$162,200	$3,290		$44,010	$176,000
76			$10,550	$162,200	$3,290		$44,010	$176,000
77			$10,550	$162,200	$3,290		$44,010	$176,000
78			$10,550	$162,200	$3,290		$44,010	$176,000
79			$10,550	$162,200	$3,290		$44,010	$176,000
80			$10,550	$162,200	$3,290		$44,010	$176,000
81			$10,550	$162,200	$3,290		$44,010	$176,000
82			$10,550	$162,200	$3,290		$44,010	$176,000
83			$10,550	$162,200	$3,290		$44,010	$176,000
84			$10,550	$162,200	$3,290		$44,010	$176,000
85			$10,550	$162,200	$3,290		$44,010	$176,000
86			$10,550	$162,200	$3,290		$44,010	$176,000
87			$10,550	$162,200	$3,290		$44,010	$176,000
88			$10,550	$162,200	$3,290		$44,010	$176,000
89			$10,550	$162,200	$3,290		$44,010	$176,000
90			$10,550	$162,200	$3,290		$44,010	$176,000
91			$10,550	$162,200	$3,290		$44,010	$176,000
92			$10,550	$162,200	$3,290		$44,010	$176,000
93			$10,550	$162,200	$3,290		$44,010	$176,000
94			$10,550	$162,200	$3,290		$44,010	$176,000
95			$10,550	$162,200	$3,290		$44,010	$176,000
96			$10,550	$162,200	$3,290		$44,010	$176,000
97			$10,550	$162,200	$3,290		$44,010	$176,000
98			$10,550	$162,200	$3,290		$44,010	$176,000
99			$10,550	$162,200	$3,290		$44,010	$176,000
TOTAL	$556,800	$159,700	$1,074,500	$16,057,800	$325,700	$2,572,500	$5,186,700	$20,743,300

Net Discount rate: 2.5% **NPV** **$9,303,000**

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TABLE A-42

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-3 (HIGH)
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 6 Wells, 2 at 30' bgs, 2 at 50' bgs, 2 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 **Dewatering and Soil Vapor Extraction System**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
30 HP, 580 SCFM Vapor Extraction Blower	EA	$11,523	1	$11,500	2005 RSMeans Environmental p 9-153; 33 13 2342
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Permanent	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	150	$5,900	2005 RSMeans Environmental p. 9-236; 33 23 1101; 6 SVE wells at 25' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	30	$700	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 6 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	120	$4,300	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 6 wells
4" Well, Grout (Annular Seal)	LF	$128.04	6	$800	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	6	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1702
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$232,800**	
4 **Pilot Study**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	3	$2,400	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,950	$2,000	Price from similar job
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 4 Total				**$54,200**	
5 **ISB Full-Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p. 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 5 Total				**$137,600**	
Subtotal				$442,200	
Professional Technical Services					
Permitting	%	7%	$442,200	$31,000	Geomatrix standard rate
Engineering Design Costs	%	12%	$442,200	$53,100	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$442,200	$35,400	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$442,200	$26,500	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$146,000	
TOTAL INITIAL IMPLEMENTATION COST				**$588,200**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

Geomatrix

TABLE A-43

RECURRING COSTS FOR ALTERNATIVE HA-3 (HIGH)
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
5	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Molassess	lbs	$1	48750	$48,750	Price from similar job
	Recirculation/Injection Labor	day	$1,600	13	$20,800	2 engineers/scientists, $100/hour
	Subtotal				**$69,550**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
8	**SEMI ANNUAL ISB MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
9	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	per year	$20,000	1	$20,000	Price from similar job
	Subtotal				**$20,000**	
10	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
11	**PROPERTY OPPORTUNITY COST (9 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-44

NET PRESENT VALUE FOR ALTERNATIVE HA-3 (HIGH)
PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Injection Costs	Semi-Annual ISB Monitoring	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	SVE / Dewatering System Monitoring	Property Opportunity Cost	25% Contingency	Yearly Total
0	$588,200							$367,500	$238,925	$1,194,600
1			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
2			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
3			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
4			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
5			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
6			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
7	$69,550	$26,620	$20,550	$162,200	$3,290			$367,500	$162,428	$812,100
8	$69,550	$26,620	$20,550	$162,200	$3,290			$367,500	$162,428	$812,100
9	$69,550	$26,620	$20,550	$162,200	$3,290			$367,500	$162,428	$812,100
10	$69,550	$26,620	$20,550	$162,200	$3,290			$367,500	$162,428	$812,100
11		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
12		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
13			$10,550	$162,200	$3,290				$44,010	$220,100
14			$10,550	$162,200	$3,290				$44,010	$220,100
15			$10,550	$162,200	$3,290				$44,010	$220,100
16			$10,550	$162,200	$3,290				$44,010	$220,100
17			$10,550	$162,200	$3,290				$44,010	$220,100
18			$10,550	$162,200	$3,290				$44,010	$220,100
19			$10,550	$162,200	$3,290				$44,010	$220,100
20			$10,550	$162,200	$3,290				$44,010	$220,100
21			$10,550	$162,200	$3,290				$44,010	$220,100
22			$10,550	$162,200	$3,290				$44,010	$220,100
23			$10,550	$162,200	$3,290				$44,010	$220,100
24			$10,550	$162,200	$3,290				$44,010	$220,100
25			$10,550	$162,200	$3,290				$44,010	$220,100
26			$10,550	$162,200	$3,290				$44,010	$220,100
27			$10,550	$162,200	$3,290				$44,010	$220,100
28			$10,550	$162,200	$3,290				$44,010	$220,100
29			$10,550	$162,200	$3,290				$44,010	$220,100
30			$10,550	$162,200	$3,290				$44,010	$220,100
31			$10,550	$162,200	$3,290				$44,010	$220,100
32			$10,550	$162,200	$3,290				$44,010	$220,100
33			$10,550	$162,200	$3,290				$44,010	$220,100
34			$10,550	$162,200	$3,290				$44,010	$220,100
35			$10,550	$162,200	$3,290				$44,010	$220,100
36			$10,550	$162,200	$3,290				$44,010	$220,100
37			$10,550	$162,200	$3,290				$44,010	$220,100
38			$10,550	$162,200	$3,290				$44,010	$220,100
39			$10,550	$162,200	$3,290				$44,010	$220,100
40			$10,550	$162,200	$3,290				$44,010	$220,100
41			$10,550	$162,200	$3,290				$44,010	$220,100
42			$10,550	$162,200	$3,290				$44,010	$220,100
43			$10,550	$162,200	$3,290				$44,010	$220,100
44			$10,550	$162,200	$3,290				$44,010	$220,100
45			$10,550	$162,200	$3,290				$44,010	$220,100
46			$10,550	$162,200	$3,290				$44,010	$220,100
47			$10,550	$162,200	$3,290				$44,010	$220,100
48			$10,550	$162,200	$3,290				$44,010	$220,100
49			$10,550	$162,200	$3,290				$44,010	$220,100
50			$10,550	$162,200	$3,290				$44,010	$220,100
51			$10,550	$162,200	$3,290				$44,010	$220,100
52			$10,550	$162,200	$3,290				$44,010	$220,100
53			$10,550	$162,200	$3,290				$44,010	$220,100
54			$10,550	$162,200	$3,290				$44,010	$220,100
55			$10,550	$162,200	$3,290				$44,010	$220,100
56			$10,550	$162,200	$3,290				$44,010	$220,100
57			$10,550	$162,200	$3,290				$44,010	$220,100
58			$10,550	$162,200	$3,290				$44,010	$220,100
59			$10,550	$162,200	$3,290				$44,010	$220,100
60			$10,550	$162,200	$3,290				$44,010	$220,100
61			$10,550	$162,200	$3,290				$44,010	$220,100
62			$10,550	$162,200	$3,290				$44,010	$220,100
63			$10,550	$162,200	$3,290				$44,010	$220,100
64			$10,550	$162,200	$3,290				$44,010	$220,100
65			$10,550	$162,200	$3,290				$44,010	$220,100
66			$10,550	$162,200	$3,290				$44,010	$220,100
67			$10,550	$162,200	$3,290				$44,010	$220,100
68			$10,550	$162,200	$3,290				$44,010	$220,100
69			$10,550	$162,200	$3,290				$44,010	$220,100
70			$10,550	$162,200	$3,290				$44,010	$220,100
71			$10,550	$162,200	$3,290				$44,010	$220,100
72			$10,550	$162,200	$3,290				$44,010	$220,100
73			$10,550	$162,200	$3,290				$44,010	$220,100
74			$10,550	$162,200	$3,290				$44,010	$220,100
75			$10,550	$162,200	$3,290				$44,010	$220,100
76			$10,550	$162,200	$3,290				$44,010	$220,100
77			$10,550	$162,200	$3,290				$44,010	$220,100
78			$10,550	$162,200	$3,290				$44,010	$220,100
79			$10,550	$162,200	$3,290				$44,010	$220,100
80			$10,550	$162,200	$3,290				$44,010	$220,100
81			$10,550	$162,200	$3,290				$44,010	$220,100
82			$10,550	$162,200	$3,290				$44,010	$220,100
83			$10,550	$162,200	$3,290				$44,010	$220,100
84			$10,550	$162,200	$3,290				$44,010	$220,100
85			$10,550	$162,200	$3,290				$44,010	$220,100
86			$10,550	$162,200	$3,290				$44,010	$220,100
87			$10,550	$162,200	$3,290				$44,010	$220,100
88			$10,550	$162,200	$3,290				$44,010	$220,100
89			$10,550	$162,200	$3,290				$44,010	$220,100
90			$10,550	$162,200	$3,290				$44,010	$220,100
91			$10,550	$162,200	$3,290				$44,010	$220,100
92			$10,550	$162,200	$3,290				$44,010	$220,100
93			$10,550	$162,200	$3,290				$44,010	$220,100
94			$10,550	$162,200	$3,290				$44,010	$220,100
95			$10,550	$162,200	$3,290				$44,010	$220,100
96			$10,550	$162,200	$3,290				$44,010	$220,100
97			$10,550	$162,200	$3,290				$44,010	$220,100
98			$10,550	$162,200	$3,290				$44,010	$220,100
99			$10,550	$162,200	$3,290				$44,010	$220,100
TOTAL	$866,400	$159,700	$1,164,500	$16,057,800	$325,700	$1,016,400	$100,800	$4,777,500	$6,117,200	$30,590,300

Net Discount rate: 2.5% **NPV** **$15,411,400**

TABLE A-45

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-4 (HIGH)
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 Cap Construction					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 Performance Monitoring Well Installation					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 6 Wells, 2 at 30' bgs, 2 at 50' bgs, 2 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 Dewatering and Soil Vapor Extraction System					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
30 HP, 580 SCFM Vapor Extraction Blower	EA	$11,523	1	$11,500	2005 RSMeans Environmental p 9-153; 33 13 2342
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Permanent	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	150	$5,900	2005 RSMeans Environmental p. 9-236; 33 23 1101; 6 SVE wells at 25' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	30	$700	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 6 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	120	$4,300	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 6 wells
4" Well, Grout (Annular Seal)	LF	$128.04	6	$800	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	6	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1702
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$232,800**	
4 ISCO Pilot Study					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Soil Sampling	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Potassium Permanganate ($KMNO_4$)	lbs	$2	3,940	$6,400	Estimate of required substrate per recirculation cell, Geomatrix past experience
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 4 Total				**$65,000**	
5 ISCO Full-Scale Installation					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p. 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	20	$16,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 5 Total				**$145,600**	
Subtotal				$461,000	
Professional Technical Services					
Permitting	%	7%	$461,000	$32,300	Geomatrix standard rate
Engineering Design Costs	%	12%	$461,000	$55,300	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$461,000	$36,900	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$461,000	$27,700	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$152,200	
TOTAL INITIAL IMPLEMENTATION COST				**$613,200**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

Geomatrix

TABLE A-46

RECURRING COSTS FOR ALTERNATIVE HA-4 (HIGH)

PSC Georgetown Facility

Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
5	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Potassium Permanganate ($KMNO_4$)	lbs	$2	236250	$382,730	Carcus Chemical Company
	Recirculation/Injection Labor	day	$1,600	30	$48,000	2 engineers/scientists, $100/hour
	Subtotal				**$430,730**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
8	**SEMI ANNUAL ISCO MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
9	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	per year	$20,000	1	$20,000	Price from similar job
	Subtotal				**$20,000**	
10	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
11	**PROPERTY OPPORTUNITY COST (9 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-47

NET PRESENT VALUE FOR ALTERNATIVE HA-4 (HIGH)

PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Injection Costs	Semi-Annual ISCO Monitoring	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	SVE / Dewatering System Monitoring	Property Opportunity Cost	25% Contingency	Yearly Total
0	$613,200							$367,500	$245,175	$1,225,900
1			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
2			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
3			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
4			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
5			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
6			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
7	$430,730	$26,620	$20,550	$162,200	$3,290			$367,500	$252,723	$1,263,600
8	$430,730	$26,620	$20,550	$162,200	$3,290			$367,500	$252,723	$1,263,600
9	$430,730	$26,620	$20,550	$162,200	$3,290			$367,500	$252,723	$1,263,600
10	$430,730	$26,620	$20,550	$162,200	$3,290			$367,500	$252,723	$1,263,600
11		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
12		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
13			$10,550	$162,200	$3,290				$44,010	$220,100
14			$10,550	$162,200	$3,290				$44,010	$220,100
15			$10,550	$162,200	$3,290				$44,010	$220,100
16			$10,550	$162,200	$3,290				$44,010	$220,100
17			$10,550	$162,200	$3,290				$44,010	$220,100
18			$10,550	$162,200	$3,290				$44,010	$220,100
19			$10,550	$162,200	$3,290				$44,010	$220,100
20			$10,550	$162,200	$3,290				$44,010	$220,100
21			$10,550	$162,200	$3,290				$44,010	$220,100
22			$10,550	$162,200	$3,290				$44,010	$220,100
23			$10,550	$162,200	$3,290				$44,010	$220,100
24			$10,550	$162,200	$3,290				$44,010	$220,100
25			$10,550	$162,200	$3,290				$44,010	$220,100
26			$10,550	$162,200	$3,290				$44,010	$220,100
27			$10,550	$162,200	$3,290				$44,010	$220,100
28			$10,550	$162,200	$3,290				$44,010	$220,100
29			$10,550	$162,200	$3,290				$44,010	$220,100
30			$10,550	$162,200	$3,290				$44,010	$220,100
31			$10,550	$162,200	$3,290				$44,010	$220,100
32			$10,550	$162,200	$3,290				$44,010	$220,100
33			$10,550	$162,200	$3,290				$44,010	$220,100
34			$10,550	$162,200	$3,290				$44,010	$220,100
35			$10,550	$162,200	$3,290				$44,010	$220,100
36			$10,550	$162,200	$3,290				$44,010	$220,100
37			$10,550	$162,200	$3,290				$44,010	$220,100
38			$10,550	$162,200	$3,290				$44,010	$220,100
39			$10,550	$162,200	$3,290				$44,010	$220,100
40			$10,550	$162,200	$3,290				$44,010	$220,100
41			$10,550	$162,200	$3,290				$44,010	$220,100
42			$10,550	$162,200	$3,290				$44,010	$220,100
43			$10,550	$162,200	$3,290				$44,010	$220,100
44			$10,550	$162,200	$3,290				$44,010	$220,100
45			$10,550	$162,200	$3,290				$44,010	$220,100
46			$10,550	$162,200	$3,290				$44,010	$220,100
47			$10,550	$162,200	$3,290				$44,010	$220,100
48			$10,550	$162,200	$3,290				$44,010	$220,100
49			$10,550	$162,200	$3,290				$44,010	$220,100
50			$10,550	$162,200	$3,290				$44,010	$220,100
51			$10,550	$162,200	$3,290				$44,010	$220,100
52			$10,550	$162,200	$3,290				$44,010	$220,100
53			$10,550	$162,200	$3,290				$44,010	$220,100
54			$10,550	$162,200	$3,290				$44,010	$220,100
55			$10,550	$162,200	$3,290				$44,010	$220,100
56			$10,550	$162,200	$3,290				$44,010	$220,100
57			$10,550	$162,200	$3,290				$44,010	$220,100
58			$10,550	$162,200	$3,290				$44,010	$220,100
59			$10,550	$162,200	$3,290				$44,010	$220,100
60			$10,550	$162,200	$3,290				$44,010	$220,100
61			$10,550	$162,200	$3,290				$44,010	$220,100
62			$10,550	$162,200	$3,290				$44,010	$220,100
63			$10,550	$162,200	$3,290				$44,010	$220,100
64			$10,550	$162,200	$3,290				$44,010	$220,100
65			$10,550	$162,200	$3,290				$44,010	$220,100
66			$10,550	$162,200	$3,290				$44,010	$220,100
67			$10,550	$162,200	$3,290				$44,010	$220,100
68			$10,550	$162,200	$3,290				$44,010	$220,100
69			$10,550	$162,200	$3,290				$44,010	$220,100
70			$10,550	$162,200	$3,290				$44,010	$220,100
71			$10,550	$162,200	$3,290				$44,010	$220,100
72			$10,550	$162,200	$3,290				$44,010	$220,100
73			$10,550	$162,200	$3,290				$44,010	$220,100
74			$10,550	$162,200	$3,290				$44,010	$220,100
75			$10,550	$162,200	$3,290				$44,010	$220,100
76			$10,550	$162,200	$3,290				$44,010	$220,100
77			$10,550	$162,200	$3,290				$44,010	$220,100
78			$10,550	$162,200	$3,290				$44,010	$220,100
79			$10,550	$162,200	$3,290				$44,010	$220,100
80			$10,550	$162,200	$3,290				$44,010	$220,100
81			$10,550	$162,200	$3,290				$44,010	$220,100
82			$10,550	$162,200	$3,290				$44,010	$220,100
83			$10,550	$162,200	$3,290				$44,010	$220,100
84			$10,550	$162,200	$3,290				$44,010	$220,100
85			$10,550	$162,200	$3,290				$44,010	$220,100
86			$10,550	$162,200	$3,290				$44,010	$220,100
87			$10,550	$162,200	$3,290				$44,010	$220,100
88			$10,550	$162,200	$3,290				$44,010	$220,100
89			$10,550	$162,200	$3,290				$44,010	$220,100
90			$10,550	$162,200	$3,290				$44,010	$220,100
91			$10,550	$162,200	$3,290				$44,010	$220,100
92			$10,550	$162,200	$3,290				$44,010	$220,100
93			$10,550	$162,200	$3,290				$44,010	$220,100
94			$10,550	$162,200	$3,290				$44,010	$220,100
95			$10,550	$162,200	$3,290				$44,010	$220,100
96			$10,550	$162,200	$3,290				$44,010	$220,100
97			$10,550	$162,200	$3,290				$44,010	$220,100
98			$10,550	$162,200	$3,290				$44,010	$220,100
99			$10,550	$162,200	$3,290				$44,010	$220,100
TOTAL	$2,336,100	$159,700	$1,164,500	$16,057,800	$325,700	$1,016,400	$100,800	$4,777,500	$6,484,600	$32,427,600

Net Discount rate: 2.5%

NPV $16,870,900

TABLE A-48

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-5 (HIGH)

PSC Georgetown Facility

Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 6 Wells, 2 at 30' bgs, 2 at 50' bgs, 2 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 **Dewatering and Soil Vapor Extraction System (3 extra ext. wells)**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower, 50 gpm	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
1000 SCFM, Vapor Recovery System	EA	$27,034	1	$27,000	2005 RSMeans Environmental p 9-154; 33 13 2361
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Carbon Assorption	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	140	$5,500	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 SVE wells at 25' bgs, 4 SVE wells at 10' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	40	$1,000	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 8 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	100	$3,600	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 4 wells, 5' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	8	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	8	$1,400	2005 RSMeans Environmental p 9-246; 33 23 1702
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$248,100**	
4 **Steam Injection**					
Similar Case Study Overall Costs	CY	$650	61,834	NA	Based on reported range of costs for published applications.
Task 4 Total				**NA**	
5 **ISB Pilot Study**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	3	$2,400	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,950	$2,000	Price from similar job
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 5 Total				**$54,200**	
6 **ISB Full-Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p. 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 6 Total				**$137,600**	
Subtotal				$457,500	
Professional Technical Services					
Permitting	%	7%	$457,500	$32,000	Geomatrix standard rate
Engineering Design Costs	%	12%	$457,500	$54,900	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$457,500	$36,600	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$457,500	$27,500	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$151,000	
TOTAL INITIAL IMPLEMENTATION COST				**$608,500**	

Notes:

1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt
6. The Cost for Steam injection was noted in NPV estimates 2 years after decomissioning of the SVE system to account for O&M

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TABLE A-49

RECURRING COSTS FOR ALTERNATIVE HA-5 (HIGH)
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (12 TOTAL YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**ANNUAL REPLACEMENT COSTS (12 TOTAL YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
5	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Molassess	lbs	$1	48750	$48,750	Price from similar job
	Recirculation/Injection Labor	day	$1,600	13	$20,800	2 engineers/scientists, $100/hour
	Subtotal				**$69,550**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
8	**SEMI ANNUAL ISB MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
9	**PROJECT MANAGEMENT (12 TOTAL YEARS)**					
	Project Management	per year	$20,000	1	$20,000	Price from similar job
	Subtotal				**$20,000**	
10	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
11	**PROPERTY OPPORTUNITY COST (19 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-50

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NET PRESENT VALUE FOR ALTERNATIVE HA-5 (HIGH)

PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Injection Costs	Semi-Annual ISB Monitoring	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	SVE / Dewatering System Monitoring	Steam Injection Costs	Property Opportunity Cost	25% Contingency	Yearly Total
0	$608,500								$367,500	$244,000	$1,220,000
1			$20,550	$162,200	$3,290				$367,500	$138,385	$691,900
2			$20,550	$162,200	$3,290	$169,400	$16,800		$367,500	$184,935	$924,700
3			$20,550	$162,200	$3,290	$169,400	$16,800		$367,500	$184,935	$924,700
4			$20,550	$162,200	$3,290	$169,400	$16,800		$367,500	$184,935	$924,700
5			$20,550	$162,200	$3,290	$169,400	$16,800		$367,500	$184,935	$924,700
6			$20,550	$162,200	$3,290	$169,400	$16,800		$367,500	$184,935	$924,700
7			$20,550	$162,200	$3,290	$169,400	$16,800		$367,500	$184,935	$924,700
8			$550						$367,500	$92,013	$460,100
9			$550					$40,192,100	$367,500	$10,140,038	$50,700,200
10			$550						$367,500	$92,013	$460,100
11			$550						$367,500	$92,013	$460,100
12			$550						$367,500	$92,013	$460,100
13			$550	$162,200	$3,290				$367,500	$133,385	$666,900
14			$550	$162,200	$3,290				$367,500	$133,385	$666,900
15	$69,550	$26,620	$20,550	$162,200	$3,290				$367,500	$162,428	$812,100
16	$69,550	$26,620	$20,550	$162,200	$3,290				$367,500	$162,428	$812,100
17	$69,550	$26,620	$20,550	$162,200	$3,290				$367,500	$162,428	$812,100
18	$69,550	$26,620	$20,550	$162,200	$3,290				$367,500	$162,428	$812,100
19		$26,620	$20,550	$162,200	$3,290				$367,500	$145,040	$725,200
20		$26,620	$20,550	$162,200	$3,290				$367,500	$145,040	$725,200
21			$10,550	$162,200	$3,290					$44,010	$220,100
22			$10,550	$162,200	$3,290					$44,010	$220,100
23			$10,550	$162,200	$3,290					$44,010	$220,100
24			$10,550	$162,200	$3,290					$44,010	$220,100
25			$10,550	$162,200	$3,290					$44,010	$220,100
26			$10,550	$162,200	$3,290					$44,010	$220,100
27			$10,550	$162,200	$3,290					$44,010	$220,100
28			$10,550	$162,200	$3,290					$44,010	$220,100
29			$10,550	$162,200	$3,290					$44,010	$220,100
30			$10,550	$162,200	$3,290					$44,010	$220,100
31			$10,550	$162,200	$3,290					$44,010	$220,100
32			$10,550	$162,200	$3,290					$44,010	$220,100
33			$10,550	$162,200	$3,290					$44,010	$220,100
34			$10,550	$162,200	$3,290					$44,010	$220,100
35			$10,550	$162,200	$3,290					$44,010	$220,100
36			$10,550	$162,200	$3,290					$44,010	$220,100
37			$10,550	$162,200	$3,290					$44,010	$220,100
38			$10,550	$162,200	$3,290					$44,010	$220,100
39			$10,550	$162,200	$3,290					$44,010	$220,100
40			$10,550	$162,200	$3,290					$44,010	$220,100
41			$10,550	$162,200	$3,290					$44,010	$220,100
42			$10,550	$162,200	$3,290					$44,010	$220,100
43			$10,550	$162,200	$3,290					$44,010	$220,100
44			$10,550	$162,200	$3,290					$44,010	$220,100
45			$10,550	$162,200	$3,290					$44,010	$220,100
46			$10,550	$162,200	$3,290					$44,010	$220,100
47			$10,550	$162,200	$3,290					$44,010	$220,100
48			$10,550	$162,200	$3,290					$44,010	$220,100
49			$10,550	$162,200	$3,290					$44,010	$220,100
50			$10,550	$162,200	$3,290					$44,010	$220,100
51			$10,550	$162,200	$3,290					$44,010	$220,100
52			$10,550	$162,200	$3,290					$44,010	$220,100
53			$10,550	$162,200	$3,290					$44,010	$220,100
54			$10,550	$162,200	$3,290					$44,010	$220,100
55			$10,550	$162,200	$3,290					$44,010	$220,100
56			$10,550	$162,200	$3,290					$44,010	$220,100
57			$10,550	$162,200	$3,290					$44,010	$220,100
58			$10,550	$162,200	$3,290					$44,010	$220,100
59			$10,550	$162,200	$3,290					$44,010	$220,100
60			$10,550	$162,200	$3,290					$44,010	$220,100
61			$10,550	$162,200	$3,290					$44,010	$220,100
62			$10,550	$162,200	$3,290					$44,010	$220,100
63			$10,550	$162,200	$3,290					$44,010	$220,100
64			$10,550	$162,200	$3,290					$44,010	$220,100
65			$10,550	$162,200	$3,290					$44,010	$220,100
66			$10,550	$162,200	$3,290					$44,010	$220,100
67			$10,550	$162,200	$3,290					$44,010	$220,100
68			$10,550	$162,200	$3,290					$44,010	$220,100
69			$10,550	$162,200	$3,290					$44,010	$220,100
70			$10,550	$162,200	$3,290					$44,010	$220,100
71			$10,550	$162,200	$3,290					$44,010	$220,100
72			$10,550	$162,200	$3,290					$44,010	$220,100
73			$10,550	$162,200	$3,290					$44,010	$220,100
74			$10,550	$162,200	$3,290					$44,010	$220,100
75			$10,550	$162,200	$3,290					$44,010	$220,100
76			$10,550	$162,200	$3,290					$44,010	$220,100
77			$10,550	$162,200	$3,290					$44,010	$220,100
78			$10,550	$162,200	$3,290					$44,010	$220,100
79			$10,550	$162,200	$3,290					$44,010	$220,100
80			$10,550	$162,200	$3,290					$44,010	$220,100
81			$10,550	$162,200	$3,290					$44,010	$220,100
82			$10,550	$162,200	$3,290					$44,010	$220,100
83			$10,550	$162,200	$3,290					$44,010	$220,100
84			$10,550	$162,200	$3,290					$44,010	$220,100
85			$10,550	$162,200	$3,290					$44,010	$220,100
86			$10,550	$162,200	$3,290					$44,010	$220,100
87			$10,550	$162,200	$3,290					$44,010	$220,100
88			$10,550	$162,200	$3,290					$44,010	$220,100
89			$10,550	$162,200	$3,290					$44,010	$220,100
90			$10,550	$162,200	$3,290					$44,010	$220,100
91			$10,550	$162,200	$3,290					$44,010	$220,100
92			$10,550	$162,200	$3,290					$44,010	$220,100
93			$10,550	$162,200	$3,290					$44,010	$220,100
94			$10,550	$162,200	$3,290					$44,010	$220,100
95			$10,550	$162,200	$3,290					$44,010	$220,100
96			$10,550	$162,200	$3,290					$44,010	$220,100
97			$10,550	$162,200	$3,290					$44,010	$220,100
98			$10,550	$162,200	$3,290					$44,010	$220,100
99			$10,550	$162,200	$3,290					$44,010	$220,100
TOTAL	$886,700	$159,700	$1,104,500	$15,246,800	$309,300	$1,016,400	$100,800	$40,192,100	$7,717,500	$16,683,400	$83,421,200

Net Discount rate: 2.5%

NPV $56,111,400

TABLE A-51

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-6 (HIGH)
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 6 Wells, 2 at 30' bgs, 2 at 50' bgs, 2 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 **Dewatering and Soil Vapor Extraction System (3 extra ext. wells)**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower, 50 gpm	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
1000 SCFM, Vapor Recovery System	EA	$27,034	1	$27,000	2005 RSMeans Environmental p 9-154; 33 13 2361
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Carbon Assorption	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	140	$5,500	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 SVE wells at 25' bgs, 4 SVE wells at 10' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	40	$1,000	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 8 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	100	$3,600	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 4 wells, 5' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	8	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	8	$1,400	2005 RSMeans Environmental p 9-246; 33 23 1702
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$248,100**	
4 **Steam Injection**					
Similar Case Study Overall Costs	CY	$650	61,834	NA	Based on reported range of costs for published applications.
Task 4 Total				**NA**	
5 **Excavation and Disposal**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
Track Mounted Excavator, 1 C.Y. bucket, +15% for loading onto trucks	BCY	$3	3,300	$9,500	2007 RSMeans Building Construction p. 528; 31 23 16.42 0200
Tanker Trailer Transport, Hazardous Waste	MI	$3	70,500	$211,500	2005 RSMeans Environmental p. 9-178; 33 190254; 3000 tons, 16.5 tons/truck, 260 miles to Arlington, OR
Landfill Hazardous Solid Bulk Waste	TON	$163	4,500	$732,600	2005 RSMeans Environmental p. 9-204; 33 19 72641
Confirmation Soil Sampling	day	$800	3	$2,400	1 engineer/scientist, Geomatrix standard rate
Analytical on Soil Samples	Lump Sum	$2,000	1	$2,000	Price from similar job
Clean Fill, Delivered	TON	$15	5,625	$84,400	Price from similar job
Dozer Backfilling, compacting in 6" to 12" lifts with Vibratory Compactor	ECY	$3	3,300	$8,700	2007 RSMeans Building Construction p. 532; 31 23 23.13 1600
Asphalt Paving	SY	$10	987	$9,900	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	15	$12,000	1 engineer/scientist, Geomatrix standard rate
Task 6 Total				**$1,083,000**	
Subtotal				$1,348,700	
Professional Technical Services					
Permitting	%	7%	$1,348,700	$94,400	Geomatrix standard rate
Engineering Design Costs	%	12%	$1,348,700	$161,800	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$1,348,700	$107,900	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$1,348,700	$80,900	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$445,000	
TOTAL INITIAL IMPLEMENTATION COST				**$1,793,700**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

TABLE A-52

RECURRING COSTS FOR ALTERNATIVE HA-6 (HIGH)
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**DEWATERING ANNUAL COSTS INCLUDING O&M (5 YEARS AFTER STEAM)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$36,000	1	$36,000	Current System Costs x 3 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$186,200**	
5	**ANNUAL REPLACEMENT COSTS**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
7	**SEMI-ANNUAL MONITORING (15 YEARS DURING GW EXTRACTION/REINJECTION)**					
	Sampling Labor	day	$1,600	4	$6,400	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	32	$9,120	ARI
	Analysis - Metals	per well	$290	32	$9,280	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$44,800**	
8	**PROJECT MANAGEMENT**					
	Project Management	per year	$25,000	1	$25,000	Price from similar job
	Subtotal				**$25,000**	
9	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
10	**PROPERTY OPPORTUNITY COST (16 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-53

NET PRESENT VALUE FOR ALTERNATIVE HA-6 (HIGH)

PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Injection Costs	Inspection & Project Management	System Annual Costs Including	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	Dewatering System Monitoring	Steam Injection Costs	Semi-Annual Monitoring (5 years after Steam Injection)	Dewatering Annual Costs Including O&M	Property Opportunity Cost	25% Contingency	Yearly Total
0	$1,793,700									$367,500	$540,300	$2,701,500
1		$25,550	$162,200	$3,290						$367,500	$139,600	$698,100
2		$25,550	$162,200	$3,290	$169,400	$16,800				$367,500	$186,200	$930,900
3		$25,550	$162,200	$3,290	$169,400	$16,800		$44,800		$367,500	$197,400	$986,900
4		$25,550	$162,200	$3,290	$169,400	$16,800		$44,800		$367,500	$197,400	$986,900
5		$25,550	$162,200	$3,290	$169,400	$16,800		$44,800		$367,500	$197,400	$986,900
6		$25,550	$162,200	$3,290	$169,400	$16,800		$44,800		$367,500	$197,400	$986,900
7		$25,550	$162,200	$3,290	$169,400	$16,800		$44,800		$367,500	$197,400	$986,900
8		$550						$44,800		$367,500	$103,200	$516,100
9		$550					$40,192,100	$44,800		$367,500	$10,151,200	$50,756,200
10		$550						$44,800		$367,500	$103,200	$516,100
11		$550						$44,800		$367,500	$103,200	$516,100
12		$550						$44,800		$367,500	$103,200	$516,100
13		$25,550		$3,290				$44,800	$186,200	$367,500	$156,800	$784,100
14		$25,550		$3,290				$44,800	$186,200	$367,500	$156,800	$784,100
15		$25,550		$3,290				$44,800	$186,200	$367,500	$156,800	$784,100
16		$25,550		$3,290				$44,800	$186,200	$367,500	$156,800	$784,100
17		$25,550		$3,290				$44,800	$186,200	$367,500	$156,800	$784,100
18		$10,550	$162,200	$3,290							$44,000	$220,000
19		$10,550	$162,200	$3,290							$44,000	$220,000
20		$10,550	$162,200	$3,290							$44,000	$220,000
21		$10,550	$162,200	$3,290							$44,000	$220,000
22		$10,550	$162,200	$3,290							$44,000	$220,000
23		$10,550	$162,200	$3,290							$44,000	$220,000
24		$10,550	$162,200	$3,290							$44,000	$220,000
25		$10,550	$162,200	$3,290							$44,000	$220,000
26		$10,550	$162,200	$3,290							$44,000	$220,000
27		$10,550	$162,200	$3,290							$44,000	$220,000
28		$10,550	$162,200	$3,290							$44,000	$220,000
29		$10,550	$162,200	$3,290							$44,000	$220,000
30		$10,550	$162,200	$3,290							$44,000	$220,000
31		$10,550	$162,200	$3,290							$44,000	$220,000
32		$10,550	$162,200	$3,290							$44,000	$220,000
33		$10,550	$162,200	$3,290							$44,000	$220,000
34		$10,550	$162,200	$3,290							$44,000	$220,000
35		$10,550	$162,200	$3,290							$44,000	$220,000
36		$10,550	$162,200	$3,290							$44,000	$220,000
37		$10,550	$162,200	$3,290							$44,000	$220,000
38		$10,550	$162,200	$3,290							$44,000	$220,000
39		$10,550	$162,200	$3,290							$44,000	$220,000
40		$10,550	$162,200	$3,290							$44,000	$220,000
41		$10,550	$162,200	$3,290							$44,000	$220,000
42		$10,550	$162,200	$3,290							$44,000	$220,000
43		$10,550	$162,200	$3,290							$44,000	$220,000
44		$10,550	$162,200	$3,290							$44,000	$220,000
45		$10,550	$162,200	$3,290							$44,000	$220,000
46		$10,550	$162,200	$3,290							$44,000	$220,000
47		$10,550	$162,200	$3,290							$44,000	$220,000
48		$10,550	$162,200	$3,290							$44,000	$220,000
49		$10,550	$162,200	$3,290							$44,000	$220,000
50		$10,550	$162,200	$3,290							$44,000	$220,000
51		$10,550	$162,200	$3,290							$44,000	$220,000
52		$10,550	$162,200	$3,290							$44,000	$220,000
53		$10,550	$162,200	$3,290							$44,000	$220,000
54		$10,550	$162,200	$3,290							$44,000	$220,000
55		$10,550	$162,200	$3,290							$44,000	$220,000
56		$10,550	$162,200	$3,290							$44,000	$220,000
57		$10,550	$162,200	$3,290							$44,000	$220,000
58		$10,550	$162,200	$3,290							$44,000	$220,000
59		$10,550	$162,200	$3,290							$44,000	$220,000
60		$10,550	$162,200	$3,290							$44,000	$220,000
61		$10,550	$162,200	$3,290							$44,000	$220,000
62		$10,550	$162,200	$3,290							$44,000	$220,000
63		$10,550	$162,200	$3,290							$44,000	$220,000
64		$10,550	$162,200	$3,290							$44,000	$220,000
65		$10,550	$162,200	$3,290							$44,000	$220,000
66		$10,550	$162,200	$3,290							$44,000	$220,000
67		$10,550	$162,200	$3,290							$44,000	$220,000
68		$10,550	$162,200	$3,290							$44,000	$220,000
69		$10,550	$162,200	$3,290							$44,000	$220,000
70		$10,550	$162,200	$3,290							$44,000	$220,000
71		$10,550	$162,200	$3,290							$44,000	$220,000
72		$10,550	$162,200	$3,290							$44,000	$220,000
73		$10,550	$162,200	$3,290							$44,000	$220,000
74		$10,550	$162,200	$3,290							$44,000	$220,000
75		$10,550	$162,200	$3,290							$44,000	$220,000
76		$10,550	$162,200	$3,290							$44,000	$220,000
77		$10,550	$162,200	$3,290							$44,000	$220,000
78		$10,550	$162,200	$3,290							$44,000	$220,000
79		$10,550	$162,200	$3,290							$44,000	$220,000
80		$10,550	$162,200	$3,290							$44,000	$220,000
81		$10,550	$162,200	$3,290							$44,000	$220,000
82		$10,550	$162,200	$3,290							$44,000	$220,000
83		$10,550	$162,200	$3,290							$44,000	$220,000
84		$10,550	$162,200	$3,290							$44,000	$220,000
85		$10,550	$162,200	$3,290							$44,000	$220,000
86		$10,550	$162,200	$3,290							$44,000	$220,000
87		$10,550	$162,200	$3,290							$44,000	$220,000
88		$10,550	$162,200	$3,290							$44,000	$220,000
89		$10,550	$162,200	$3,290							$44,000	$220,000
90		$10,550	$162,200	$3,290							$44,000	$220,000
91		$10,550	$162,200	$3,290							$44,000	$220,000
92		$10,550	$162,200	$3,290							$44,000	$220,000
93		$10,550	$162,200	$3,290							$44,000	$220,000
94		$10,550	$162,200	$3,290							$44,000	$220,000
95		$10,550	$162,200	$3,290							$44,000	$220,000
96		$10,550	$162,200	$3,290							$44,000	$220,000
97		$10,550	$162,200	$3,290							$44,000	$220,000
98		$10,550	$162,200	$3,290							$44,000	$220,000
99		$10,550	$162,200	$3,290							$44,000	$220,000
TOTAL	$1,793,700	$1,174,500	$14,435,800	$309,300	$1,016,400	$100,800	$40,192,100	$672,000	$931,000	$6,615,000	$16,809,100	$84,046,100

Net Discount rate: 2.5%

NPV $57,177,400

J:\8770.000 PSC GT\048\Appendix A\Rev SWFS Cost Estimate-ver-05.2(High)

TABLE A-54

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-1 (LOW)

PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **CAP CONSTRUCTION**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction Cost Data p. 24; 02 21 13.09 0020
Subtotal				**$5,100**	
Professional Technical Services					
Permitting	%	7%	$5,100	$400	Geomatrix standard rate
Engineering Design Costs	%	20%	$5,100	$1,000	from EPA, 2000, Exh. 5-8
Construction Management	%	15%	$5,100	$800	from EPA, 2000, Exh. 5-8
Project Management	%	10%	$5,100	$500	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$2,700	
TOTAL INITIAL IMPLEMENTATION COST				**$7,800**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

Geomatrix

TABLE A-55

RECURRING COSTS FOR ALTERNATIVE HA-1 (LOW)

PSC Georgetown Facility

Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
3	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$31	13	$400	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$2,970**	
4	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	

Notes:

1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-56

NET PRESENT VALUE FOR ALTERNATIVE HA-1 (LOW)
PSC Georgetown Facility
Seattle, Washington

Year	Implementation Cost	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	15% Contingency	Yearly Total
0	$7,800				$1,170	$9,000
1		$10,550	$162,200	$2,970	$26,358	$202,100
2		$10,550	$162,200	$2,970	$26,358	$202,100
3		$10,550	$162,200	$2,970	$26,358	$202,100
4		$10,550	$162,200	$2,970	$26,358	$202,100
5		$10,550	$162,200	$2,970	$26,358	$202,100
6		$10,550	$162,200	$2,970	$26,358	$202,100
7		$10,550	$162,200	$2,970	$26,358	$202,100
8		$10,550	$162,200	$2,970	$26,358	$202,100
9		$10,550	$162,200	$2,970	$26,358	$202,100
10		$10,550	$162,200	$2,970	$26,358	$202,100
11		$10,550	$162,200	$2,970	$26,358	$202,100
12		$10,550	$162,200	$2,970	$26,358	$202,100
13		$10,550	$162,200	$2,970	$26,358	$202,100
14		$10,550	$162,200	$2,970	$26,358	$202,100
15		$10,550	$162,200	$2,970	$26,358	$202,100
16		$10,550	$162,200	$2,970	$26,358	$202,100
17		$10,550	$162,200	$2,970	$26,358	$202,100
18		$10,550	$162,200	$2,970	$26,358	$202,100
19		$10,550	$162,200	$2,970	$26,358	$202,100
20		$10,550	$162,200	$2,970	$26,358	$202,100
21		$10,550	$162,200	$2,970	$26,358	$202,100
22		$10,550	$162,200	$2,970	$26,358	$202,100
23		$10,550	$162,200	$2,970	$26,358	$202,100
24		$10,550	$162,200	$2,970	$26,358	$202,100
25		$10,550	$162,200	$2,970	$26,358	$202,100
26		$10,550	$162,200	$2,970	$26,358	$202,100
27		$10,550	$162,200	$2,970	$26,358	$202,100
28		$10,550	$162,200	$2,970	$26,358	$202,100
29		$10,550	$162,200	$2,970	$26,358	$202,100
30		$10,550	$162,200	$2,970	$26,358	$202,100
31		$10,550	$162,200	$2,970	$26,358	$202,100
32		$10,550	$162,200	$2,970	$26,358	$202,100
33		$10,550	$162,200	$2,970	$26,358	$202,100
34		$10,550	$162,200	$2,970	$26,358	$202,100
35		$10,550	$162,200	$2,970	$26,358	$202,100
36		$10,550	$162,200	$2,970	$26,358	$202,100
37		$10,550	$162,200	$2,970	$26,358	$202,100
38		$10,550	$162,200	$2,970	$26,358	$202,100
39		$10,550	$162,200	$2,970	$26,358	$202,100
40		$10,550	$162,200	$2,970	$26,358	$202,100
41		$10,550	$162,200	$2,970	$26,358	$202,100
42		$10,550	$162,200	$2,970	$26,358	$202,100
43		$10,550	$162,200	$2,970	$26,358	$202,100
44		$10,550	$162,200	$2,970	$26,358	$202,100
45		$10,550	$162,200	$2,970	$26,358	$202,100
46		$10,550	$162,200	$2,970	$26,358	$202,100
47		$10,550	$162,200	$2,970	$26,358	$202,100
48		$10,550	$162,200	$2,970	$26,358	$202,100
49		$10,550	$162,200	$2,970	$26,358	$202,100
50		$10,550	$162,200	$2,970	$26,358	$202,100
51		$10,550	$162,200	$2,970	$26,358	$202,100
52		$10,550	$162,200	$2,970	$26,358	$202,100
53		$10,550	$162,200	$2,970	$26,358	$202,100
54		$10,550	$162,200	$2,970	$26,358	$202,100
55		$10,550	$162,200	$2,970	$26,358	$202,100
56		$10,550	$162,200	$2,970	$26,358	$202,100
57		$10,550	$162,200	$2,970	$26,358	$202,100
58		$10,550	$162,200	$2,970	$26,358	$202,100
59		$10,550	$162,200	$2,970	$26,358	$202,100
60		$10,550	$162,200	$2,970	$26,358	$202,100
61		$10,550	$162,200	$2,970	$26,358	$202,100
62		$10,550	$162,200	$2,970	$26,358	$202,100
63		$10,550	$162,200	$2,970	$26,358	$202,100
64		$10,550	$162,200	$2,970	$26,358	$202,100
65		$10,550	$162,200	$2,970	$26,358	$202,100
66		$10,550	$162,200	$2,970	$26,358	$202,100
67		$10,550	$162,200	$2,970	$26,358	$202,100
68		$10,550	$162,200	$2,970	$26,358	$202,100
69		$10,550	$162,200	$2,970	$26,358	$202,100
70		$10,550	$162,200	$2,970	$26,358	$202,100
71		$10,550	$162,200	$2,970	$26,358	$202,100
72		$10,550	$162,200	$2,970	$26,358	$202,100
73		$10,550	$162,200	$2,970	$26,358	$202,100
74		$10,550	$162,200	$2,970	$26,358	$202,100
75		$10,550	$162,200	$2,970	$26,358	$202,100
76		$10,550	$162,200	$2,970	$26,358	$202,100
77		$10,550	$162,200	$2,970	$26,358	$202,100
78		$10,550	$162,200	$2,970	$26,358	$202,100
79		$10,550	$162,200	$2,970	$26,358	$202,100
80		$10,550	$162,200	$2,970	$26,358	$202,100
81		$10,550	$162,200	$2,970	$26,358	$202,100
82		$10,550	$162,200	$2,970	$26,358	$202,100
83		$10,550	$162,200	$2,970	$26,358	$202,100
84		$10,550	$162,200	$2,970	$26,358	$202,100
85		$10,550	$162,200	$2,970	$26,358	$202,100
86		$10,550	$162,200	$2,970	$26,358	$202,100
87		$10,550	$162,200	$2,970	$26,358	$202,100
88		$10,550	$162,200	$2,970	$26,358	$202,100
89		$10,550	$162,200	$2,970	$26,358	$202,100
90		$10,550	$162,200	$2,970	$26,358	$202,100
91		$10,550	$162,200	$2,970	$26,358	$202,100
92		$10,550	$162,200	$2,970	$26,358	$202,100
93		$10,550	$162,200	$2,970	$26,358	$202,100
94		$10,550	$162,200	$2,970	$26,358	$202,100
95		$10,550	$162,200	$2,970	$26,358	$202,100
96		$10,550	$162,200	$2,970	$26,358	$202,100
97		$10,550	$162,200	$2,970	$26,358	$202,100
98		$10,550	$162,200	$2,970	$26,358	$202,100
99		$10,550	$162,200	$2,970	$26,358	$202,100
TOTAL	$7,800	$1,044,500	$16,057,800	$294,000	$2,610,600	$20,016,900

Net Discount rate: 2.5% **NPV** **$7,211,300**

TABLE A-57

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-2 (LOW)
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 4 Wells, 2 at 30' bgs, 2 at 50' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 **Pilot Study**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	3	$2,400	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,950	$2,000	Price from similar job
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 3 Total				**$54,200**	
4 **Full-Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 4 Total				**$137,600**	
Subtotal				$209,400	
Professional Technical Services					
Permitting	%	7%	$209,400	$14,700	Geomatrix standard rate
Engineering Design Costs	%	12%	$209,400	$25,100	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$209,400	$16,800	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$209,400	$12,600	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$69,200	
TOTAL INITIAL IMPLEMENTATION COST				**$278,600**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

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TABLE A-58

RECURRING COSTS FOR ALTERNATIVE HA-2 (LOW)

PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
3	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
4	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Molassess	lbs	$1	29250	$29,250	Price from similar job
	Recirculation/Injection Labor	day	$1,600	8	$12,800	2 engineers/scientists, $100/hour
	Subtotal				**$42,050**	
6	**SEMI ANNUAL ISB MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
7	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	per year	$15,000	1	$15,000	Price from similar job
	Subtotal				**$15,000**	
8	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
9	**PROPERTY OPPORTUNITY COST (5 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-59

NET PRESENT VALUE FOR ALTERNATIVE HA-2 (LOW)

PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Semi-Annual Injection	Semi-Annual ISB Monitoring	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	Property Opportunity Cost	25% Contingency	Yearly Total
0	$278,600					$367,500	$161,525	$646,100
1	$42,050	$26,620	$15,550	$162,200	$3,290	$367,500	$154,303	$617,200
2	$42,050	$26,620	$15,550	$162,200	$3,290	$367,500	$154,303	$617,200
3	$42,050	$26,620	$15,550	$162,200	$3,290	$367,500	$154,303	$617,200
4	$42,050	$26,620	$15,550	$162,200	$3,290	$367,500	$154,303	$617,200
5		$26,620	$15,550	$162,200	$3,290	$367,500	$143,790	$575,200
6		$26,620	$15,550	$162,200	$3,290	$367,500	$143,790	$575,200
7			$10,550	$162,200	$3,290		$44,010	$176,000
8			$10,550	$162,200	$3,290		$44,010	$176,000
9			$10,550	$162,200	$3,290		$44,010	$176,000
10			$10,550	$162,200	$3,290		$44,010	$176,000
11			$10,550	$162,200	$3,290		$44,010	$176,000
12			$10,550	$162,200	$3,290		$44,010	$176,000
13			$10,550	$162,200	$3,290		$44,010	$176,000
14			$10,550	$162,200	$3,290		$44,010	$176,000
15			$10,550	$162,200	$3,290		$44,010	$176,000
16			$10,550	$162,200	$3,290		$44,010	$176,000
17			$10,550	$162,200	$3,290		$44,010	$176,000
18			$10,550	$162,200	$3,290		$44,010	$176,000
19			$10,550	$162,200	$3,290		$44,010	$176,000
20			$10,550	$162,200	$3,290		$44,010	$176,000
21			$10,550	$162,200	$3,290		$44,010	$176,000
22			$10,550	$162,200	$3,290		$44,010	$176,000
23			$10,550	$162,200	$3,290		$44,010	$176,000
24			$10,550	$162,200	$3,290		$44,010	$176,000
25			$10,550	$162,200	$3,290		$44,010	$176,000
26			$10,550	$162,200	$3,290		$44,010	$176,000
27			$10,550	$162,200	$3,290		$44,010	$176,000
28			$10,550	$162,200	$3,290		$44,010	$176,000
29			$10,550	$162,200	$3,290		$44,010	$176,000
30			$10,550	$162,200	$3,290		$44,010	$176,000
31			$10,550	$162,200	$3,290		$44,010	$176,000
32			$10,550	$162,200	$3,290		$44,010	$176,000
33			$10,550	$162,200	$3,290		$44,010	$176,000
34			$10,550	$162,200	$3,290		$44,010	$176,000
35			$10,550	$162,200	$3,290		$44,010	$176,000
36			$10,550	$162,200	$3,290		$44,010	$176,000
37			$10,550	$162,200	$3,290		$44,010	$176,000
38			$10,550	$162,200	$3,290		$44,010	$176,000
39			$10,550	$162,200	$3,290		$44,010	$176,000
40			$10,550	$162,200	$3,290		$44,010	$176,000
41			$10,550	$162,200	$3,290		$44,010	$176,000
42			$10,550	$162,200	$3,290		$44,010	$176,000
43			$10,550	$162,200	$3,290		$44,010	$176,000
44			$10,550	$162,200	$3,290		$44,010	$176,000
45			$10,550	$162,200	$3,290		$44,010	$176,000
46			$10,550	$162,200	$3,290		$44,010	$176,000
47			$10,550	$162,200	$3,290		$44,010	$176,000
48			$10,550	$162,200	$3,290		$44,010	$176,000
49			$10,550	$162,200	$3,290		$44,010	$176,000
50			$10,550	$162,200	$3,290		$44,010	$176,000
51			$10,550	$162,200	$3,290		$44,010	$176,000
52			$10,550	$162,200	$3,290		$44,010	$176,000
53			$10,550	$162,200	$3,290		$44,010	$176,000
54			$10,550	$162,200	$3,290		$44,010	$176,000
55			$10,550	$162,200	$3,290		$44,010	$176,000
56			$10,550	$162,200	$3,290		$44,010	$176,000
57			$10,550	$162,200	$3,290		$44,010	$176,000
58			$10,550	$162,200	$3,290		$44,010	$176,000
59			$10,550	$162,200	$3,290		$44,010	$176,000
60			$10,550	$162,200	$3,290		$44,010	$176,000
61			$10,550	$162,200	$3,290		$44,010	$176,000
62			$10,550	$162,200	$3,290		$44,010	$176,000
63			$10,550	$162,200	$3,290		$44,010	$176,000
64			$10,550	$162,200	$3,290		$44,010	$176,000
65			$10,550	$162,200	$3,290		$44,010	$176,000
66			$10,550	$162,200	$3,290		$44,010	$176,000
67			$10,550	$162,200	$3,290		$44,010	$176,000
68			$10,550	$162,200	$3,290		$44,010	$176,000
69			$10,550	$162,200	$3,290		$44,010	$176,000
70			$10,550	$162,200	$3,290		$44,010	$176,000
71			$10,550	$162,200	$3,290		$44,010	$176,000
72			$10,550	$162,200	$3,290		$44,010	$176,000
73			$10,550	$162,200	$3,290		$44,010	$176,000
74			$10,550	$162,200	$3,290		$44,010	$176,000
75			$10,550	$162,200	$3,290		$44,010	$176,000
76			$10,550	$162,200	$3,290		$44,010	$176,000
77			$10,550	$162,200	$3,290		$44,010	$176,000
78			$10,550	$162,200	$3,290		$44,010	$176,000
79			$10,550	$162,200	$3,290		$44,010	$176,000
80			$10,550	$162,200	$3,290		$44,010	$176,000
81			$10,550	$162,200	$3,290		$44,010	$176,000
82			$10,550	$162,200	$3,290		$44,010	$176,000
83			$10,550	$162,200	$3,290		$44,010	$176,000
84			$10,550	$162,200	$3,290		$44,010	$176,000
85			$10,550	$162,200	$3,290		$44,010	$176,000
86			$10,550	$162,200	$3,290		$44,010	$176,000
87			$10,550	$162,200	$3,290		$44,010	$176,000
88			$10,550	$162,200	$3,290		$44,010	$176,000
89			$10,550	$162,200	$3,290		$44,010	$176,000
90			$10,550	$162,200	$3,290		$44,010	$176,000
91			$10,550	$162,200	$3,290		$44,010	$176,000
92			$10,550	$162,200	$3,290		$44,010	$176,000
93			$10,550	$162,200	$3,290		$44,010	$176,000
94			$10,550	$162,200	$3,290		$44,010	$176,000
95			$10,550	$162,200	$3,290		$44,010	$176,000
96			$10,550	$162,200	$3,290		$44,010	$176,000
97			$10,550	$162,200	$3,290		$44,010	$176,000
98			$10,550	$162,200	$3,290		$44,010	$176,000
99			$10,550	$162,200	$3,290		$44,010	$176,000
TOTAL	$446,800	$159,700	$1,074,500	$16,057,800	$325,700	$2,572,500	$5,159,200	$20,633,300

Net Discount rate: 2.5% **NPV** **$9,202,100**

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TABLE A-60

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-3 (LOW)
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 Cap Construction					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 Performance Monitoring Well Installation					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 6 Wells, 2 at 30' bgs, 2 at 50' bgs, 2 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 Dewatering and Soil Vapor Extraction System					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
30 HP, 580 SCFM Vapor Extraction Blower	EA	$11,523	1	$11,500	2005 RSMeans Environmental p 9-153; 33 13 2342
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Permanent	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	150	$5,900	2005 RSMeans Environmental p. 9-236; 33 23 1101; 6 SVE wells at 25' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	30	$700	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 6 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	120	$4,300	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 6 wells
4" Well, Grout (Annular Seal)	LF	$128.04	6	$800	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	6	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1702
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$232,800**	
4 Pilot Study					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	3	$2,400	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,950	$2,000	Price from similar job
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 4 Total				**$54,200**	
5 ISB Full-Scale Installation					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p. 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p. 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 5 Total				**$137,600**	
Subtotal				$442,200	
Professional Technical Services					
Permitting	%	7%	$442,200	$31,000	Geomatrix standard rate
Engineering Design Costs	%	12%	$442,200	$53,100	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$442,200	$35,400	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$442,200	$26,500	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$146,000	
TOTAL INITIAL IMPLEMENTATION COST				**$588,200**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

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TABLE A-61

RECURRING COSTS FOR ALTERNATIVE HA-3 (LOW)
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
5	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Molassess	lbs	$1	29250	$29,250	Price from similar job
	Recirculation/Injection Labor	day	$1,600	8	$12,800	2 engineers/scientists, $100/hour
	Subtotal				**$42,050**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
8	**SEMI ANNUAL ISB MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
9	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	per year	$20,000	1	$20,000	Price from similar job
	Subtotal				**$20,000**	
10	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
11	**PROPERTY OPPORTUNITY COST (9 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-62

NET PRESENT VALUE FOR ALTERNATIVE HA-3 (LOW)

PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Injection Costs	Semi-Annual ISB Monitoring	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	SVE / Dewatering System Monitoring	Property Opportunity Cost	25% Contingency	Yearly Total
0	$588,200							$367,500	$238,925	$1,194,600
1			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
2			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
3	$42,050	$26,620	$20,550	$162,200	$3,290			$367,500	$155,553	$777,800
4	$42,050	$26,620	$20,550	$162,200	$3,290			$367,500	$155,553	$777,800
5	$42,050	$26,620	$20,550	$162,200	$3,290			$367,500	$155,553	$777,800
6	$42,050	$26,620	$20,550	$162,200	$3,290			$367,500	$155,553	$777,800
7		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
8		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
9			$10,550	$162,200	$3,290				$44,010	$220,100
10			$10,550	$162,200	$3,290				$44,010	$220,100
11			$10,550	$162,200	$3,290				$44,010	$220,100
12			$10,550	$162,200	$3,290				$44,010	$220,100
13			$10,550	$162,200	$3,290				$44,010	$220,100
14			$10,550	$162,200	$3,290				$44,010	$220,100
15			$10,550	$162,200	$3,290				$44,010	$220,100
16			$10,550	$162,200	$3,290				$44,010	$220,100
17			$10,550	$162,200	$3,290				$44,010	$220,100
18			$10,550	$162,200	$3,290				$44,010	$220,100
19			$10,550	$162,200	$3,290				$44,010	$220,100
20			$10,550	$162,200	$3,290				$44,010	$220,100
21			$10,550	$162,200	$3,290				$44,010	$220,100
22			$10,550	$162,200	$3,290				$44,010	$220,100
23			$10,550	$162,200	$3,290				$44,010	$220,100
24			$10,550	$162,200	$3,290				$44,010	$220,100
25			$10,550	$162,200	$3,290				$44,010	$220,100
26			$10,550	$162,200	$3,290				$44,010	$220,100
27			$10,550	$162,200	$3,290				$44,010	$220,100
28			$10,550	$162,200	$3,290				$44,010	$220,100
29			$10,550	$162,200	$3,290				$44,010	$220,100
30			$10,550	$162,200	$3,290				$44,010	$220,100
31			$10,550	$162,200	$3,290				$44,010	$220,100
32			$10,550	$162,200	$3,290				$44,010	$220,100
33			$10,550	$162,200	$3,290				$44,010	$220,100
34			$10,550	$162,200	$3,290				$44,010	$220,100
35			$10,550	$162,200	$3,290				$44,010	$220,100
36			$10,550	$162,200	$3,290				$44,010	$220,100
37			$10,550	$162,200	$3,290				$44,010	$220,100
38			$10,550	$162,200	$3,290				$44,010	$220,100
39			$10,550	$162,200	$3,290				$44,010	$220,100
40			$10,550	$162,200	$3,290				$44,010	$220,100
41			$10,550	$162,200	$3,290				$44,010	$220,100
42			$10,550	$162,200	$3,290				$44,010	$220,100
43			$10,550	$162,200	$3,290				$44,010	$220,100
44			$10,550	$162,200	$3,290				$44,010	$220,100
45			$10,550	$162,200	$3,290				$44,010	$220,100
46			$10,550	$162,200	$3,290				$44,010	$220,100
47			$10,550	$162,200	$3,290				$44,010	$220,100
48			$10,550	$162,200	$3,290				$44,010	$220,100
49			$10,550	$162,200	$3,290				$44,010	$220,100
50			$10,550	$162,200	$3,290				$44,010	$220,100
51			$10,550	$162,200	$3,290				$44,010	$220,100
52			$10,550	$162,200	$3,290				$44,010	$220,100
53			$10,550	$162,200	$3,290				$44,010	$220,100
54			$10,550	$162,200	$3,290				$44,010	$220,100
55			$10,550	$162,200	$3,290				$44,010	$220,100
56			$10,550	$162,200	$3,290				$44,010	$220,100
57			$10,550	$162,200	$3,290				$44,010	$220,100
58			$10,550	$162,200	$3,290				$44,010	$220,100
59			$10,550	$162,200	$3,290				$44,010	$220,100
60			$10,550	$162,200	$3,290				$44,010	$220,100
61			$10,550	$162,200	$3,290				$44,010	$220,100
62			$10,550	$162,200	$3,290				$44,010	$220,100
63			$10,550	$162,200	$3,290				$44,010	$220,100
64			$10,550	$162,200	$3,290				$44,010	$220,100
65			$10,550	$162,200	$3,290				$44,010	$220,100
66			$10,550	$162,200	$3,290				$44,010	$220,100
67			$10,550	$162,200	$3,290				$44,010	$220,100
68			$10,550	$162,200	$3,290				$44,010	$220,100
69			$10,550	$162,200	$3,290				$44,010	$220,100
70			$10,550	$162,200	$3,290				$44,010	$220,100
71			$10,550	$162,200	$3,290				$44,010	$220,100
72			$10,550	$162,200	$3,290				$44,010	$220,100
73			$10,550	$162,200	$3,290				$44,010	$220,100
74			$10,550	$162,200	$3,290				$44,010	$220,100
75			$10,550	$162,200	$3,290				$44,010	$220,100
76			$10,550	$162,200	$3,290				$44,010	$220,100
77			$10,550	$162,200	$3,290				$44,010	$220,100
78			$10,550	$162,200	$3,290				$44,010	$220,100
79			$10,550	$162,200	$3,290				$44,010	$220,100
80			$10,550	$162,200	$3,290				$44,010	$220,100
81			$10,550	$162,200	$3,290				$44,010	$220,100
82			$10,550	$162,200	$3,290				$44,010	$220,100
83			$10,550	$162,200	$3,290				$44,010	$220,100
84			$10,550	$162,200	$3,290				$44,010	$220,100
85			$10,550	$162,200	$3,290				$44,010	$220,100
86			$10,550	$162,200	$3,290				$44,010	$220,100
87			$10,550	$162,200	$3,290				$44,010	$220,100
88			$10,550	$162,200	$3,290				$44,010	$220,100
89			$10,550	$162,200	$3,290				$44,010	$220,100
90			$10,550	$162,200	$3,290				$44,010	$220,100
91			$10,550	$162,200	$3,290				$44,010	$220,100
92			$10,550	$162,200	$3,290				$44,010	$220,100
93			$10,550	$162,200	$3,290				$44,010	$220,100
94			$10,550	$162,200	$3,290				$44,010	$220,100
95			$10,550	$162,200	$3,290				$44,010	$220,100
96			$10,550	$162,200	$3,290				$44,010	$220,100
97			$10,550	$162,200	$3,290				$44,010	$220,100
98			$10,550	$162,200	$3,290				$44,010	$220,100
99			$10,550	$162,200	$3,290				$44,010	$220,100
TOTAL	$756,400	$159,700	$1,124,500	$16,057,800	$325,700	$338,800	$33,600	$3,307,500	$5,526,000	$27,634,700

Net Discount rate: 2.5%

NPV **$13,101,700**

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TABLE A-63

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-4 (LOW)

PSC Georgetown Facility

Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 6 Wells, 2 at 30' bgs, 2 at 50' bgs, 2 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 **Dewatering and Soil Vapor Extraction System**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
30 HP, 580 SCFM Vapor Extraction Blower	EA	$11,523	1	$11,500	2005 RSMeans Environmental p 9-153; 33 13 2342
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Permanent	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	150	$5,900	2005 RSMeans Environmental p. 9-236; 33 23 1101; 6 SVE wells at 25' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	30	$700	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 6 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	120	$4,300	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 6 wells
4" Well, Grout (Annular Seal)	LF	$128.04	6	$800	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	6	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1702
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$232,800**	
4 **ISCO Pilot Study**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Soil Sampling	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Potassium Permanganate ($KMNO_4$)	lbs	$2	3,940	$6,400	Estimate of required substrate per recirculation cell, Geomatrix past experience
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 4 Total				**$65,000**	
5 **ISCO Full-Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p. 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	20	$16,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 5 Total				**$145,600**	
Subtotal				$461,000	
Professional Technical Services					
Permitting	%	7%	$461,000	$32,300	Geomatrix standard rate
Engineering Design Costs	%	12%	$461,000	$55,300	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$461,000	$36,900	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$461,000	$27,700	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$152,200	
TOTAL INITIAL IMPLEMENTATION COST				**$613,200**	

Notes:

1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

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TABLE A-64

RECURRING COSTS FOR ALTERNATIVE HA-4 (LOW)
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (18 YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**ANNUAL REPLACEMENT COSTS (18 YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
5	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Potassium Permanganate ($KMNO_4$)	lbs	$2	78750	$127,580	Carcus Chemical Company
	Recirculation/Injection Labor	day	$1,600	10	$16,000	2 engineers/scientists, $100/hour
	Subtotal				**$143,580**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
8	**SEMI ANNUAL ISCO MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
9	**PROJECT MANAGEMENT (18 YEARS)**					
	Project Management	per year	$20,000	1	$20,000	Price from similar job
	Subtotal				**$20,000**	
10	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
11	**PROPERTY OPPORTUNITY COST (9 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-65

NET PRESENT VALUE FOR ALTERNATIVE HA-4 (LOW)
PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Injection Costs	Semi-Annual ISCO Monitoring	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	SVE / Dewatering System Monitoring	Property Opportunity Cost	25% Contingency	Yearly Total
0	$613,200							$367,500	$245,175	$1,225,900
1			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
2			$20,550	$162,200	$3,290	$169,400	$16,800	$367,500	$184,935	$924,700
3	$143,580	$26,620	$20,550	$162,200	$3,290			$367,500	$180,935	$904,700
4	$143,580	$26,620	$20,550	$162,200	$3,290			$367,500	$180,935	$904,700
5	$143,580	$26,620	$20,550	$162,200	$3,290			$367,500	$180,935	$904,700
6	$143,580	$26,620	$20,550	$162,200	$3,290			$367,500	$180,935	$904,700
7		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
8		$26,620	$20,550	$162,200	$3,290			$367,500	$145,040	$725,200
9			$10,550	$162,200	$3,290				$44,010	$220,100
10			$10,550	$162,200	$3,290				$44,010	$220,100
11			$10,550	$162,200	$3,290				$44,010	$220,100
12			$10,550	$162,200	$3,290				$44,010	$220,100
13			$10,550	$162,200	$3,290				$44,010	$220,100
14			$10,550	$162,200	$3,290				$44,010	$220,100
15			$10,550	$162,200	$3,290				$44,010	$220,100
16			$10,550	$162,200	$3,290				$44,010	$220,100
17			$10,550	$162,200	$3,290				$44,010	$220,100
18			$10,550	$162,200	$3,290				$44,010	$220,100
19			$10,550	$162,200	$3,290				$44,010	$220,100
20			$10,550	$162,200	$3,290				$44,010	$220,100
21			$10,550	$162,200	$3,290				$44,010	$220,100
22			$10,550	$162,200	$3,290				$44,010	$220,100
23			$10,550	$162,200	$3,290				$44,010	$220,100
24			$10,550	$162,200	$3,290				$44,010	$220,100
25			$10,550	$162,200	$3,290				$44,010	$220,100
26			$10,550	$162,200	$3,290				$44,010	$220,100
27			$10,550	$162,200	$3,290				$44,010	$220,100
28			$10,550	$162,200	$3,290				$44,010	$220,100
29			$10,550	$162,200	$3,290				$44,010	$220,100
30			$10,550	$162,200	$3,290				$44,010	$220,100
31			$10,550	$162,200	$3,290				$44,010	$220,100
32			$10,550	$162,200	$3,290				$44,010	$220,100
33			$10,550	$162,200	$3,290				$44,010	$220,100
34			$10,550	$162,200	$3,290				$44,010	$220,100
35			$10,550	$162,200	$3,290				$44,010	$220,100
36			$10,550	$162,200	$3,290				$44,010	$220,100
37			$10,550	$162,200	$3,290				$44,010	$220,100
38			$10,550	$162,200	$3,290				$44,010	$220,100
39			$10,550	$162,200	$3,290				$44,010	$220,100
40			$10,550	$162,200	$3,290				$44,010	$220,100
41			$10,550	$162,200	$3,290				$44,010	$220,100
42			$10,550	$162,200	$3,290				$44,010	$220,100
43			$10,550	$162,200	$3,290				$44,010	$220,100
44			$10,550	$162,200	$3,290				$44,010	$220,100
45			$10,550	$162,200	$3,290				$44,010	$220,100
46			$10,550	$162,200	$3,290				$44,010	$220,100
47			$10,550	$162,200	$3,290				$44,010	$220,100
48			$10,550	$162,200	$3,290				$44,010	$220,100
49			$10,550	$162,200	$3,290				$44,010	$220,100
50			$10,550	$162,200	$3,290				$44,010	$220,100
51			$10,550	$162,200	$3,290				$44,010	$220,100
52			$10,550	$162,200	$3,290				$44,010	$220,100
53			$10,550	$162,200	$3,290				$44,010	$220,100
54			$10,550	$162,200	$3,290				$44,010	$220,100
55			$10,550	$162,200	$3,290				$44,010	$220,100
56			$10,550	$162,200	$3,290				$44,010	$220,100
57			$10,550	$162,200	$3,290				$44,010	$220,100
58			$10,550	$162,200	$3,290				$44,010	$220,100
59			$10,550	$162,200	$3,290				$44,010	$220,100
60			$10,550	$162,200	$3,290				$44,010	$220,100
61			$10,550	$162,200	$3,290				$44,010	$220,100
62			$10,550	$162,200	$3,290				$44,010	$220,100
63			$10,550	$162,200	$3,290				$44,010	$220,100
64			$10,550	$162,200	$3,290				$44,010	$220,100
65			$10,550	$162,200	$3,290				$44,010	$220,100
66			$10,550	$162,200	$3,290				$44,010	$220,100
67			$10,550	$162,200	$3,290				$44,010	$220,100
68			$10,550	$162,200	$3,290				$44,010	$220,100
69			$10,550	$162,200	$3,290				$44,010	$220,100
70			$10,550	$162,200	$3,290				$44,010	$220,100
71			$10,550	$162,200	$3,290				$44,010	$220,100
72			$10,550	$162,200	$3,290				$44,010	$220,100
73			$10,550	$162,200	$3,290				$44,010	$220,100
74			$10,550	$162,200	$3,290				$44,010	$220,100
75			$10,550	$162,200	$3,290				$44,010	$220,100
76			$10,550	$162,200	$3,290				$44,010	$220,100
77			$10,550	$162,200	$3,290				$44,010	$220,100
78			$10,550	$162,200	$3,290				$44,010	$220,100
79			$10,550	$162,200	$3,290				$44,010	$220,100
80			$10,550	$162,200	$3,290				$44,010	$220,100
81			$10,550	$162,200	$3,290				$44,010	$220,100
82			$10,550	$162,200	$3,290				$44,010	$220,100
83			$10,550	$162,200	$3,290				$44,010	$220,100
84			$10,550	$162,200	$3,290				$44,010	$220,100
85			$10,550	$162,200	$3,290				$44,010	$220,100
86			$10,550	$162,200	$3,290				$44,010	$220,100
87			$10,550	$162,200	$3,290				$44,010	$220,100
88			$10,550	$162,200	$3,290				$44,010	$220,100
89			$10,550	$162,200	$3,290				$44,010	$220,100
90			$10,550	$162,200	$3,290				$44,010	$220,100
91			$10,550	$162,200	$3,290				$44,010	$220,100
92			$10,550	$162,200	$3,290				$44,010	$220,100
93			$10,550	$162,200	$3,290				$44,010	$220,100
94			$10,550	$162,200	$3,290				$44,010	$220,100
95			$10,550	$162,200	$3,290				$44,010	$220,100
96			$10,550	$162,200	$3,290				$44,010	$220,100
97			$10,550	$162,200	$3,290				$44,010	$220,100
98			$10,550	$162,200	$3,290				$44,010	$220,100
99			$10,550	$162,200	$3,290				$44,010	$220,100
TOTAL	$1,187,500	$159,700	$1,124,500	$16,057,800	$325,700	$338,800	$33,600	$3,307,500	$5,633,800	$28,173,600

Net Discount rate: 2.5%

NPV $13,575,500

TABLE A-66

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-5 (LOW)
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 6 Wells, 2 at 30' bgs, 2 at 50' bgs, 2 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 **Dewatering and Soil Vapor Extraction System (3 extra ext. wells)**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower, 50 gpm	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
1000 SCFM, Vapor Recovery System	EA	$27,034	1	$27,000	2005 RSMeans Environmental p 9-154; 33 13 2361
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Carbon Assorpti	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	140	$5,500	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 SVE wells at 25' bgs, 4 SVE wells at 10' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	40	$1,000	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 8 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	100	$3,600	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 4 wells, 5' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	8	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	8	$1,400	2005 RSMeans Environmental p 9-246; 33 23 1702
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$248,100**	
4 **Steam Injection**					
Similar Case Study Overall Costs	CY	$200	61,834	NA	Based on reported range of costs for published applications.
Task 4 Total				**NA**	
5 **ISB Pilot Study**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	200	$7,800	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	40	$1,100	2005 RSMeans Environmental p 9-211; 33 23 0112; 10' of casing for 4 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	160	$4,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	4	$500	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	4	$700	2005 RSMeans Environmental p 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	1	$1,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 1 extraction well at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	50	$2,000	2005 RSMeans Environmental p. 9-236; 33 23 1101; 1 extraction well at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	10	$500	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 1 well
6" PVC, Schedule 80, Well Screen	LF	$48.93	40	$2,000	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 1 well
6" Well, Grout (Annular Seal)	LF	$188.69	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	1	$200	2005 RSMeans Environmental p 9-246; 33 23 1703
Construction Oversight	day	$800	3	$2,400	1 engineer/scientist, Geomatrix standard rate
Recirculation/Injection Labor	day	$1,600	4	$6,400	2 engineers/scientists, Geomatrix standard rate
Equipment	day	$200	2	$400	General Equipment, Geomatrix standard rate
Molassess	lbs	$1	1,950	$2,000	Price from similar job
Performancce Monitoring Labor	day	$1,600	1	$1,600	2 engineers/scientists, Geomatrix standard rate
Analytical	Lump Sum	$2,000	1	$2,000	Price from similar job
Reporting	Lump Sum	$15,000	1	$15,000	Price from similar job
Task 5 Total				**$54,200**	
6 **ISB Full-Scale Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
8" dia. Hollow Stem Auger Drilling (Injection Wells)	LF	$39.20	900	$35,300	2005 RSMeans Environmental p. 9-236; 33 23 1101; 18 injection wells at 50' bgs
4" PVC, Schedule 80, Well Casing	LF	$26.93	180	$4,800	2005 RSMeans Environmental p. 9-211; 33 23 0112; 10' of casing for 18 wells
4" PVC, Schedule 80, Well Screen	LF	$29.03	720	$20,900	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 18 wells
4" Well, Grout (Annular Seal)	LF	$128.04	18	$2,300	2005 RSMeans Environmental p. 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	18	$3,100	2005 RSMeans Environmental p. 9-246; 33 23 1702
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	9	$15,800	2005 RSMeans Environmental p. 9-224; 33 23 0526; 9 extraction wells at 50' bgs
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	450	$17,600	2005 RSMeans Environmental p. 9-236; 33 23 1101; 9 extraction wells at 50' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	90	$4,100	2005 RSMeans Environmental p. 9-211; 33 23 0103; 10' of casing for 9 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	360	$17,600	2005 RSMeans Environmental p 9-215; 33 23 0203; 40' of screen for 9 wells
6" Well, Grout (Annular Seal)	LF	$188.69	9	$1,700	2005 RSMeans Environmental p. 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	9	$1,900	2005 RSMeans Environmental p. 9-246; 33 23 1703
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	10	$1,000	General Equipment, Geomatrix standard rate
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Task 6 Total				**$137,600**	
Subtotal				$457,500	
Professional Technical Services					
Permitting	%	7%	$457,500	$32,000	Geomatrix standard rate
Engineering Design Costs	%	12%	$457,500	$54,900	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$457,500	$36,600	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$457,500	$27,500	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$151,000	
TOTAL INITIAL IMPLEMENTATION COST				**$608,500**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

Geomatrix

TABLE A-67

RECURRING COSTS FOR ALTERNATIVE HA-5 (LOW)
PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION (12 TOTAL YEARS)**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M (18 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**ANNUAL REPLACEMENT COSTS (12 TOTAL YEARS)**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
5	**SEMI-ANNUAL INJECTION (4 YEARS)**					
	Molassess	lbs	$1	29250	$29,250	Price from similar job
	Recirculation/Injection Labor	day	$1,600	8	$12,800	2 engineers/scientists, $100/hour
	Subtotal				**$42,050**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
8	**SEMI ANNUAL ISB MONITORING (6 YEARS)**					
	Sampling Labor	day	$1,600	2	$3,200	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	12	$3,420	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$26,620**	
9	**PROJECT MANAGEMENT (12 TOTAL YEARS)**					
	Project Management	per year	$20,000	1	$20,000	Price from similar job
	Subtotal				**$20,000**	
10	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
11	**PROPERTY OPPORTUNITY COST (19 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-68

NET PRESENT VALUE FOR ALTERNATIVE HA-5 (LOW)
PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Injection Costs	Semi-Annual ISB Monitoring	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	SVE / Dewatering System Monitoring	Steam Injection Costs	Property Opportunity Cost	25% Contingency	Yearly Total
0	$608,500								$367,500	$244,000	$1,220,000
1			$20,550	$162,200	$3,290				$367,500	$138,385	$691,900
2			$20,550	$162,200	$3,290	$169,400	$16,800		$367,500	$184,935	$924,700
3			$20,550	$162,200	$3,290	$169,400	$16,800		$367,500	$184,935	$924,700
4			$550						$367,500	$92,013	$460,100
5			$550					$12,366,800	$367,500	$3,183,713	$15,918,600
6			$550						$367,500	$92,013	$460,100
7			$550						$367,500	$92,013	$460,100
8			$550						$367,500	$92,013	$460,100
9			$550						$367,500	$92,013	$460,100
10			$550						$367,500	$92,013	$460,100
11	$42,050	$26,620	$20,550	$162,200	$3,290				$367,500	$155,553	$777,800
12	$42,050	$26,620	$20,550	$162,200	$3,290				$367,500	$155,553	$777,800
13	$42,050	$26,620	$20,550	$162,200	$3,290				$367,500	$155,553	$777,800
14	$42,050	$26,620	$20,550	$162,200	$3,290				$367,500	$155,553	$777,800
15		$26,620	$20,550	$162,200	$3,290				$367,500	$145,040	$725,200
16		$26,620	$20,550	$162,200	$3,290				$367,500	$145,040	$725,200
17			$10,550	$162,200	$3,290					$44,010	$220,100
18			$10,550	$162,200	$3,290					$44,010	$220,100
19			$10,550	$162,200	$3,290					$44,010	$220,100
20			$10,550	$162,200	$3,290					$44,010	$220,100
21			$10,550	$162,200	$3,290					$44,010	$220,100
22			$10,550	$162,200	$3,290					$44,010	$220,100
23			$10,550	$162,200	$3,290					$44,010	$220,100
24			$10,550	$162,200	$3,290					$44,010	$220,100
25			$10,550	$162,200	$3,290					$44,010	$220,100
26			$10,550	$162,200	$3,290					$44,010	$220,100
27			$10,550	$162,200	$3,290					$44,010	$220,100
28			$10,550	$162,200	$3,290					$44,010	$220,100
29			$10,550	$162,200	$3,290					$44,010	$220,100
30			$10,550	$162,200	$3,290					$44,010	$220,100
31			$10,550	$162,200	$3,290					$44,010	$220,100
32			$10,550	$162,200	$3,290					$44,010	$220,100
33			$10,550	$162,200	$3,290					$44,010	$220,100
34			$10,550	$162,200	$3,290					$44,010	$220,100
35			$10,550	$162,200	$3,290					$44,010	$220,100
36			$10,550	$162,200	$3,290					$44,010	$220,100
37			$10,550	$162,200	$3,290					$44,010	$220,100
38			$10,550	$162,200	$3,290					$44,010	$220,100
39			$10,550	$162,200	$3,290					$44,010	$220,100
40			$10,550	$162,200	$3,290					$44,010	$220,100
41			$10,550	$162,200	$3,290					$44,010	$220,100
42			$10,550	$162,200	$3,290					$44,010	$220,100
43			$10,550	$162,200	$3,290					$44,010	$220,100
44			$10,550	$162,200	$3,290					$44,010	$220,100
45			$10,550	$162,200	$3,290					$44,010	$220,100
46			$10,550	$162,200	$3,290					$44,010	$220,100
47			$10,550	$162,200	$3,290					$44,010	$220,100
48			$10,550	$162,200	$3,290					$44,010	$220,100
49			$10,550	$162,200	$3,290					$44,010	$220,100
50			$10,550	$162,200	$3,290					$44,010	$220,100
51			$10,550	$162,200	$3,290					$44,010	$220,100
52			$10,550	$162,200	$3,290					$44,010	$220,100
53			$10,550	$162,200	$3,290					$44,010	$220,100
54			$10,550	$162,200	$3,290					$44,010	$220,100
55			$10,550	$162,200	$3,290					$44,010	$220,100
56			$10,550	$162,200	$3,290					$44,010	$220,100
57			$10,550	$162,200	$3,290					$44,010	$220,100
58			$10,550	$162,200	$3,290					$44,010	$220,100
59			$10,550	$162,200	$3,290					$44,010	$220,100
60			$10,550	$162,200	$3,290					$44,010	$220,100
61			$10,550	$162,200	$3,290					$44,010	$220,100
62			$10,550	$162,200	$3,290					$44,010	$220,100
63			$10,550	$162,200	$3,290					$44,010	$220,100
64			$10,550	$162,200	$3,290					$44,010	$220,100
65			$10,550	$162,200	$3,290					$44,010	$220,100
66			$10,550	$162,200	$3,290					$44,010	$220,100
67			$10,550	$162,200	$3,290					$44,010	$220,100
68			$10,550	$162,200	$3,290					$44,010	$220,100
69			$10,550	$162,200	$3,290					$44,010	$220,100
70			$10,550	$162,200	$3,290					$44,010	$220,100
71			$10,550	$162,200	$3,290					$44,010	$220,100
72			$10,550	$162,200	$3,290					$44,010	$220,100
73			$10,550	$162,200	$3,290					$44,010	$220,100
74			$10,550	$162,200	$3,290					$44,010	$220,100
75			$10,550	$162,200	$3,290					$44,010	$220,100
76			$10,550	$162,200	$3,290					$44,010	$220,100
77			$10,550	$162,200	$3,290					$44,010	$220,100
78			$10,550	$162,200	$3,290					$44,010	$220,100
79			$10,550	$162,200	$3,290					$44,010	$220,100
80			$10,550	$162,200	$3,290					$44,010	$220,100
81			$10,550	$162,200	$3,290					$44,010	$220,100
82			$10,550	$162,200	$3,290					$44,010	$220,100
83			$10,550	$162,200	$3,290					$44,010	$220,100
84			$10,550	$162,200	$3,290					$44,010	$220,100
85			$10,550	$162,200	$3,290					$44,010	$220,100
86			$10,550	$162,200	$3,290					$44,010	$220,100
87			$10,550	$162,200	$3,290					$44,010	$220,100
88			$10,550	$162,200	$3,290					$44,010	$220,100
89			$10,550	$162,200	$3,290					$44,010	$220,100
90			$10,550	$162,200	$3,290					$44,010	$220,100
91			$10,550	$162,200	$3,290					$44,010	$220,100
92			$10,550	$162,200	$3,290					$44,010	$220,100
93			$10,550	$162,200	$3,290					$44,010	$220,100
94			$10,550	$162,200	$3,290					$44,010	$220,100
95			$10,550	$162,200	$3,290					$44,010	$220,100
96			$10,550	$162,200	$3,290					$44,010	$220,100
97			$10,550	$162,200	$3,290					$44,010	$220,100
98			$10,550	$162,200	$3,290					$44,010	$220,100
99			$10,550	$162,200	$3,290					$44,010	$220,100
TOTAL	$776,700	$159,700	$1,064,500	$14,922,400	$302,700	$338,800	$33,600	$12,366,800	$6,247,500	$9,053,200	$45,270,400

Net Discount rate: 2.5%

NPV $27,757,500

TABLE A-69

IMPLEMENTATION COSTS FOR ALTERNATIVE HA-6 (LOW)
PSC Georgetown Facility
Seattle, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Cap Construction**					
Mobilization/Demobilization	Lump Sum	$2,000	1	$2,000	Price from similar job
3" Asphalt Paving	SY	$10	167	$1,700	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	1	$100	PID rental, Geomatrix standard rate
Task 1 Total				**$4,600**	
2 **Performance Monitoring Well Installation**					
Mobilization/Demobilization	Lump Sum	$3,000	1	$3,000	2005 RSMeans Environmental p. 9-243; 33 23 1201
Drill and Install 2" PVC Monitoring Well	LF	$31	160	$5,000	2005 RSMeans Environmental p. 9-253; 33 23 2504; 6 Wells, 2 at 30' bgs, 2 at 50' bgs, 2 at 90' bgs
Surveying	day	$495	1	$500	RSMeans Building Construction p. 24; 02 21 13.09 0020
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Equipment	day	$100	5	$500	PID rental, Geomatrix standard rate
Task 2 Total				**$13,000**	
3 **Dewatering and Soil Vapor Extraction System (3 extra ext. wells)**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
1.5' Dia. 19' Packing Height Stripper, with Blower, 50 gpm	EA	$17,045	1	$17,000	2005 RSMeans Environmental p 9-124; 33 13 0715
Internal Parts for Air Stripper	FT	$3,782	2	$5,700	2005 RSMeans Environmental p 9-125; 33 13 0736
1"-3.5" Packing for Air Stripper Tower	CF	$18	34	$600	2005 RSMeans Environmental p 9-125; 33 13 0738
1.5' Diameter Tower, Skid Mount	EA	$913	1	$900	2005 RSMeans Environmental p 9-127; 33 26 0752
Air Stripper System Controls	Lump Sum	$2,500	1	$2,500	Similar system intallation quote
50 gpm, 100' Head, 3 hp, Centrifugal Pump	EA	$902	1	$900	2005 RSMeans Environmental p 9-277; 33 29 0103
4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, w/ controls	EA	$1,755	3	$5,300	2005 RSMeans Environmental p 9-224; 33 23 0526
1500 CFM Fluidized Bed Gas Scrubber, Single Stage, Off-Gas	EA	$36,300	1	$36,300	2005 RSMeans Environmental p 9-157; 33 13 9101
1000 SCFM Simple Thermal Oxidizer	MO	$3,687	12	$44,200	2005 RSMeans Environmental p 9-78; 33 07 0404; Total Cost divided by 24 for monthly rental
1000 SCFM, Vapor Recovery System	EA	$27,034	1	$27,000	2005 RSMeans Environmental p 9-154; 33 13 2361
SVE System Controls	Lump Sum	$2,000	1	$2,000	Similar system intallation quote
50 gpm, 1,050 lb Fill, High-density Polyethylene, Carbon Assorption	EA	$5,457	2	$10,900	2005 RSMeans Environmental p. 9-148; 33 13 2016
2"PVC, Schedule 80, Connection Piping	LF	$3.83	300	$1,100	2005 RSMeans Environmental p 9-258; 33 26 0428
4" PVC, Schedule 80, Connection Piping	LF	$8.99	300	$2,700	2005 RSMeans Environmental p 9-258; 33 26 0430
2" PVC Piping Including Fiitings & Hangers	LF	$10.47	100	$1,000	2005 RSMeans Environmental p 9-257; 33 26 0404
4" PVC Piping Including Fittings & Hangers	LF	$13.55	100	$1,400	2005 RSMeans Environmental p 9-258; 33 26 0406
8" dia. Hollow Stem Auger Drilling (Extraction Wells)	LF	$39.20	120	$4,700	2005 RSMeans Environmental p. 9-236; 33 23 1101; 3 extraction wells at 40' bgs
6" PVC, Schedule 80, Well Casing	LF	$45.75	30	$1,400	2005 RSMeans Environmental p 9-211; 33 23 0103; 10' of casing for 3 wells
6" PVC, Schedule 80, Well Screen	LF	$48.93	90	$4,400	2005 RSMeans Environmental p 9-215; 33 23 0203; 30' of screen for 3 wells
6" Well, Grout (Annular Seal)	LF	$188.69	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1803
6" Well, Locking Cap	EA	$208.03	3	$600	2005 RSMeans Environmental p 9-246; 33 23 1703
Precast Concrete Vaults for Extraction Wells	EA	$722	3	$2,200	2005 RSMeans Environmental p 9-248; 33 23 2201
8" dia. Hollow Stem Auger Drilling (SVE Extraction Wells)	LF	$39.20	140	$5,500	2005 RSMeans Environmental p. 9-236; 33 23 1101; 4 SVE wells at 25' bgs, 4 SVE wells at 10' bgs
4" PVC, Schedule 40, Well Casing	LF	$24.66	40	$1,000	2005 RSMeans Environmental p 9-211; 33 23 0102; 5' of casing for 8 wells
4" PVC, Schedule 40, Well Screen	LF	$35.95	100	$3,600	2005 RSMeans Environmental p 9-215; 33 23 0202; 20' of screen for 4 wells, 5' of screen for 4 wells
4" Well, Grout (Annular Seal)	LF	$128.04	8	$1,000	2005 RSMeans Environmental p 9-246; 33 23 1802
4" Well, Locking Cap	EA	$170.52	8	$1,400	2005 RSMeans Environmental p 9-246; 33 23 1702
Automatic Controls/Panel	EA	$50,000	1	$50,000	Price from similar job
Portable Building, 18' ceiling, Installed	SF	$6	400	$2,200	2005 RSMeans Environmental p. 9-81; 33 07 9905
Construction Oversight	day	$800	10	$8,000	1 engineer/scientist, Geomatrix standard rate
Task 3 Total				**$248,100**	
4 **Steam Injection**					
Similar Case Study Overall Costs	CY	$200	61,834	NA	Based on reported range of costs for published applications.
Task 4 Total				**NA**	
5 **Excavation and Disposal**					
Mobilization/Demobilization	Lump Sum	$10,000	1	$10,000	Price from similar job
Track Mounted Excavator, 1 C.Y. bucket, +15% for loading onto truck	BCY	$3	1,100	$3,200	2007 RSMeans Building Construction p. 528; 31 23 16.42 0200
Tanker Trailer Transport, Hazardous Waste	MI	$3	23,500	$70,500	2005 RSMeans Environmental p. 9-178; 33 190254; 3000 tons, 16.5 tons/truck, 260 miles to Arlington, OR
Landfill Hazardous Solid Bulk Waste	TON	$163	1,500	$244,200	2005 RSMeans Environmental p. 9-204; 33 19 72641
Confirmation Soil Sampling	day	$800	1	$800	1 engineer/scientist, Geomatrix standard rate
Analytical on Soil Samples	Lump Sum	$2,000	1	$2,000	Price from similar job
Clean Fill, Delivered	TON	$15	1,875	$28,100	Price from similar job
Dozer Backfilling, compacting in 6" to 12" lifts with Vibratory Compa	ECY	$3	1,100	$2,900	2007 RSMeans Building Construction p. 532; 31 23 23.13 1600
Asphalt Paving	SY	$10	329	$3,300	RSMeans Building Construction p. 548; 32 12 16.13 0460
Construction Oversight	day	$800	5	$4,000	1 engineer/scientist, Geomatrix standard rate
Task 6 Total				**$369,000**	
Subtotal				$634,700	
Professional Technical Services					
Permitting	%	7%	$634,700	$44,400	Geomatrix standard rate
Engineering Design Costs	%	12%	$634,700	$76,200	from EPA, 2000, Exh. 5-8
Construction Management	%	8%	$634,700	$50,800	from EPA, 2000, Exh. 5-8
Project Management	%	6%	$634,700	$38,100	from EPA, 2000, Exh. 5-8
Subtotal, Professional Services				$209,500	
TOTAL INITIAL IMPLEMENTATION COST				**$844,200**	

Notes:
1. 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. 40 hour work week.
4. Level D PPE.
5. Assume all paving 3" asphalt

Geomatrix

TABLE A-70

RECURRING COSTS FOR ALTERNATIVE HA-6 (LOW)

PSC Georgetown Facility
Seattle, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**INSPECTION**					
	Site Inspection	EA	$550	1	$550	2005 RSMeans Environmental p. 9-81; 33 08 0501
	Subtotal				**$550**	
2	**SVE / DEWATERING ANNUAL COSTS INCLUDING O&M (4 YEARS)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$48,000	1	$48,000	Current System Costs x 4 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Current System Costs
	Subtotal				**$169,400**	
3	**TREATMENT SYSTEM ANNUAL COSTS INCLUDING O&M**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$12,000	1	$12,000	Current System Costs
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$162,200**	
4	**DEWATERING ANNUAL COSTS INCLUDING O&M (5 YEARS AFTER STEAM)**					
	Annual operation labor	day	$800	52	$41,600	1 engineer/scientist, Geomatrix standard rate
	Electricity	Lump sum	$4,800	1	$4,800	Current System Costs
	Waste Water Discharge	Lump sum	$36,000	1	$36,000	Current System Costs x 3 (to account for more discharge water)
	Misc. Maintenance	Lump sum	$70,000	1	$70,000	Current System Costs
	Treatment system cleaning	Lump sum	$28,800	1	$28,800	Current System Costs
	Well Maintenance	per well	$5,000	1	$5,000	Est. 10% of wells need maintence
	Subtotal				**$186,200**	
5	**ANNUAL REPLACEMENT COSTS**					
	Controls & Instruments	EA	$100	1	$100	Price from similar job
	Surface Cover Maintenance	per year	$400	1	$400	Price from similar job
	Discharge Permit (Annualized, 5 year permit)	per year	$2,000	1	$2,000	Current System Costs
	Monitoring Well Installation (2" PVC)	LF	$55	13	$720	2005 RSMeans Environmental p. 9-253; 33 23 2504
	Waste Disposal	drum	$50	1	$70	Price from similar job
	Subtotal				**$3,290**	
6	**SVE / DEWATERING SYSTEM MONITORING (4 YEARS)**					
	Monthly Vapor Sample Collection Labor	day	$800	12	$9,600	1 engineer/scientist, Geomatrix standard rate
	Analysis - VOCs, Ethenes	per sample	$600	12	$7,200	Air Toxics Inc.
	Subtotal				**$16,800**	
7	**SEMI-ANNUAL MONITORING (15 YEARS DURING GW EXTRACTION/REINJECTION)**					
	Sampling Labor	day	$1,600	4	$6,400	2 engineers/scientists, $100/hour
	Analysis - VOCs, Ethenes	per well	$285	32	$9,120	ARI
	Analysis - Metals	per well	$290	32	$9,280	ARI
	Reporting	per round	$10,000	2	$20,000	Price from similar job
	Subtotal				**$44,800**	
8	**PROJECT MANAGEMENT**					
	Project Management	per year	$25,000	1	$25,000	Price from similar job
	Subtotal				**$25,000**	
9	**PROJECT MANAGEMENT AFTER IMPLEMENTATION**					
	Project Management	per year	$10,000	1	$10,000	Price from similar job
	Subtotal				**$10,000**	
10	**PROPERTY OPPORTUNITY COST (16 YEARS)**					
	Opportunity Cost	year	$367,500	1	$367,500	Using an interest cost of 7%
	Subtotal				**$367,500**	

Notes:
1. All costs in 2007 Dollars.
2. All costs taken from the 2005 Means Environmental were increased by 10%
3. Assumed 40 hour work week.
4. No taxes have been included.

TABLE A-71

NET PRESENT VALUE FOR ALTERNATIVE HA-6 (LOW)

PSC Georgetown Facility
Seattle, Washington

Year	Implementation & Injection Costs	Inspection & Project Management	Treatment System Annual Costs Including O&M	Annual Replacement Costs	SVE / Dewatering Annual Costs including O&M	SVE / Dewatering System Monitoring	Steam Injection Costs	Semi-Annual Monitoring (5 years after Steam Injection)	Dewatering Annual Costs Including O&M	Property Opportunity Cost	25% Contingency	Yearly Total
0	$844,200									$367,500	$302,900	$1,514,600
1		$25,550	$162,200	$3,290				$44,800		$367,500	$150,800	$754,100
2		$25,550	$162,200	$3,290	$169,400	$16,800		$44,800		$367,500	$197,400	$986,900
3		$25,550	$162,200	$3,290	$169,400	$16,800		$44,800		$367,500	$197,400	$986,900
4		$550						$44,800		$367,500	$103,200	$516,100
5		$550					$12,366,800	$44,800		$367,500	$3,194,900	$15,974,600
6		$550						$44,800		$367,500	$103,200	$516,100
7		$550						$44,800		$367,500	$103,200	$516,100
8		$550						$44,800		$367,500	$103,200	$516,100
9		$550						$44,800	$186,200	$367,500	$149,800	$748,900
10		$550						$44,800	$186,200	$367,500	$149,800	$748,900
11		$25,550		$3,290				$44,800	$186,200	$367,500	$156,800	$784,100
12		$25,550		$3,290				$44,800	$186,200	$367,500	$156,800	$784,100
13		$25,550		$3,290				$44,800	$186,200	$367,500	$156,800	$784,100
14		$10,550	$162,200	$3,290							$44,000	$220,000
15		$10,550	$162,200	$3,290							$44,000	$220,000
16		$10,550	$162,200	$3,290							$44,000	$220,000
17		$10,550	$162,200	$3,290							$44,000	$220,000
18		$10,550	$162,200	$3,290							$44,000	$220,000
19		$10,550	$162,200	$3,290							$44,000	$220,000
20		$10,550	$162,200	$3,290							$44,000	$220,000
21		$10,550	$162,200	$3,290							$44,000	$220,000
22		$10,550	$162,200	$3,290							$44,000	$220,000
23		$10,550	$162,200	$3,290							$44,000	$220,000
24		$10,550	$162,200	$3,290							$44,000	$220,000
25		$10,550	$162,200	$3,290							$44,000	$220,000
26		$10,550	$162,200	$3,290							$44,000	$220,000
27		$10,550	$162,200	$3,290							$44,000	$220,000
28		$10,550	$162,200	$3,290							$44,000	$220,000
29		$10,550	$162,200	$3,290							$44,000	$220,000
30		$10,550	$162,200	$3,290							$44,000	$220,000
31		$10,550	$162,200	$3,290							$44,000	$220,000
32		$10,550	$162,200	$3,290							$44,000	$220,000
33		$10,550	$162,200	$3,290							$44,000	$220,000
34		$10,550	$162,200	$3,290							$44,000	$220,000
35		$10,550	$162,200	$3,290							$44,000	$220,000
36		$10,550	$162,200	$3,290							$44,000	$220,000
37		$10,550	$162,200	$3,290							$44,000	$220,000
38		$10,550	$162,200	$3,290							$44,000	$220,000
39		$10,550	$162,200	$3,290							$44,000	$220,000
40		$10,550	$162,200	$3,290							$44,000	$220,000
41		$10,550	$162,200	$3,290							$44,000	$220,000
42		$10,550	$162,200	$3,290							$44,000	$220,000
43		$10,550	$162,200	$3,290							$44,000	$220,000
44		$10,550	$162,200	$3,290							$44,000	$220,000
45		$10,550	$162,200	$3,290							$44,000	$220,000
46		$10,550	$162,200	$3,290							$44,000	$220,000
47		$10,550	$162,200	$3,290							$44,000	$220,000
48		$10,550	$162,200	$3,290							$44,000	$220,000
49		$10,550	$162,200	$3,290							$44,000	$220,000
50		$10,550	$162,200	$3,290							$44,000	$220,000
51		$10,550	$162,200	$3,290							$44,000	$220,000
52		$10,550	$162,200	$3,290							$44,000	$220,000
53		$10,550	$162,200	$3,290							$44,000	$220,000
54		$10,550	$162,200	$3,290							$44,000	$220,000
55		$10,550	$162,200	$3,290							$44,000	$220,000
56		$10,550	$162,200	$3,290							$44,000	$220,000
57		$10,550	$162,200	$3,290							$44,000	$220,000
58		$10,550	$162,200	$3,290							$44,000	$220,000
59		$10,550	$162,200	$3,290							$44,000	$220,000
60		$10,550	$162,200	$3,290							$44,000	$220,000
61		$10,550	$162,200	$3,290							$44,000	$220,000
62		$10,550	$162,200	$3,290							$44,000	$220,000
63		$10,550	$162,200	$3,290							$44,000	$220,000
64		$10,550	$162,200	$3,290							$44,000	$220,000
65		$10,550	$162,200	$3,290							$44,000	$220,000
66		$10,550	$162,200	$3,290							$44,000	$220,000
67		$10,550	$162,200	$3,290							$44,000	$220,000
68		$10,550	$162,200	$3,290							$44,000	$220,000
69		$10,550	$162,200	$3,290							$44,000	$220,000
70		$10,550	$162,200	$3,290							$44,000	$220,000
71		$10,550	$162,200	$3,290							$44,000	$220,000
72		$10,550	$162,200	$3,290							$44,000	$220,000
73		$10,550	$162,200	$3,290							$44,000	$220,000
74		$10,550	$162,200	$3,290							$44,000	$220,000
75		$10,550	$162,200	$3,290							$44,000	$220,000
76		$10,550	$162,200	$3,290							$44,000	$220,000
77		$10,550	$162,200	$3,290							$44,000	$220,000
78		$10,550	$162,200	$3,290							$44,000	$220,000
79		$10,550	$162,200	$3,290							$44,000	$220,000
80		$10,550	$162,200	$3,290							$44,000	$220,000
81		$10,550	$162,200	$3,290							$44,000	$220,000
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83		$10,550	$162,200	$3,290							$44,000	$220,000
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86		$10,550	$162,200	$3,290							$44,000	$220,000
87		$10,550	$162,200	$3,290							$44,000	$220,000
88		$10,550	$162,200	$3,290							$44,000	$220,000
89		$10,550	$162,200	$3,290							$44,000	$220,000
90		$10,550	$162,200	$3,290							$44,000	$220,000
91		$10,550	$162,200	$3,290							$44,000	$220,000
92		$10,550	$162,200	$3,290							$44,000	$220,000
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95		$10,550	$162,200	$3,290							$44,000	$220,000
96		$10,550	$162,200	$3,290							$44,000	$220,000
97		$10,550	$162,200	$3,290							$44,000	$220,000
98		$10,550	$162,200	$3,290							$44,000	$220,000
99		$10,550	$162,200	$3,290							$44,000	$220,000
TOTAL	$844,200	$1,064,500	$14,435,800	$302,700	$338,800	$33,600	$12,366,800	$582,400	$931,000	$5,145,000	$9,010,200	$45,051,600

Net Discount rate: 2.5%

NPV **$27,853,600**

APPENDIX B

HCIM Area Remediation Levels

TECHNICAL MEMORANDUM NO. 5:
REMEDIAL ALTERNATIVES
DEVELOPMENT & EVALUATION
SITE WIDE FEASIBILITY STUDY,
APPENDIX B, HCIM AREA REMEDIATION
LEVEL EVALUATION
PSC Georgetown Facility
Seattle, Washington

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Project 8770.005

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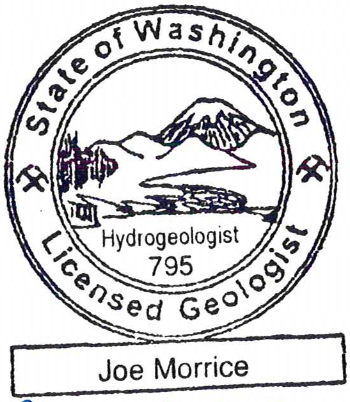

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APPENDIX B
HCIM AREA REMEDIATION LEVEL EVALUATION
PSC Georgetown Facility
Seattle, Washington

1.0 INTRODUCTION

This appendix presents modeling to support selection of remediation levels for the area located inside the Hydraulic Control Interim Measures (HCIM) barrier wall at the Philip Services Corporation (PSC) former dangerous waste treatment and storage facility (the facility). As constructed, the low permeability subsurface barrier wall combined with groundwater withdrawal inside the wall area to create an inward gradient is effectively containing site constituents of concern (COCs). The area within the barrier wall is referred to as the HCIM Area. Based on recent groundwater monitoring events, the HCIM has resulted in a steep decline of COCs in monitoring wells downgradient of the HCIM Area and groundwater monitoring trend charts in the 2006 HCIM Annual Performance Monitoring Report (Geomatrix, 2007b) indicate a reduction in VOC concentrations downgradient as far as Fourth Avenue (Geomatrix, 2007b). Based on this data the HCIM is working as proposed and is a critical part of the various alternatives being evaluated in the Site Wide Feasibility Study. However, since the HCIM is a containment technology and since all alternatives being evaluated for the HCIM Area cleanup rely on this containment approach, Ecology is concerned that if the HCIM fails, i.e. the barrier wall breaks, releases from the HCIM Area could potentially result in exposure to downgradient receptors. For this reason, Ecology has requested PSC develop remediation levels that would be protective of off-site receptors, specifically the Duwamish Waterway, under some assumed future barrier wall failure and resulting loss of containment of COCs.

The intent of the developing remediation levels is to allow an evaluation of HCIM Area alternatives with respect to each alternative’s ability to achieve remediation levels for reasonable assumptions for barrier wall failure. Technical Memorandum 1 (Geomatrix, 2006a) calculated remediation levels for the Outside Area and Conditional Point of Compliance (CPOC). The remediation levels developed for the CPOC can be used as the “no wall” scenario since COC concentrations inside the HCIM Area would need to meet those remediation levels at the CPOC if the wall did not exist. This appendix, therefore, evaluates various scenarios of wall failure to provide a ranges of remediation levels to which alternatives can be compared against as part of the evaluation of Protectiveness and Risk Reduction (one of MTCA's criteria for the evaluation of alternatives).

Development of potential failure scenarios and associated remediation levels are documented in the following sections.

2.0 CONCEPTUAL MODEL OF WALL FAILURE

In order to estimate remediation levels for the area located inside the conditional point of compliance (HCIM barrier wall), it is necessary to establish a scenario for failure of the barrier wall. The barrier wall is expected to have a very long life, as it is constructed of earthen materials that are not likely to degrade in the subsurface environment. Structural failure of the barrier wall due to a major earthquake is considered the most likely cause of failure for the barrier wall. Barrier walls using slurry trenching techniques for installation have been in place for approximately 80 years with the technology originating in Europe. Barrier walls are typically installed using either soil/clay mixes or cement/clay mixes with bentonite being the most commonly used clay. Cement/bentonite walls are common for applications requiring the wall to have strength such as long-term dewatering applications and dam stability reinforcement. Soil/clay walls are more common for contaminant containment where lateral forces are not great and the primary goal is a low permeability. The barrier wall installed using slurry trench methods at the PSC facility is a cement/clay wall. Due to site constraints the wall was installed by vibrating beam technology which results in a relatively thin wall (6 inches in thickness) as opposed to excavated slurry trenches which result in a thick wall up to 3 feet in thickness. Ecology is concerned that the relatively thin and more rigid wall (compared to a soil/clay wall which is plastic in nature) could be more likely to fail during an earthquake. Although data are not available on slurry wall failures, large seismic events are viewed as having the most potential for barrier wall failure. Since we cannot use an existing example of a barrier wall failure and it is not possible to predict the size or specific location of a seismic event, there is no one failure scenario that can be anticipated. For this reason, we developed a range of potential scenarios that would result in different severities of wall breakage to develop a range of potential releases and allow modeling to develop various remediation levels. The following four conceptual failure scenarios were developed for evaluation:

1. Earthquake motion produces a single, vertical, 6-inch wide crack extending along the entire vertical depth of the downgradient side of the barrier wall.

2. Earthquake motion produces four vertical, 6-inch wide cracks (total of 2 feet of wall failure) extending along the entire vertical depth of the downgradient side of the barrier wall. The cracks are evenly distributed along the horizontal length of the wall.

3. Earthquake motion produces 12 vertical, 6-inch wide cracks (total of 6 feet of wall failure) extending along the entire vertical depth of the downgradient side of the barrier wall. The cracks are evenly distributed along the horizontal length of the wall.

4. Earthquake motion completely reduces the barrier wall material to cobble-sized rubble, and 25 percent of the wall material is replaced by relatively permeable aquifer material. This would produce the equivalent of 100 feet of open space along the 400-foot downgradient side of the wall.

These failure scenarios range from unlikely but reasonable major earthquake failure scenarios (e.g., single or multiple cracks) to an extremely unlikely, absolute worst-case endpoint with the entire wall reduced to rubble.

The following assumptions were made for each of the failure scenarios:

1. Groundwater flow rates through open areas in the wall were equal to ambient, area-wide groundwater flow rates in the water table/shallow and intermediate depth interval aquifers. This, therefore assumes that the breaks in the wall extend through both downgradient and upgradient portions of the wall.

2. Groundwater within the Outside Area had been remediated to or below cleanup levels prior to failure of the barrier wall, such that the HCIM area is only source of contaminants.

The assumption that the maximum historically detected COC concentrations would be exposed by the cracks is a highly conservative assumption. It is more likely that any exposed concentrations would be lower since the highest COC concentrations are located within the interior of the HCIM area, rather than along the downgradient edge of the wall.

The assumption that ambient COC concentrations were negligible simplifies modeling and acknowledges the low probability for wall failure. This conceptual model was used to assess remediation levels for the HCIM Area.

2.0 FATE AND TRANSPORT MODELING APPROACH

This section presents modeling approach used to evaluate fate and transport of organic COCs from the HCIM area downgradient to the Duwamish Waterway and establish remediation levels protective of surface water receptors for each failure scenario. This evaluation did not consider the potential vapor intrusion pathway since cleanup levels would need to be met for this pathway.

There are 50 organic COCs for the water table and shallow depth intervals (hereafter referred to as the shallow depth interval) and 23 organic COCs for the intermediate depth interval for which fate and transport from the HCIM were evaluated. Modeling of the exposed HCIM Area constituents was performed using BIOCHLOR, and the general modeling approach is consistent with that presented in Technical Memorandum No.1. BIOCHLOR models were developed for 49 COCs, including the chlorinated VOCs and benzene, toluene, ethylbenzene, and total xylenes (BTEX compounds). These models were then used to develop potential remediation levels for these COCs under each wall failure scenario.

Fate and transport of 24 non-halogenated hydrocarbon COCs in the shallow depth interval were not directly modeled. Remediation levels for these COCs were instead developed based on the remediation levels of other hydrocarbon COCs, specifically ethylbenzene, which exhibited the least attenuation of the BTEX compounds. The remediation level for a given COC (RL_{COC}) was calculated using the following equation:

$$RL_{COC} = (CUL_{COC}/CUL_{ethylbenzene}) * RL_{ethylbenzene}$$

Where CUL_{COC} is the cleanup level of the COC, $CUL_{ethylbenzene}$) is the ethylbenzene cleanup level, and $RL_{ethylbenzene}$ is the ethylbenzene remediation level.

The following sections discuss selection of the BIOCHLOR model input parameters. Model parameters are also summarized on Tables B-1 and B-2.

2.1 GENERAL MODEL PARAMETERS

General model input parameters, including hydraulic conductivity, hydraulic gradient, porosity, soil bulk density, and soil total organic carbon content, are the same as those used in Technical Memorandum No. 1. Groundwater seepage velocities were calculated based on hydraulic conductivity, hydraulic gradient, and effective porosity values for each depth interval. The groundwater seepage velocity applied in the model for the shallow depth interval was 187 feet per year (ft/yr). The groundwater seepage velocity in the intermediate depth interval in the vicinity of the facility was 6.1 ft/yr. The predominantly silty sand and silt material in the intermediate depth interval near the facility grades to a less silty, sand to the west. Based on a review of drilling logs, it appears that the predominantly silty sand and silt material extends at least 400 feet to the west of the facility. The groundwater velocities west of this area are likely higher than the 6.1 ft/yr estimated for near the facility. The groundwater seepage velocity applied in the model west of these locations (i.e., 400 feet downgradient of the facility) was 187 ft/yr, the same as the water table/shallow depth intervals. BIOCHLOR was not developed to account for variable flow rates along a flow path. A modified modeling approach was developed for the intermediate depth interval, as discussed in Section 2.4 of this appendix.

Chemical-specific organic Koc are the same as were used for the selection of indicator COCs and the fate and transport modeling in Technical Memorandum No.1. Longitudinal (α_x) dispersivity was calculated based on the flow path length to the waterway. Transverse (α_y) dispersivity was set equal to 0.1 times α_x, based on the standard of practice and best professional judgment.

2.2 BIODEGRADATION HALF LIVES

Biodegradation half lives for PCE, TCE, DCE, and VC are the same as were used in Technical Memorandum No.1. The VC biodegradation half life of 2.4 years used in Technical Memorandum No.1 is three times the half life estimated through model calibration. The larger half life was selected previously to provide conservative remediation levels in and is used in this analysis for the same reasons.

Biodegradation half lives for other COCs are the literature values presented in Technical Memorandum for use in selecting indicator COCs. For several COCs there were either no reliable data on biodegradation half lives, or the literature indicated that biodegradation is negligible. In these cases, it was assumed that no biodegradation would occur and the biodegradation half life in the BIOCHLOR model was set equal to 10^{99} years.

2.3 SOURCE AREA TERMS

Source area concentrations were varied methodically until modeled concentrations at the Duwamish Waterway were below cleanup levels. The maximum source area concentration for a given failure scenario that met cleanup levels was selected as the remediation level. The source type was modeled as "continuous", meaning that concentrations exiting the HCIM barrier wall were assumed to be constant over time.

The source area width was varied, depending on the failure scenario. BIOCHLOR is not capable of modeling multiple sources, as would be the case with a series of failure cracks in the wall. Two approaches for accounting for multiple cracks were evaluated. The first approach was to use superposition, where model results for a single crack are multiplied by the number of cracks. The second approach modeled the source area width as equal to the total lateral open area along the length of the wall, such that four 6-inch cracks were modeled as a single 2 foot opening. Modeled concentrations at the Duwamish Waterway showed differences of less than 1 percent between the two approaches. For ease in model development and to allow direct comparison of model results between failure scenarios, the second approach described above was used for modeling the source area width.

2.4 INTERMEDIATE DEPTH INTERVAL MODEL APPROACH

Groundwater within the intermediate depth interval is expected to show two substantially different flow regimes. Near the facility, intermediate depth interval soils are predominantly interbedded silty sand and silt, and groundwater is estimated to flow at a velocity of about 6.1 ft/yr. Beginning approximately 400 feet downgradient from the facility, the intermediate aquifer materials become less silty and less interbedded. At this point the groundwater velocity is expected to be higher; more similar to the shallow depth interval of the aquifer. For the purposes of this evaluation, groundwater velocities in the intermediate depth interval 400 feet downgradient from the facility were assumed to be equal to the velocities in the water table and shallow depth intervals, or 187 ft/yr.

The different flow velocities observed in the intermediate depth interval require an appropriate modeling approach. The hydraulic component of the equations used in the BIOCHLOR model is based on a uniform groundwater velocity and does not allow for the use of different groundwater velocities in different locations. As noted above, the two groundwater flow rates observed in the intermediate depth interval do not fit the assumption of uniform flow inherent in the BIOCHLOR model. For this reason, the intermediate depth interval modeling was done by running the model in two steps, as follows. In the first step, the model was run using the 6.1 ft/yr velocity. The modeled steady state concentration at the downgradient end of the low velocity zone (established at 400 feet downgradient from the facility) was then used as the initial concentration to model the remaining flow path from the downgradient location to the Duwamish Waterway. Based on the 3,800-foot distance from the facility to the Duwamish Waterway, the first 400 feet was modeled with the 6.1 ft/yr seepage velocity and the remaining 3,400 feet with the 187 ft/yr velocity.

3.0 RESULTS

Based on the conceptual model of the failure scenarios outlined above and modeling using BIOCHLOR, remediation levels were developed that met groundwater cleanup levels prior to discharge to the Duwamish Waterway. Modeled remediation levels for each failure scenario in the shallow and intermediate depth intervals are presented in Tables B-3 and B-4, respectively. For reference, the maximum historical detected COC concentrations in each depth interval are also presented. In several cases the modeled remediation levels exceeded concentrations of 1 percent (10,000,000 μg/L). In these cases the remediation level is indicated as >10,000,000 μg/L.

Based on these results, maximum measured concentrations inside the HCIM are equal to or less than remediation levels protective of the Duwamish Waterway for wall failures of up to approximately 6 feet of lateral open area (twelve 6-inch cracks). Under the complete wall failure scenario maximum measured concentrations of the chlorinated ethenes, PCE, TCE, DCE, and VC in the shallow depth interval as well as several relatively non-degradable COCs in the shallow and intermediate depth intervals exceed remediation levels protective of the Duwamish Waterway. However, maximum concentrations of most other COCs, including chlorinated ethanes and non-halogenated hydrocarbons in the shallow depth interval and biodegradable hydrocarbons and the chlorinated ethenes and ethanes and in the intermediate depth interval, would be below remediation levels.

TABLE B-1

GENERAL MODEL INPUT PARAMETERS

PSC Georgetown Facility
Seattle, Washington

Parameter	Value	Units	Source
Advection - Shallow Depth Interval			
Hydraulic Conductivity	0.032	cm/s	Geometric mean of water table and shallow depth interval hydraulic conductivity values
Hydraulic Gradient	0.0017	ft/ft	Site-wide average for the water table and shallow sample intervals from the RI Report
Effective Porosity	0.3	unitless	Ecology default value
Seepage Velocity - Shallow Depth Interval	187.6	ft/yr	Calculated from conductivity times gradient divided by porosity
Advection - Intermediate Depth Interval			
Hydraulic Conductivity - Near PSC Facility	0.0011	cm/s	Geometric mean of intermediate sample interval hydraulic conductivity values
Hydraulic Gradient	0.0016	ft/ft	Site-wide average for the intermediate depth interval from the RI Report
Effective Porosity	0.3	unitless	Ecology default value
Seepage Velocity - Near PSC Facility	6.1	ft/yr	Calculated from conductivity near facility times gradient divided by porosity
Seepage Velocity - Downgradient of PSC Facility	187.6	ft/yr	Assumed to be same as water table and shallow depth interval seepage velocity
Dispersion			
α_x	41.6	Feet	Based on flow path length, calculated using modified Xu and Ekstein equation
α_y	4.2	Feet	Assumed as 0.1 times α_x, based on standard of practice
α_z	0	Feet	No vertical dispersion into intermediate unit assumed
Adsorption			
Soil Bulk Density	1.51	kg/L	Ecology default value
Fraction Organic Carbon	0.001	unitless	Ecology default value
Model Dimensions			
Model Length	3800	Feet	Distance from barrier wall to Duwamish River
Model Width	300	Feet	Sufficiently wide to define downgradient plume
Source Area Width	0.5 to 100	Feet	Variable, depending on Failure Scenario
Simulation Time	1,000	Years	Sufficient time to reach steady state conditions

TABLE B-2

PARTITIONING AND BIODEGRADATION INPUT PARAMETERS

PSC Georgetown Facility
Seattle, Washington

Constituent	Constituent Class	Koc (L/Kg)	Half Life (Years)
Tetrachloroethene	HAL VOC	265	1.2
Trichloroethene	HAL VOC	94	3
cis-1,2-Dichloroethene	HAL VOC	35.5	0.65
trans-1,2-Dichloroethene	HAL VOC	38	0.65
1,1-Dichloroethene	HAL VOC	65	0.65
Vinyl chloride	HAL VOC	18.6	2.4
1,1,1-Trichloroethane	HAL VOC	135	0.83
1,1-Dichloroethane	HAL VOC	53	0.31
1,2-Dichloroethane	HAL VOC	38	0.45
Chloroethane	HAL VOC	37.6	1
Chloroform	HAL VOC	53	2.4
1,2-Dichlorobenzene	MISC	379	No Degradation
1,4-Dichlorobenzene	MISC	616	No Degradation
1,4-Dioxane	MISC	4	No Degradation
2,4-Dimethylphenol	MISC	210	Biodegrades
2-Methylphenol	MISC	21.9	Biodegrades
4-Methylphenol	MISC	48.7	Biodegrades
Aroclor 1016	MISC	107,285	Not Determined
Aroclor 1232	MISC	107,285	Not Determined
Carbon disulfide	MISC	45.7	Not Determined
Cyanide	MISC	4.5	Biodegrades
Methylphenol	MISC	21.9	Biodegrades
Pentachlorophenol	MISC	592	Not Determined
Phenol	MISC	29	1.5
1,2,4-Trimethylbenzene	Non-HAL HC	3,715	No Degradation
1,3,5-Trimethylbenzene	Non-HAL HC	1,622	No Degradation
1-Methyl naphthalene	Non-HAL HC	730	Biodegrades
2-Hexanone	Non-HAL HC	24	Biodegrades
2-Methylnaphthalene	Non-HAL HC	2,512	Biodegrades
Benzene	Non-HAL HC	62	1.1
Benzo(a)anthracene	Non-HAL HC	357,537	Biodegrades
Benzo(b)fluoranthene	Non-HAL HC	1,230,000	Biodegrades
Benzo(k)fluoranthene	Non-HAL HC	1,230,000	Biodegrades
Benzoic acid	Non-HAL HC	398,000	
Chrysene	Non-HAL HC	398,000	Biodegrades
Cumene	Non-HAL HC	2,818	Not Determined
Dibenzo(a,h)anthracene	Non-HAL HC	1,789,101	Biodegrades
Diesel	Non-HAL HC	2,510	Biodegrades
Ethylbenzene	Non-HAL HC	204	1.6
Gasoline	Non-HAL HC	800	2
Indeno(1,2,3-cd)pyrene	Non-HAL HC	3,470,000	Biodegrades
Lube Oil	Non-HAL HC	2,510	2

TABLE B-2

PARTITIONING AND BIODEGRADATION INPUT PARAMETERS

PSC Georgetown Facility
Seattle, Washington

Constituent	Constituent Class	Koc (L/Kg)	Half Life (Years)
Methyl isobutyl ketone (MIBK)	Non-HAL HC	19	Biodegrades
Naphthalene	Non-HAL HC	1,191	0.53
n-Hexane	Non-HAL HC	1,468	Biodegrades
Propylbenzene	Non-HAL HC	741	Not Determined
sec-Butylbenzene	Non-HAL HC	891	Not Determined
Styrene	Non-HAL HC	912	No Degradation
Toluene	Non-HAL HC	140	0.98
Xylenes (Total)	Non-HAL HC	196	1.2

TABLE B-3

SHALLOW AND WATER TABLE DEPTH INTERVAL REMEDIATION LEVELS

PSC Georgetown Facility
Seattle, Washington

Constituent	Constituent Class	SWFS CUL (µg/L)	Maximum Measured Concentration (µg/L)	Failure Scenario and Remediation Level (µg/L)				Basis for Remediation Levels
				Single 6-Inch Crack	Four 6-Inch Cracks	Twelve 6-Inch Cracks	Complete Wall Failure	
Tetrachloroethene	HAL VOC	0.2	282	20,000	4,000	280	20	BIOCHLOR Model - Ethenes
Trichloroethene	HAL VOC	0.8	612	35,000	5,000	610	40	BIOCHLOR Model - Ethenes
cis-1,2-Dichloroethene	HAL VOC	165	14,500	100,000 (1)	35,000 (1)	21,000 (1)	1,200 (1)	BIOCHLOR Model - Ethenes
trans-1,2-Dichloroethene	HAL VOC	1,691	7,120	100,000 (1)	35,000 (1)	21,000 (1)	1,200 (1)	BIOCHLOR Model - Ethenes
1,1-Dichloroethene	HAL VOC	25	106	100,000 (1)	35,000 (1)	21,000 (1)	1,200 (1)	BIOCHLOR Model - Ethenes
Vinyl chloride	HAL VOC	2.04	15,400	1,000,000	35,000	15,000	900	BIOCHLOR Model - Ethenes
1,1,1-Trichloroethane	HAL VOC	11	1,980	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
1,1-Dichloroethane	HAL VOC	47	2,040	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
1,2-Dichloroethane	HAL VOC	30.6	1,100	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
Chloroethane	HAL VOC	461	1,530	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
Chloroform	HAL VOC	28	82	6,000,000	1,500,000	500,000	9,400	BIOCHLOR Model
1,2-Dichlorobenzene	MISC	14	51.5	12,500	3,100	1,040	63	BIOCHLOR, No Degradation
1,4-Dichlorobenzene	MISC	2.5	25	2,200	550	180	11	BIOCHLOR, No Degradation
1,4-Dioxane	MISC	94.9	207	84,000	21,000	7,000	425	BIOCHLOR, No Degradation
2,4-Dimethylphenol	MISC	28.5	921	25,000	6,300	2,100	130	BIOCHLOR, No Degradation
2-Methylphenol	MISC	13	282	11,500	2,800	960	59	BIOCHLOR, No Degradation
4-Methylphenol	MISC	108	1,930	96,000	23,000	8,000	480	BIOCHLOR, No Degradation
Aroclor 1016	MISC	0.005	15.4	4.5	1.1	0.4	0.023	BIOCHLOR, No Degradation
Aroclor 1232	MISC	0.005	25.9	4.5	1.1	0.4	0.023	BIOCHLOR, No Degradation
Carbon disulfide	MISC	0.92	9.76	821	200	68	4.2	BIOCHLOR, No Degradation
Cyanide	MISC	10	48.9	8,900	2,200	740	45	BIOCHLOR, No Degradation
Methylphenol	MISC	1,650	2,680	1,400,000	360,000	120,000	7,400	BIOCHLOR, No Degradation
Pentachlorophenol	MISC	2.5	48.7	2,250	560	180	11	BIOCHLOR, No Degradation
Phenol	MISC	118	6,630	100,000	26,000	8,700	530	BIOCHLOR, No Degradation
1,2,4-Trimethylbenzene	Non-HAL HC	78	951	69,000	17,000	5,700	350	BIOCHLOR, No Degradation
1,3,5-Trimethylbenzene	Non-HAL HC	55.7	755	49,000	12,000	4,100	250	BIOCHLOR, No Degradation

TABLE B-3

SHALLOW AND WATER TABLE DEPTH INTERVAL REMEDIATION LEVELS

PSC Georgetown Facility
Seattle, Washington

Constituent	Constituent Class	SWFS CUL (µg/L)	Maximum Measured Concentration (µg/L)	Failure Scenario and Remediation Level (µg/L)				Basis for Remediation Levels
				Single 6-Inch Crack	Four 6-Inch Cracks	Twelve 6-Inch Cracks	Complete Wall Failure	
1-Methyl naphthalene	Non-HAL HC	2.1	2.82	5,753,425	1,467,123	489,041	28,767	Ratio to ethylbenzene RL
2-Hexanone	Non-HAL HC	99	523	>10,000,000	>10,000,000	>10,000,000	1,356,164	Ratio to ethylbenzene RL
2-Methylnaphthalene	Non-HAL HC	2.1	21.7	5,753,425	1,467,123	489,041	28,767	Ratio to ethylbenzene RL
Benzene	Non-HAL HC	11.7	103	>10,000,000	>10,000,000	>10,000,000	4,400,000	BIOCHLOR Model
Benzo(a)anthracene	Non-HAL HC	0.02	0.0212	54,795	13,973	4,658	274	Ratio to ethylbenzene RL
Benzo(b)fluoranthene	Non-HAL HC	0.019	0.0417	53,151	13,553	4,518	266	Ratio to ethylbenzene RL
Benzo(k)fluoranthene	Non-HAL HC	0.018	0.0938	49,315	12,575	4,192	247	Ratio to ethylbenzene RL
Benzoic acid	Non-HAL HC	42	649	>10,000,000	>10,000,000	9,780,822	575,342	Ratio to ethylbenzene RL
Chrysene	Non-HAL HC	0.018	0.0741	49,315	12,575	4,192	247	Ratio to ethylbenzene RL
Cumene	Non-HAL HC	7.3	76	20,000,000	5,100,000	1,700,000	100,000	Ratio to ethylbenzene RL
Dibenzo(a,h)anthracene	Non-HAL HC	0.016	77.6	44,384	11,318	3,773	222	Ratio to ethylbenzene RL
Diesel	Non-HAL HC	500	224,000	>10,000,000	>10,000,000	>10,000,000	6,849,315	Ratio to ethylbenzene RL
Ethylbenzene	Non-HAL HC	7.3	21,900	20,000,000	5,100,000	1,700,000	100,000	BIOCHLOR Model
Gasoline	Non-HAL HC	800	161,000	>10,000,000	>10,000,000	>10,000,000	10,958,904	Ratio to ethylbenzene RL
Indeno(1,2,3-cd)pyrene	Non-HAL HC	0.02	0.0592	54,795	13,973	4,658	274	Ratio to ethylbenzene RL
Lube Oil	Non-HAL HC	500	1,490	>10,000,000	>10,000,000	>10,000,000	6,849,315	Ratio to ethylbenzene RL
Methyl isobutyl ketone (MIBK)	Non-HAL HC	170	806	>10,000,000	>10,000,000	>10,000,000	2,328,767	Ratio to ethylbenzene RL
Naphthalene	Non-HAL HC	12	362	32,876,712	8,383,562	2,794,521	164,384	Ratio to ethylbenzene RL
n-Hexane	Non-HAL HC	1	4.21	2,739,726	698,630	232,877	13,699	Ratio to ethylbenzene RL
Propylbenzene	Non-HAL HC	7.3	172	>10,000,000	5,100,000	1,700,000	100,000	Ratio to ethylbenzene RL
sec-Butylbenzene	Non-HAL HC	4.6	202	12,577,111	3,207,163	1,069,054	62,886	Ratio to ethylbenzene RL
Styrene	Non-HAL HC	0.5	47.4	1,369,863	349,315	116,438	6,849	Ratio to ethylbenzene RL
Toluene	Non-HAL HC	9.8	66,900	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model
Xylenes (Total)	Non-HAL HC	141	15,900	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model

(1) Remediation level is for total dichloroethenes.
> remediation level is greater than the indicated concentration

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TABLE B-4

INTERMEDIATE DEPTH INTERVAL REMEDIATION LEVELS

PSC Georgetown Facility
Seattle, Washington

Constituent	Constituent Class	SWFS CUL (µg/L)	Maximum Measured Concentration (µg/L)	Failure Scenario and Remediation Level (µg/L)				Basis for Remediation Level
				Single 6-Inch Crack	Four 6-Inch Cracks	Twelve 6-Inch Cracks	Complete Wall Failure	
Tetrachloroethene	HAL VOC	0.20	40.3	>10,000,000	>10,000,000	5,000,000	200,000	BIOCHLOR Model - Ethenes
Trichloroethene	HAL VOC	0.79	143,000	>10,000,000	>10,000,000	5,000,000	400,000	BIOCHLOR Model - Ethenes
cis-1,2-Dichloroethene	HAL VOC	165	85,400	>10,000,000 (1)	>10,000,000 (1)	>10,000,000 (1)	2,000,000 (1)	BIOCHLOR Model - Ethenes
trans-1,2-Dichloroethene	HAL VOC	1,691	12,800	>10,000,000 (1)	>10,000,000 (1)	>10,000,000 (1)	2,000,000 (1)	BIOCHLOR Model - Ethenes
1,1-Dichloroethene	HAL VOC	25	1,380	>10,000,000 (1)	>10,000,000 (1)	>10,000,000 (1)	2,000,000 (1)	BIOCHLOR Model - Ethenes
Vinyl chloride	HAL VOC	2.04	67,200	>10,000,000	>10,000,000	>10,000,000	2,000,000	BIOCHLOR Model - Ethenes
1,1,1-Trichloroethane	HAL VOC	11	16.5	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
1,1-Dichloroethane	HAL VOC	47	1,040	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model - Ethanes
1,2-Dichlorobenzene	MISC	14	197	12,500	3,100	1,000	64	BIOCHLOR, No Degradation
2,4-Dimethylphenol	MISC	28.5	444	25,000	6,300	2,100	130	BIOCHLOR, No Degradation
2-Methylphenol	MISC	13	302	11,600	2,900	970	59	BIOCHLOR, No Degradation
4-Methylphenol	MISC	108	2,230	96,000	24,000	8,000	490	BIOCHLOR, No Degradation
Carbon disulfide	MISC	0.92	46.6	800	200	69	4.2	BIOCHLOR, No Degradation
Cyanide	MISC	10	64.9	8,900	2,200	750	46	BIOCHLOR, No Degradation
Phenol	MISC	118	4,670	100,000	26,500	8,800	540	BIOCHLOR, No Degradation
1,2,4-Trimethylbenzene	Non-HAL HC	78	475	69,000	17,000	5,800	350	BIOCHLOR, No Degradation
Benzene	Non-HAL HC	11.7	73.6	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model
Diesel	Non-HAL HC	500	1,500	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model
Ethylbenzene	Non-HAL HC	7.3	2,200	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model
Lube Oil	Non-HAL HC	500	516	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model
Styrene	Non-HAL HC	0.5	6.1	450	110	37	2.3	BIOCHLOR, No Degradation
Toluene	Non-HAL HC	9.8	3,520	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model
Xylenes (Total)	Non-HAL HC	141	884	>10,000,000	>10,000,000	>10,000,000	>10,000,000	BIOCHLOR Model

(1) Remediation level is for total dichloroethenes.
\> remediation level is greater than the indicated concentration

APPENDIX C

Technology Comparisons

APPENDIX C
REMEDIAL TECHNOLOGY PERFORMANCE
HCIM AREA

PSC Georgetown Facility
Seattle, Washington

Ecology has requested that PSC evaluate the capabilities and performance of groundwater remediation technologies that may be implemented at the PSC Georgetown facility and estimate the time frame for these technologies to reach cleanup levels and remediation levels. The remediation technologies evaluated include:

- Monitored natural attenuation;
- Enhanced anaerobic bioremediation;
- In situ chemical oxidation;
- In situ thermal treatment (steam injection); and
- Groundwater extraction for mass reduction.

Several factors within the HCIM Area limit the ability of PSC to estimate cleanup time frames with any degree of certainty, including the suspected presence and nature of distribution of DNAPL. PSC performed a literature review to identify other sites with conditions similar to the PSC Georgetown facility where these technologies were implemented. When available, information on the performance of the remediation technologies was reviewed, including mass reduction achieved, time frame, and cost. In addition, significant hurdles that were encountered during the implementation of these technologies were also identified. The results of this literature review are summarized on Tables C-1 through C-19. The conditions (e.g., COCs, contaminant mass, lithology, depth of impacts, etc.) of the sites where these technologies were implemented were then compared and contrasted to the conditions at the PSC Georgetown facility. Finally, the potential performance of these technologies was estimated for the PSC Georgetown site based on their performance at other sites (taking into account differing conditions between the facility and the other sites). In addition, the time frame for each HCIM area remedial alternative to achieve cleanup levels was also estimated. It should be stressed that time frames for achieving cleanup levels cannot be calculated accurately for in situ technologies and alternatives, particularly where site conditions are extremely complex. As a result, the time frames provided should be considered relative to each other rather than explicit time frames.

MONITORED NATURAL ATTENUATION

As shown on Tables C-1 through C-3, multiple Air Force facilities were identified where monitored natural attenuation was evaluated for use at petroleum hydrocarbon and chlorinated solvent sites. At Kelly Air Force Base, it was estimated that source removal (excavation) and natural attenuation would reduce concentrations of benzene in groundwater from 2,800 µg/L to below groundwater quality standards within 10 years. However, the mechanism under which petroleum hydrocarbons were attenuating at the site (e.g., dispersion, aerobic oxidation, anaerobic oxidation, etc.) was not identified in the information reviewed. For sites where free-phase hydrocarbons were present, BTEX compounds were estimated to naturally attenuate below cleanup standards within approximately 30 years.

Multiple Air Force sites with chlorinated solves (PCE, TCE, and associated daughter products) were also evaluated for natural attenuation. The degree and rate of intrinsic bioremediation was determined to be highly site specific and dependent upon the groundwater biochemistry and geochemistry at the site under consideration. The study concluded that quantifying intrinsic bioremediation at chlorinated solvent sites is difficult.

Although free-phase petroleum hydrocarbons have not been observed within the HCIM Area, elevated concentrations of ethylbenzene (21.9 mg/L), toluene (66.9 mg/L), and total xylenes (15.9 mg/L) have been detected in the water table and shallow depth groundwater intervals. Groundwater conditions within the HCIM Area are significantly different than the sites evaluated in the Air Force study due to the presence of the barrier wall, which limits off-site migration of COCs and groundwater recharge of the HCIM Area. However, it can be reasonably assumed that intrinsic bioremediation would reduce concentrations of petroleum compounds within HCIM Area groundwater below cleanup standards within 20 to 30 years within the Shallow Aquifer based on results of monitored natural attenuation observed at other sites (see Tables C-2 and C-3). This time frame is likely optimistic since hydrocarbons biodegrade primarily under aerobic conditions and the HCIM Area is expected to remain anaerobic for a long time.

Although intrinsic bioremediation was observed at 14 Air Force sites with chlorinated solvent impacts in groundwater, the degree and rate of natural attenuation were highly variable. As discussed in Technical Memorandum No. 1, DNAPL is suspected to be present in two locations in the HCIM Area based on detected groundwater concentrations in the intermediate zone. The conceptual site model assumes that DNAPL is likely present primarily in the intermediate aquifer, which is consists of interbedded silty sands and sandy silts. However, DNAPL ganglia may remain in the shallow depth interval in limited quantities. Intrinsic bioremediation is unlikely to reduce concentrations of chlorinated solvents in the intermediate groundwater depth interval in the foreseeable future due to the fact that the majority of the DNAPL mass is likely sorbed to the silt or within the silt and as such will not be amenable to fast biodegradation. In addition, DNAPL and highly impacted source areas have not been shown to naturally attenuate in a reasonable time frame. For cost estimating purposes, groundwater cleanup levels for chlorinated VOCs would not likely be attained for the water table/shallow interval and intermediate depth interval for at least 100 to 250 years—in essence the foreseeable future.

ENHANCED ANAEROBIC BIOREMEDIATION

As shown in Tables C-4 through C-8, several sites were identified where enhanced anaerobic bioremediation was implemented to reduce concentrations of chlorinated solvents, including three sites where the presence of DNAPL was suspected. Although results varied, significant reductions in concentrations were observed at all sites with reported data. At the Pinellas Northeast Site (suspected DNAPL site), VOC concentrations were reduced between approximately 60 and 90 percent (%) within 2 months of initiating enhanced anaerobic bioremediation. It should be noted, however, that a significant portion of the concentration reductions observed were likely due to groundwater mixing and contaminant redistribution resulting from the groundwater recirculation system installed at the site. At the Boone site (part of a study of multiple dry cleaner sites), PCE concentrations were reduced by 85 to 95%. However, based on a pre-biostimulation PCE concentration of 89,800 µg/L, PCE concentrations above 5,000 µg/L remain at one of the sites remediated.

Based on a review of available data, enhanced anaerobic bioremediation could conservatively be expected to reduce VOC concentrations in the water table/shallow depth interval in the HCIM Area by approximately 75% in less than 5 years. However, significant concentrations of chlorinated VOCs would remain. Based on maximum detected concentrations in the HCIM Area, remaining cis-1,2-DCE, and vinyl chloride concentrations could be as high as 3,600 µg/L, and 3,900 µg/L, respectively. It is anticipated that natural attenuation of the remaining VOC would achieve cleanup levels in the water table/shallow depth interval within approximately 30 to 40 years following the completion of enhanced anaerobic bioremediation activities (Table C-20); however, remediation of the Intermediate Aquifer would not likely be possible using enhanced anaerobic bioremediation due to the issue of interbedded silt and sand discussed above. As a result, diffusion from the Intermediate Aquifer to the Shallow Aquifer is likely and concentrations would remain above cleanup levels for the foreseeable future.

IN SITU CHEMICAL OXIDATION

Two studies were identified during the literature review that evaluated the performance of in situ chemical oxidation at sites with halogenated VOCs (Tables C-9 and C-10). At the Cape Canaveral Air Force Station, a dilute solution of potassium permanganate (1.4 to 2%) was used to treat TCE in groundwater to a depth of 45 feet bgs. As shown on Table C-9 the mass of dissolved phase TCE and DNAPL was reduced by 77 and 76%, respectively. Approximately 840,000 gallons of permanganate solution were injected during three injection events [approximately 150,000 pounds of permanganate (ITRC, 2005)]. The greatest mass reductions occurred in the upper treatment zone, which consisted of coarse grained sandy soils. Oxidant distribution was limited in some portions of the study area due to local heterogeneities.

The second study identified during the literature review evaluated the performance of ISCO at six dry cleaner sites. DNAPL was reported or suspected to be present at five of the six sites. Potassium permanganate was used as the oxidant at three of the sites. Cleanup goals were achieved at one of the six sites. Concentrations of chlorinated solvents at the remaining sites were not significantly reduced, or were not reduced below cleanup goals. The mass reduction achieved at each site was not reported. It should be noted that at sites where DNAPL is present, significant reductions in DNAPL mass must be achieved in order to reduce concentrations of dissolved phase organics.

Based on the amount of mass reduction achieved at the Cape Canaveral site, in situ chemical oxidation may reduce the mass of halogenated VOCs in the water table/shallow groundwater depth interval within the HCIM Area by 75% within 4 years (the duration of the proposed ISCO program). However, a significant mass of chlorinated VOCs would remain within the treatment zone. In addition, the studies all indicate that success is greatly reduced by heterogeneous soils, and as a result ISOC is not considered to be effective for significantly reducing VOCs within the Intermediate Aquifer. As a result, ISOC is not proposed for the Intermediate Aquifer. Similar to enhanced anaerobic bioremediation, it is anticipated that natural attenuation of the remaining VOC concentrations would be expected to achieve cleanup levels in the water table/shallow depth interval within approximately 30 to 40 years following the completion of the ISCO program (Table C-20) if the Intermediate Aquifer was also able to be remediated. Since the Intermediate Aquifer cannot be effectively treated with ISOC, diffusion and mixing of COCs from the intermediate to the shallow groundwater would keep COC concentrations above cleanup levels for the foreseeable future.

STEAM INJECTION

As shown on Tables C-11 to C-14, several studies were identified during the literature review that evaluated the use of thermal technologies to reduce dissolved-phase VOC concentrations and DNAPL mass in groundwater. At a former electronics manufacturing facility in Skokie, Illinois, steam injection reduced the area of halogenated solvent impacts (TCE, TCA, and DCE) from approximately 115,000 square feet to approximately 23,000 square feet (80%). However, the amount of contaminant mass removed by steam injection was not identified. Six-phase thermal heating was subsequently conducted at the site in areas where subsurface features (man-made) reduced the effectiveness of the steam injection system. Reductions in groundwater concentrations achieved by six-phase heating ranged from 92 to 96%. The treatment depth for of steam and six-phase heating at the site was 24 feet, and the treated groundwater interval was 17 feet in thickness.

At a telecommunications manufacturing facility in Chicago, Illinois, steam-enhanced groundwater and vapor-phase extraction removed approximately 25,900 pounds of chlorinated VOCs and minerals spirits. The contaminant mass present at the site prior to treatment was not provided. Mean TCE concentrations were reduced from 45,000 to 500 µg/L during 24 months of system operation. Prior to treatment, both LNAPL and DNAPL were present in soil and groundwater at the facility. During the duration of the study, the number of wells that indicated the potential presence of DNAPL (TCE concentration of 10 mg/L or greater) was reduced from 13 to 1. The lithology of the treatment zone consists primarily of highly permeable glacial till. Steam injection was conducted at depths up to 45 feet bgs at the site.

The steam injection system included in HCIM Area Alternatives HA-5 and HA-6 is similar to the system implemented at the Illinois telecommunications manufacturing facility. However, several key differences between the HCIM Area and the Illinois site may result in lower mass reductions within the HCIM Area, including:

- The depth of the targeted treatment zone in the HCIM Area extends to 90 feet bgs;
- The intermediate depth interval consists of discontinuous interbedded silty sand and sandy silt lenses;

- The presence of the HCIM barrier wall and the TASCO building precludes the treatment of a significant portion (approximately 40%) of the suspected DNAPL areas.

If the steam injection system proposed for Alternatives HA-5 and HA-6 reduced the mass of dissolved-phase organics and DNAPL by 90% in the treatment area (an optimistic assumption based on the Chicago study), 46% of the original COC mass would remain within the HCIM Area. This reduction in mass is unlikely to reduce concentrations of dissolved-phase organics at intermediate depth due to the continued presence of DNAPL. Enhanced anaerobic bioremediation and monitored natural attenuation (Alternative HA-5) may take up to an additional 20 to 30 years to reduce the remaining VOC concentrations below cleanup levels in the water table/shallow depth interval (Table C-20). Monitored natural attenuation in the intermediate depth interval would be unlikely to reduce VOC concentrations below cleanup levels for up to 120 years (Table C-21. As a result, diffusion and mixing from the intermediate zone to the shallow zone will likely result in VOC concentrations not being reached in the shallow zone for the foreseeable future.

PUMP AND TREAT

Five sites with pump and treat systems were identified during the literature that had similar conditions to the PSC Georgetown facility, including the presence of DNAPL and elevated metals concentrations (Tables C-15 through C-19). At the Lawrence Livermore National Laboratory site in California, a groundwater recovery and treatment system removed an estimated VOC mass of 21.8 pounds from 93.8 million gallons of groundwater over a period of 6 years (at a total cost of $38.6M, including installation and operation of an SVE system (Table C-15). It is estimated that the groundwater extraction system at the site would need to operate for 55 years to achieve MCLs. The size and depth of the targeted treatment area were not identified in the information provided.

At the Solid State Circuits Superfund Site in Missouri (Table C-17), a groundwater recovery and treatment system removed approximately 2,800 pounds of TCE during approximately 10 years of operations (1987 through 1996). Seven groundwater extraction wells, installed to depths of 90 to 985 feet bgs, were pumped at an average total rate of 34 gpm. The size of the VOC plume and mass of contaminants present were not identified in the information provided. TCE concentrations remained well above cleanup goals (5 µg/L) at the end of the study.

A groundwater pump and treat system at the Odessa Chromium II Superfund Site (Table C-19) removed 141 pounds of chromium from 121 million gallons of treated groundwater over

4 years of operation (Dec. 1993 – Dec. 1997). The system included 10 extractions wells installed to depths of 70 and 165 feet bgs. Treated groundwater was reinjected at the 20-acre site. Similar to the HCIM Area, the site was surrounded by a low-permeability barrier wall. Chromium concentrations in all 10 extraction wells were below the cleanup goal by December 1999, and the system was decommissioned. Problems encountered during initial startup operations of the system included clogging of injection wells and precipitation of iron and calcium on a multimedia filter (part of the groundwater treatment system).

Alternative HA-6 includes operation of a groundwater recovery system following the completion of steam injection in the HCIM Area. As discussed above, steam injection would reduce the mass of VOC in HCIM Area groundwater (dissolved phase and DNAPL) by approximately 54%. Based on the mass reductions achieved at similar sites, the pump and treat system could potentially reduce organic COC concentrations below cleanup levels in the water table/shallow depth interval within 10 to 15 years (Table C-20), but the organic COC concentrations in the intermediate depth interval are unlikely to be reduced below cleanup levels for up 200 years (Table C-21). As a result, COC concentrations in the shallow aquifer are likely to continually be impacted for years to come. It should also be noted that pump and treat relies on groundwater moving by contaminant mass and solubilizing the COCs such that they can be captured by the pump and treat. However, in reality pumping wells create an increase in groundwater velocity toward the pump which lessens the chance for COCs to become soluble. This results in less mass than expected being removed and longer remediation time frames. For this reason, pump and treat has not been used for mass removal in recent years, but remains effective as a hydraulic control.

REFERENCES

ITRC (Interstate Technology Regulatory Council), Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater, January 2005.

TABLE C-1

EXAMPLE APPLICATION OF MONITORED NATURAL ATTENUATION FOR GASOLINE IN SOIL, GROUNDWATER, AND SOIL VAPOR

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Kelly Air Force Base **Location:** Kelly AFB, Texas **Contaminants:** Gasoline constituents BTEX concentrations in groundwater measured as high as 2,807 µ/L in November 1997 **Type/Quantity of Media Treated:** Soil, groundwater, and soil gas • Source area plus dissolved plume covers 1.5 acres • The site is underlain by silty clay; with a distinct clay unit from 35 to 40 feet (ft) bgs • Groundwater occurs primarily in silt and possibly caliche seams that produce only small amounts of water; static groundwater levels range from 5 to 25 ft bgs, depending on location and season • Hydraulic conductivity of the silty clay unit is 0.2 to 0.5 ft/day based on slug tests, and the estimated horizontal groundwater flow velocity is 31 ft/year. **Description:** As a result of UST integrity testing in 1989, the former Building 2093 Gas Station at Kelly Air Force Base, Texas, was found to be leaking, and the UST and associated piping were removed in 1991. Site investigations found BTEX contamination in the groundwater. A 1-year bioventing pilot test was concluded in January 1995; the test results indicated that site soils were not sufficiently permeable to enable use of this in situ source reduction technique. In 1995, the dispensing islands and remaining below-grade piping were removed, and 2,750 cubic yards of soil in the area of the former tank pad and dispensing islands were excavated. Based on a RBCA analysis, the Texas Natural Resources Conservation Commission (TNRCC) issued a no-further-action memorandum closing the site based on plume stability, the occurrence of natural attenuation of fuel residuals, and the conclusion that site contamination will not pose a significant risk to potential receptors.	Monitored Natural Attenuation: Monitoring network not described	**Regulatory Requirements/Cleanup Goals:** TNRCC Plan A target concentrations for Category II aquifers and TNRCC target concentrations for construction worker exposure are the cleanup goals for affected groundwater. **Results:** Based on a Tier 1 screening, only the Plan A concentration for benzene of 0.0294 mg/L was exceeded, and benzene in groundwater and soil was identified as a contaminant of potential concern. Fate and transport modeling using the analytical code BIOSCREEN indicated that the maximum migration distance of dissolved benzene from the source area will be approximately 300 ft, and that dissolved benzene concentrations will be below groundwater quality standards within 10 years. Results of groundwater sampling events indicated that the dissolved contaminant plume is not increasing in areal extent, and that natural attenuation indicator parameters exhibit trends associated with a plume that is being naturally degraded. The site was identified as a candidate for immediate closure according to TNRCC guidance. The Air Force will restrict use of the shallow groundwater at the site until all dissolved benzene concentrations decrease below TNRCC Plan A Category II criterion of 0.0294 mg/L. Maximum-detected concentrations of BTEX in soil gas were compared to the chemical-specific OSHA 8-hour time-weighted average permissible exposure limits (PELs), and there were no exceedances.	July 1997 to July 1998	Not provided.

TABLE C-2

EXAMPLE APPLICATION OF MONITORED NATURAL ATTENUATION FOR PETROLEUM HYDROCARBONS IN GROUNDWATER

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Multiple AF Sites **Location:** Multiple locations throughout U.S. **Contaminants:** BTEX, Total Petroleum Hydrocarbons (TPH) • BTEX concentrations were measured as high as 46,300 μ/L (benzene), 57,000 μ/L (toluene), 4,410 μ/L (ethylbenzene), and 68,000 μ/L (xylenes) • TPH concentrations were measured as high as 120,000 mg/L **Type/Quantity of Media Treated:** Groundwater • Depths to groundwater ranged from 0 to 48 feet (ft) bgs • Plume areas ranged from 0.3 to 60 acres • Average groundwater temperatures ranged from 5.5 to 26.9°C • Aquifer matrices ranged from silty clays to coarse sand and gravel **Description:** In June 1993, the Air Force Center for Environmental Excellence (AFCEE), in cooperation with EPA/ORD, began an initiative to evaluate the effectiveness of MNA for remediation of groundwater contaminated with fuel hydrocarbons (also, refer to separate report about use of MNA for groundwater contaminated with chlorinated solvents). From 1993 to 1998, field demonstrations of MNA were conducted at 42 Air Force sites throughout the country. This included installing additional sampling points at the sites and collecting and evaluating data over a period of time. The sites were evaluated for evidence that fuel hydrocarbons were being naturally attenuated, and to identify the degree and rate of attenuation. Data showed that fuel hydrocarbons were undergoing natural attenuation at all 42 Air Force sites, and that the degree and rate of intrinsic bioremediation was site-specific, involving processes such as sulfate reduction, methanogenesis, iron reduction, denitrification, and aerobic oxidation. The effect on plume size varied, with the plume stable at 35 sites, receding at six sites, and expanding at one site. For sites with measurable free-phase product, the average predicted time frame for dissolved BTEX to naturally attenuate to below cleanup standards was estimated at approximately 30 years; the addition of engineered source reduction reduced the estimate to 20 years or less, depending on type of source reduction used.	Monitored Natural Attenuation (MNA) • Intrinsic bioremediation including sulfate reduction, methanogenesis, denitrification, and aerobic oxidation. • During the demonstrations, groundwater was sampled for contaminant concentrations, and other parameters including pH, temperature, conductivity, oxidation/reduction potential, dissolved oxygen, nitrate, nitrite, sulfate, sulfide, ferrous iron, total iron, methane, carbon dioxide, and alkalinity; geochemical trends and biodegradation rates also were evaluated.	**Regulatory Requirements/Cleanup Goals:** • Goals of the demonstration included evaluating the potential for fuel hydrocarbons to be naturally attenuated, the type of biodegradation processes taking place, and the effect on plume size. **Results:** • Fuel hydrocarbons were undergoing natural attenuation at all 42 Air Force sites. • Key biodegradation processes were identified, in decreasing order of assimilative capacity, as sulfate reduction, methanogenesis, iron reduction, denitrification, and aerobic oxidation; the total BTEX assimilative capacity of groundwater averaged 64 mg/L. • With respect to plume size, 35 sites had plumes that appeared to be stable, six sites had plumes that were receding, and one site had a plume that was expanding. • For sites with measurable free-phase product, the average predicted time frame for dissolved BTEX to naturally attenuate to below cleanup standards was estimated at approximately 30 years; the addition of engineered source reduction reduced the estimate to 20 years or less, depending on type of source reduction used. • Regulatory authorities have approved the partial or full use of MNA with institutional controls at 17 of the 42 sites.	Field demonstrations conducted between July 1993 and December 1998. Periods of operation were not provided for each site.	The average cost per site in this demonstration for completing site characterization using existing monitoring wells and a Geoprobe®, laboratory and data analysis, fate and transport modeling, and reporting was $125,000. A recommended long-term monitoring program for MNA, including an average network of 11 wells, has a projected average annual cost of $192,000.

TABLE C-3

EXAMPLE APPLICATION OF MONITORED NATURAL ATTENUATION FOR CHLORINATED SOLVENTS IN GROUNDWATER

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Multiple AF Sites **Location:** Multiple locations throughout U.S. **Contaminants:** Chlorinated Solvents • Chlorinated aliphatic hydrocarbons, including TCE, cis- and trans-1,2-DCE,1,1-DCE, and VC • TCE was the most pervasive contaminant, followed by cis-1,2-DCE - found at13 of 14 sites Maximum values for TCE ranged from 39,400 µg/L to 259 µg/L Maximum values for DCE ranged from 4,590 µg/L to 1,400 µg/L Maximum values for VC ranged from 1,350 µg/L to 1.3 µg/L **Type/Quantity of Media Treated:** Groundwater • Depths to groundwater ranged from 0 to 60 feet (ft) bgs • Plume areas ranged from 1.6 to 210 acres • Average groundwater temperatures ranged from 9.1 to 25.6°C • Aquifer matrices ranged from clays to coarse sand and gravel **Description:** In June 1993, the Air Force Center for Environmental Excellence (AFCEE), in cooperation with EPA/ORD, began an initiative to evaluate the effectiveness of monitored natural attenuation (MNA) for remediation of groundwater contaminated with chlorinated solvents (also, refer to separate report about use of MNA for groundwater contaminated with fuel hydrocarbons). From 1993 to 1999, field demonstrations of MNA were conducted at 14 Air Force sites throughout the country. This included installing additional sampling points at the sites and collecting and evaluating data over a period of time. The sites were evaluated for evidence that chlorinated solvents were being naturally attenuated, and to identify the degree and rate of attenuation. Data showed that chlorinated solvents were undergoing natural attenuation at all 14 Air Force sites, and that the degree and rate of intrinsic bioremediation was highly site-specific, and depended on the bio- and geo-chemistries of groundwater at the sites. The effect on plume size varied, with the plume expanding at three sites, remaining stable or expanding slowly at six sites, and remaining stable or receding at five sites. The study concluded that use of MNA for remediation of chlorinated solvents is highly site-specific, and that quantifying intrinsic bioremediation is difficult. The study states that engineered alternatives, such as source reduction, also should be evaluated to determine how they would limit plume migration and/or accelerate attainment of target cleanup levels.	Monitored Natural Attenuation (MNA) • During the demonstrations, groundwater was sampled for contaminant concentrations, and other parameters including pH, temperature, conductivity, oxidation/reduction potential, dissolved oxygen, nitrate, nitrite, sulfate, sulfide, ferrous iron, total iron, and dissolved hydrogen; geochemical trends and biodegradation rates also were evaluated. • Four types of plume behavior were studies - Type 1 (anaerobic groundwater conditions with anthropogenic carbon); Type 2 (anaerobic groundwater conditions with native carbon); Type 3 (aerobic groundwater conditions with anthropogenic and/or native carbon); and mixed (different portions of the groundwater plume exhibiting different types of behavior).	**Regulatory Requirements/Cleanup Goals:** • Goals of the demonstration included evaluating the potential for chlorinated solvents to be naturally attenuated, the type of attenuation processes taking place, and the effect on plume size. **Results:** • Chlorinated solvents were undergoing natural attenuation at all 14 Air Force sites. • The degree and rate of intrinsic bioremediation was highly site-specific, and depended on the bio- and geo-chemistries of groundwater at the sites. • 11 of the sites exhibited mixed behavior, with nine exhibiting Type 1 coupled with either Type 2 or Type 3, and two sites exhibiting Type 2 behavior coupled with Type 3. Three of the sites exhibited primarily Type 1 behavior. • With respect to plume size, three sites had expanding plumes, six sites had plumes that were either stable or expanding slowly, and five sites had plumes that were either stable or receding.	• Field demonstrations conducted between July 1993 and August 1999. • Periods of operation were not provided for each site.	Typical Natural Attenuation Treatability Study Costs: Site Visit / Technical Support $9,010 Work Plan / Regulatory Approval $20,300 Field Work Labor $9,760 Field Work Other Direct Costs (ODCs): Survey/Supplies/ Per Diem $6,150 Geoprobe/Cone Penetrometer Operation $878 Data Analysis/Analytical $18,200 Total Field Work ODCs $25,300 Modeling $19,400 Treatability Study Report $38,100 TOTAL $147,098

TABLE C-4

EXAMPLE APPLICATION OF ENHANCED ANAEROBIC BIOREMEDIATION FOR CHLORINATED SOLVENTS IN GROUNDWATER

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Pinellas Northeast Site **Location:** Largo, Florida **Contaminants:** Chlorinated solvents, including trichloroethene, methylene chloride, dichloroethene, and vinyl chloride Concentrations ranged from 10-400 mg/kg DNAPL suspected to occur in localized areas **Type/Quantity of Media Treated:** Groundwater • Water table present approximately 3-4 feet (ft) below ground surface (bgs) • Aquifer characterized as sandy • Hydraulic conductivity of surficial aquifer in study is relatively heterogeneous; zones of reduced hydraulic conductivity occur at depths between 10 to 14 ft and 22 to 29 ft • Approximately 250,000 gallons of water were treated **Description:** The Pinellas STAR Center operated from 1956 to 1994, manufacturing neutron generators and other electronic and mechanical components for nuclear weapons under contract to the U.S. Department of Energy and its predecessor agencies. The Northeast site is associated with the location of a former waste solvent staging and storage area. In the 1950s and 1960s, an existing swampy area at the site was used for staging and burial of construction debris and drums, some of which contained solvents. The site consists of a shallow groundwater aquifer contaminated with a variety of VOCs, including chlorinated solvents such as trichloroethene, methylene chloride, dichloroethene, and vinyl chloride. From February 7, 1997, to June 30, 1997, a demonstration using in situ anaerobic bioremediation was conducted at the site. The demonstration was part of a program at the Pinellas STAR Center to evaluate several innovative remediation technologies that could enhance the cost or performance of an existing pump-and-treat system. The pilot system was located in an area of the site that had total chlorinated contaminant concentrations in groundwater generally ranging from 10-400 mg/kg, with one monitoring well having concentrations in excess of 2,900 mg/kg. The bioremediation pilot system consisted of three 8-ft deep gravel-filled, surface infiltration trenches and two 240-ft long horizontal wells with 30-ft screened intervals. The horizontal wells, directly underlying and parallel to the middle surface trench, were at 16- and 26-ft depths. The study area was about 45 ft by 45 ft and extended from the surface down to a thick, clay confining layer 30 ft below the surface. Groundwater was extracted from the upper horizontal well and recirculated via the surface trenches and the lower horizontal well while benzoate, lactate, and methanol were added to the recirculated water to serve as nutrients for the dechlorinating bacteria.	In Situ Anaerobic Bioremediation • Three, 8-ft deep gravel-filled, surface infiltration trenches and two, 240-ft long horizontal wells with 30-ft screened intervals. • Groundwater extracted from upper horizontal well and recirculated via surface trenches and lower horizontal well at a rate of about 1.5 gpm. • Benzoate, lactate, and methanol added to recirculated water to serve as nutrients for dechlorinating bacteria. • 250,000 gallons of water circulated during pilot study over 5-month period	**Regulatory Requirements/Cleanup Goals:** The objectives of this demonstration included evaluating the use of nutrient injection to enhance in situ anaerobic biological degradation of chlorinated VOCs in areas of moderate contaminant concentrations and obtaining operating and performance data on this technology. **Results:** Evaluated use of nutrient injection to enhance in situ anaerobic biological degradation of chlorinated VOCs in areas of moderate contaminant concentrations. Obtained operating and performance data to optimize the design and operation of a full-scale system. VOC concentrations reduced 60% - 91% within 4 to 8 weeks after nutrient arrival. Contaminant reduction probably result of groundwater mixing and contaminant redistribution. Limiting factors for successful, cost effective implementation are ability to deliver appropriate nutrients to all contaminated areas and hydraulic travel times.	February 7, 1997, to June 30, 1997	Mobilization and preparatory work $35,000 Monitoring, sampling, testing, and analysis $87,536 Groundwater collection and control $238,310 Biological treatment $23,748 General requirements $12,480 TOTAL $397,074

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TABLE C-5

EXAMPLE APPLICATION OF ENHANCED ANAEROBIC BIOREMEDIATION AT MULTIPLE DRY CLEANER SITES

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Multiple (5) Dry Cleaner Sites - In Situ Bioremediation **Location:** -- Blacks Cleaners, Portland, Oregon • Boone Dry Cleaners, Jackson, Tennessee • Carousel Cleaners, Oregon City, Oregon • Former 60 Minute Cleaners, Ft. Myers, Florida • Village Green Shopping Center, Rockledge, Florida **Contaminants:** Blacks (Groundwater) cis-1,2-DCE - 39 mg/L; dichlorobenzenes - 0.003 mg/L; PCE - 8.7 mg/L; TCE - 10.4 mg/L; vinyl chloride 0.35 mg/L; xylenes 0.05 mg/L (Soil) cis-1,2-DCE - 10.9 mg/kg; PCE - 1,100 mg/kg; TCE - 91.6 mg/kg; vinyl chloride - 0.14 mg/kg Boone (Groundwater) 1,1-DCE - 2.7 µg/L; benzene - 32,100 µg/L; cis-1,2-DCE - 1780 µg/L; m-xylene - 16,300 µg/L; PCE - 89,800 µg/L; trans-1,2-DCE - 6.0 µg/L; TCE – 610 µg/L; vinyl chloride - 220 µg/L (Soil): cis-1,2-DCE - 156 µg/kg; lead - 151 mg/kg; m-xylene - 283 µg/kg; PCE - 6,090 mg/kg; trans-1-2-DCE - 13 µg/kg; TCE - 39 µg/kg Carousel (Groundwater) PCE - up to 25,700 µg/L (Soil) PCE - up to 7,000 mg/kg Former 60 (Groundwater) 1,1-DCA - 8.6 µg/l; 1,1-DCE - 1,050 µg/l; benzene - 150 µg/l; cis-1,2-DCE - 2,321 µg/l; MTBE - 29.5 µg/l; PCE - 6,820 µg/l; trans- 1,2-DCE - 150 µg/l; TCE - 2,040 µg/l; vinyl chloride - 150 µg/l (Soil): PCE - 1,800 µg/kg; TCE - 2.97 µg/kg Village Green (Groundwater) cis-1,2-DCE - 8,550 µg/L; PCE - 27,300 µg/L; TCE - 7,900 µg/L; vinyl chloride – 780 µg/L (Soil) PCE - 564,000 µg/kg; TCE - 5,007 µg/kg **Type/Quantity of Media Treated:** Soil, groundwater, DNAPL • Blacks: Groundwater, soil, DNAPL; depth to groundwater: varies seasonally from 6 to 12 feet (ft) • Boone: Groundwater, soil; depth to groundwater: 10.11 ft (shallow); 45.87 (intermediate); 65.85 (deep) • Carousel: Groundwater, soil; depth to groundwater: seasonally varies from 10 to 20 ft bgs • Former 60: Groundwater, soil; depth to groundwater: 4 ft bgs • Village Green: Groundwater, soil, DNAPL; depth to groundwater: 4 ft bgs **Description:** In situ bioremediation was conducted at five drycleaner sites contaminated primarily with chlorinated solvents from dry cleaning operations. PCE, TCE, DCE, and vinyl chloride were the main contaminants of concern in soil and groundwater. At two sites (Blacks and Village Green), DNAPLs were present. The remediations, including full-scale and pilot-scale bioremediation, involved the subsurface injection of various additives such as sodium lactate, soybean oil, corn syrup, Simple Green®, vegetable oil, BioRem H-10, and ethyl lactate. Results of the bioremediation were available for four of the five sites. Reductions in PCE and TCE concentrations and increases in PCE and TCE biodegradation products were reported for all four sites. At Boone, the remedy of corn syrup, Simple Green, and vegetable oil caused the vegetable oil to float on top of water. A lesson learned from this application was that remedial designs that call for injections of oil containing nutrient-enriched emulsions should consider the separation of oil from the emulsion.	In situ bioremediation - various additives Blacks - In-situ bioremediation using sodium lactate followed by emulsified soybean oil. System includes three horizontal injection points beneath building footprint, a horizontal injection system in former source area, and several vertical injection wells between dry cleaner facility and adjacent apartment building. Boone - In-situ bioremediation using corn syrup, Simple Green®, and vegetable oil: • Twelve 4" injection wells and eight 2" pilot test monitoring wells installed to a depth of 18 ft. Carousel - In situ bioremediation using BioRem H-10. Former 60 - In situ bioremediation using ethyl lactate injection/groundwater withdrawal and re-injection: • A total of 110 gallons injected in a 1-2% solution. Village Green - In situ bioremediation using ethyl lactate: • 12 injection points and 7 recovery wells installed in the source area for the bioremediation. • In dissolved phase portion, 4 shallow and 5 deep injection wells were installed. A total of 880 gallons of ethyl lactate were pumped into the 12 injection points above the source area.	**Regulatory Requirements/Cleanup Goals:** Blacks: Cleanup goals primarily based on vapor intrusion into buildings; preliminary remediation goals (PRGs) for groundwater: 1 µg/L PCE; 100 µg/L TCE; and 20 µg/L vinyl chloride. Boone: Soil - EPA Region 9 PRGs; Groundwater – MCLs. Carousel: Final cleanup goals yet to be established. Likely cleanup goals for groundwater and soil will be based on vapor intrusion modeling, and protection of deep aquifer at the MCL of 5 µg/L for PCE. Former 60: Groundwater - PCE - 3 µg/L, TCE - 3 µg/L, cis-1,2-DCE - 70 µg/L, trans-1,2-DCE - 100 µg/L; 1,1-DCE - 7 µg/L; vinyl chloride - 1.0 µg/L. Soil: PCE - 30 µg/kg; TCE - 30 µg/kg. Village Green: Groundwater - PCE - 3 µg/L, TCE - 3 µg/L, cis-1,2-DCE - 70 µg/L. Soil (leachability): PCE - 30 µg/kg; TCE - 30 µg/kg. **Results:** Blacks - Not available. Boone - Wells with greatest PCE impact indicated an 85-95% decrease by August 2002. Carousel - BioRem H-10 was able to degrade PCE without generation and accumulation of more toxic daughter products, namely TCE and vinyl chloride. Former 60 - There was a rapid decrease in PCE concentrations in system influent in the first quarter of system operation, coupled with an increase in cis-1,2-DCE in groundwater influent concentrations. Village Green - The site is currently in natural attenuation monitoring with semi-annual dilute ethyl lactate dosing. Confirmatory soil sampling revealed that maximum PCE contaminant concentrations in soil decreased from 564,000 µg/kg to 2,300 µg/kg.	• Blacks - Summer 2002 to present (Full-scale) • Boone - April to December 2002 • Carousel - Spring 2001 to Winter 2003 • Former 60 - March 13, 2004, to date unknown • Village Green – November 12, 2002, to February 13, 2003	**Blacks:** Cost for design and implementation $30,000 O&M per year for periodic injection of electron donor and bacterial treatment $35,000 x 5 years, to 2007 $17,5000 On going groundwater, soil gas, and indoor air monitoring per year $20,000 x 5 years, to 2007 $100,000 TOTAL $305,000 **Boone and Village Green:** **Carousel:** Cost Data unavailable 2-year pilot demonstrations costs for the injection system and monitoring $75,000 BioRem contributed the H-10 bacteria product for the study $0 TOTAL $75,000 **Former 60:** Design $32,300 Construction $107,500 O&M for the first year (include ethyl lactate, injection, monitoring, and reporting) $140,200 TOTAL $280,000

TABLE C-6

EXAMPLE APPLICATION OF ENHANCED ANAEROBIC BIOREMEDIATION FOR VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Idaho National Engineering and Environmental Laboratory (INEEL) **Location:** Idaho Falls, Idaho **Contaminants:** • VOCs • TCE, PCE, 1,2-DCE • Two mile long TCE plume; TCE concentration ranged from 100 mg/L at source zone to 5 µg/L at distal end of plume • Source area (DNAPL) - about 200 ft in diameter **Type/Quantity of Media Treated:** Groundwater • TCE plume located in a fractured basalt aquifer, 200 to 200 feet (ft) below ground surface (bgs) • Unconfined aquifer; groundwater flow - 0.35 to 0.79 ft/day **Description:** At the Test Area North (TAN) at INEEL, liquid wastes containing solvents and radionuclides were injected into an aquifer between 1953 and 1972, resulting in groundwater contamination at the site. TCE, PCE, and 1,2-DCE and radionuclides are present in the groundwater, and the contaminant plume is about 2-miles long and 200 to 450 ft deep. In 1999, a demonstration of ISB was initiated at the TAN site to treat the source area of the contaminant plume and the more dilute dissolved plume with natural attenuation. Sodium lactate was injected into the subsurface using one injection well and extracted using one well located downgradient of the source to create a treatment cell about 492-ft long. After a 1-year period, TCE concentrations in a number of wells were reduced to non-detectable levels and evidence of natural attenuation was observed in the dissolved plume. The system continued to operate through 2001. According to DOE, the technical applicability of ISB is dependent upon site geology, concentrations of native nutrients, and the natural oxidation potential of the subsurface.	In Situ Bioremediation (ISB) • Sodium lactate (electron donor) injection, extraction, above-ground air stripping, and re-injection. • Weekly sodium lactate injections from January to September 1999; no lactate injections from September 2000 to February 2000 because electron donor had accumulated in the aquifer; March 2000 on, bi-monthly injections performed. • 492-ftlong treatment cell created by one injection well and one extraction well; extraction well operated continuously at an extraction rate of 190 L/min.	**Regulatory Requirements/Cleanup Goals:** No specific cleanup levels identified for the demonstration. **Results:** After 1 year of operation, TCE levels were to non-detectable levels in a number of wells, including the original injection well and three monitoring wells where TCE concentrations were the highest. Monitoring data indicate that TCE is being degraded by natural attenuation.	1999 - 2000	Capital Cost 3,750,000 O&M cost for 15 years 31,508,000 D&D cost 152,000 TOTAL 35,410,000

TABLE C-7

EXAMPLE APPLICATION OF ENHANCED ANAEROBIC BIOREMEDIATION FOR PETROLEUM HYDROCARBONS AND CONSTITUENTS IN GROUNDWATER

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Multiple Service Station Sites **Location:** - Brentwood, California • Vancouver, Washington • Great Bend, Kansas **Contaminants:** Benzene, toluene, ethylbenzene, and xylenes (BTEX) and total petroleum hydrocarbons (TPH) **Type/Quantity of Media Treated:** Groundwater - estimated 20,400 square feet for Fourth Plain; estimates were not provided for Balfour Road or Steve's Standard. **Description:** Contamination at each site resulted from leaks in underground petroleum storage tanks and supply pipelines at or near retail dispensing locations. Refined petroleum product was released to the subsurface soil and groundwater at each site for unknown periods of time, until being detected in the 1990s. The three sites were cleaned up under their respective state voluntary cleanup programs. Oversight was performed by the respective state agency without EPA's involvement. Enhanced bioremediation using ORC® was selected by the lead contractors for each of the sites because it was expected to reduce the mass of contaminants in the aquifer by more than 50% in only 6 months, thereby reducing risk to human health and the environment from exposure to contaminated groundwater, and because it required a smaller capital investment and lower operating expenses than alternative technologies, such as pump and treat. Regenesis Bioremediation Products, Inc. (Regenesis) indicated that enhanced bioremediation using ORC® was not expected to treat the groundwater to the federal maximum contaminant levels (MCL), but that the treatment would reduce substantially the dissolved-phase mass of contaminants present in the aquifer, as well as reduce sources characterized as moderate smear zones. Enhanced bioremediation was performed at the three sites, using application of ORC®. ORC® is a proprietary formulation based on magnesium peroxide and is available from Regenesis. According to Regenesis, the quantity of ORC® required for a site is based on several factors including the estimated mass of contaminant at the site (dissolved-phase concentration) and the specific properties of the aquifer such as porosity and thickness. Details on the specific applications of this technology at each of the three sites are included in the report. As of October 1997, the cleanup goals had not been met at either the Balfour Road or Fourth Plain sites; however, the geometric mean concentration and mass of benzene, total BTEX, and TPH had been reduced by approximately 50% in the aquifers in only 6 months for roughly $50,000 per site. In addition, at the Steve's Standard site, the concentration and mass of benzene, total BTEX, and TPH had been reduced in portions of the aquifer. The report presents a detailed summary of the progress at each site and the plans for future activities at the sites.	Enhanced Bioremediation of Groundwater using ORC® • ORC® (oxygen release compound) is a proprietary formulation based on magnesium peroxide and is available from Regenesis. • ORC® is applied to the groundwater using different methods and dosages (dosage based on several factors including the estimated mass of contaminant at the site and the specific properties of the aquifer). • Details of the application method and dosage for each site are included in the report.	**Regulatory Requirements/Cleanup Goals:** Balfour Road - federal MCLs for groundwater. Fourth Plain - benzene - 0.005 mg/L, total BTEX - 0.095 mg/L and TPH - 1.0 mg/L. Steve's Standard - no cleanup goals; demonstration project. **Results:** Balfour Road and Fourth Plain sites - the cleanup goals had not been met at either the Balfour Road or Fourth Plain sites as of October 1997. The geometric mean concentration and mass of benzene, total BTEX, and TPH had been reduced by approximately 50%. Steve's Standard - over the first 7 months of operation, the concentration and mass of benzene, total BTEX, and TPH had been reduced; however, over the next 9 months, concentrations appeared to stabilize or rise slightly; a continuing source was identified at the site.	• Balfour Road: December 1995 to present (report covers the period through October 1997) • Fourth Plain: July 1996 to present (report covers the period through October 1997) • Steve's Standard: July 1996 to present (report covers the period through October 1997)	**Balfour Road:** Treatment Cost $33,500 Other $8,100 TOTAL $41,600 **Fourth Plain:** Treatment Cost $35,700 Other $1,600 TOTAL $37,300 **Steve's Standard:** (two service stations located next to each other) Treatment Cost $93,400 Other $2,600 TOTAL $96,000

TABLE C-8

EXAMPLE APPLICATION OF ENHANCED ANAEROBIC BIOREMEDIATION FOR PETROLEUM HYDROCARBONS AND MTBE IN GROUNDWATER

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Brownfield Site **Location:** Chattanooga, Tennessee **Contaminants:** MTBE, BTEX, TPH • MTBE concentrations as high as 5,000 µg/L • BTEX concentrations as high as 8,000 µg/L • TPH concentrations as high as 300,000 µg/L • Plume containing MTBE and benzene covers approximately 16,000 square feet; TPH plume covers approximately 66,000 square feet (1.5 acres) **Type/Quantity of Media Treated:** Groundwater • On-site groundwater is located within a tight clay soil horizon at 5-7 bgs • Off-site groundwater is located in bedrock consisting of limestone and shale beds at depths of greater than 10 feet (ft) bgs **Description**: As a result of leaking USTs, gasoline, diesel fuel, and waste oil releases occurred at an abandoned gasoline service station in a mixed-use area. The service station has no remaining on-site structures or facilities. The releases resulted in contamination of soil and groundwater at the site with MTBE, BTEX, and petroleum constituents. Concentrations of contaminants measured in groundwater at the site were as high as MTBE at 5,000 µg/L, benzene at 8,000 µg/L, and total petroleum hydrocarbons at 300,000 µg/L. The vendor estimated that 1,500 cubic yards of soil at the site were impacted by the contamination. In the mid-1990s, the USTs were removed and decommissioned. Beginning in January 1999, in situ bioremediation using the Enzyme-Catalyzed In Situ Dissolved Oxygen Treatment (DO-IT) process was used to treat groundwater at the site. This process uses a combination of proprietary multi-enzyme complexes and a consortium of TPH degrading bacteria, with supplemental oxygen, to biodegrade MTBE, BTEX, and TPH contaminants. At this site, three horizontal injection wells, two vertical injection wells, and three extraction/recovery wells were installed within the plume. In January 1999, the initial inoculation of approximately 75 gallons of enzymes and 150 gallons of bacteria was performed. Subsequently, 5 gallons of enzymes and 10 gallons of bacteria have been added to the oxygenated water each month to maintain the microbial population. As of December 1999, after 360 days of operation, the concentrations of MTBE, BTEX, and TPH have been reduced by more than 70%. However, cleanup goals were not reached for benzene or TPH in the groundwater during this time, and treatment is ongoing. The technology vendor reported that this application was aided by the design of injection galleries that were specific to the low permeability of the soil formation and the intended injection approach.	In Situ Bioremediation • In situ bioremediation using the Enzyme-Catalyzed In Situ Dissolved Oxygen Treatment (DO-IT) process; patented process uses a combination of proprietary multi-enzyme complexes (proteins that are extracted from living TPH-degrading bacterial cultures), and a consortium of total petroleum hydrocarbon (TPH) degrading bacteria, with supplemental oxygen; generates a concentration of dissolved oxygen in water of approximately 40 mg/L. • Three horizontal injection wells, two vertical injection wells, and three extraction/recovery wells were installed within the plume. • Groundwater was extracted from down-gradient locations, amended by adding oxygenated water, nutrients, and the enzyme/bacterial consortium mixture, and then re-injected using the horizontal and vertical injection wells; layout provided for both treatment and hydraulic control. • Initial inoculation in January 1999 consisted of approximately 75 gallons of enzymes and 150 gallons of bacteria; each month, 5 gallons of enzymes and 10 gallons of bacteria have been added to the oxygenated water to maintain the microbial population.	**Regulatory Requirements/Cleanup Goals:** The cleanup criteria specified for this site were benzene - 100 mg/kg in soil and 70 µg/L in groundwater, and TPH - 1,000 mg/kg in soil and 1,000 µg/L in groundwater. No cleanup levels were specified for MTBE; however, MTBE was identified as a contaminant of concern for the site. **Results:** Results were available for the first 360 days of operation (January to December 1999) from well MW-2 (the well with the highest concentrations of contaminants). MTBE concentrations were reduced from approximately 5,000 µg/L to approximately 200 µg/L. Benzene concentrations were reduced from as high as 8,000 µg/L to less than approximately 1,000 µg/L. TPH concentrations were reduced from as high as 300,000 µg/L to less than approximately 50,000 µg/L. Benzene and TPH concentrations remain above cleanup goals; treatment system operation is ongoing.	January 1999 to present (data available through December 1999)	Start-up costs, including initial inoculation $30,000 Monthly maintenance have been approximately $4,000 through December 1999 is 12x monthly, $48,000 TOTAL $78,000

TABLE C-9

EXAMPLE APPLICATION OF IN SITU CHEMICAL OXIDATION FOR HALOGENATED VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER AT CAPE CANAVERAL

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Cape Canaveral Air Force Station, Launch Complex 34 **Location:** Cape Canaveral, Florida **Contaminants:** Halogenated VOCs TCE - Estimated mass of 6,122 kg in test plot DNAPL - 5,039 kg of the TCE mass was estimated to be DNAPL **Type/Quantity of Media Treated:** Groundwater • Test plot size - 75 ft by 50 ft by 45 ft **Description:** A 1998 site investigation at the Cape Canaveral Air Force Station in Florida identified a large DNAPL source at Launch Complex 34. Historical activities at the site included discharging wastes generated from rocket engine and parts cleaning operations into discharge pits. Chlorinated solvents, including TCE, were used in these cleaning operations. The Interagency DNAPL Consortium selected this site for demonstrating DNAPL treatment technologies. One of the technologies tested was in situ chemical oxidation (ISCO). A field demonstration of ISCO was performed from September 8, 1999 to April 17, 2000, with the post-demonstration monitoring performed through February 2001. During the 8-month demonstration, more than 840,000 gallons of permanganate solution were injected in three phases. Following the first injection, monitoring results showed that local heterogeneities limited oxidant distribution in some areas. A second and third phase of injections were performed, focusing on those portions of the plot where interim monitoring results showed that the area had not received sufficient oxidant during the previous cycle. ISCO reduced the concentrations of dissolved TCE in the groundwater and reduced the mass of TCE and DNAPL in the test plot by 77% and 76%, respectively. While less than the target of 90%, the removal percentage was considered to be significant for the technology. The best distribution of the oxidant occurred in the upper sandy soils; distribution of oxidant was more difficult in finer-grained soils. Local geologic heterogeneities and native organic matter content may limit oxidant distribution in some regions.	In situ chemical oxidation (ISCO) • Field demonstration of ISCO - source zone test plot was 75 ft by 50 ft by 45 ft deep. • A total of 842,985 gal of permanganate solution (1.4% to 2%) was injected into the test plot in 3 phases over a period of 8 months; vendor designed and supplied a continuous mix and automated feed system for the demonstration. • First injection September to October 1999 - a total of 304,763 gallons of solution were injected, first into the upper unit, then into the middle unit, followed by the lower unit; a GeoProbe equipped with a specially designed tip was used to inject the solution; the estimated radius of influence was 10-12 ft; however, local heterogeneities limited oxidant distribution in some areas. • The second (November 1999) and third (March to April 2000) injections - focused only on those portions of the plot where interim monitoring results showed that the area had not received sufficient oxidant during the previous cycle; a total of 87,483 gallons of solution were injected during the second cycle and 450,739 gallons during the third cycle. • One major system interruption occurred during the demonstration – hurricane in September 1999.	**Regulatory Requirements/Cleanup Goals:** The objective of the field demonstration was to reduce the contaminant mass by 90%. **Results:** The mass of TCE and DNAPL was reduced by 77% and 76%, respectively; while less than the target of 90%, the removal percentage was considered to be significant for the technology. The highest level of removal was observed in the upper sand zone, indicating that the oxidant distribution was most efficient in the coarser soils in this zone. TCE and DNAPL removal pathways included destruction by oxidation, migration to the surrounding aquifer, and migration to the vadose zone and atmosphere. Dissolved TCE levels decreased in most parts of the test plot, with several monitoring wells showing levels below the MCL of 5 ug/L.	September 8, 1999, to April 17, 2000	Total cost for field demonstration, including costs for design, procurement, equipment and oxidant, mobilization/demobilization, and process monitoring, was approximately $1,000,000 Vendor indicated that about 15% of the cost was due to use of the technology at a demonstration rather than a full-scale application TOTAL $1,000,000

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TABLE C-10

EXAMPLE APPLICATION OF IN SITU CHEMICAL OXIDATION AT DRY CLEANERS FACILITIES

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Multiple (6) Dry Cleaner Sites **Location:** - Butler Cleaners #1, Jacksonville, Florida • Butler Cleaners #2, Jacksonville, Florida • Former Quick-N-Easy Wash-O-Mat and Former Artistic Cleaners, Wichita, Kansas • Hanner's Cleaners, Pompano Beach, Florida • Paul's Classic Dry Cleaners, Wisconsin • Swift Cleaners, Jacksonville, Florida **Contaminants:** Chlorinated Solvents • All of the sites were contaminated with PCE and TCE. • Concentrations varied by site ranging with concentrations ranging from 1 to 42 mg/L for PCE and 0.02 to 012 mg/L for TCE. • Five sites reported that DNAPLs were present or likely to be present. **Description:** In situ chemical oxidation was conducted at six dry cleaner sites contaminated with chlorinated solvents from dry cleaning operations with TCE and PCE as the primary contaminants in groundwater. At three sites solutions of potassium permanganate were injected into the subsurface, at two sites solutions of hydrogen peroxide and catalyst were injected into the subsurface, and at one site an ozone in-well air sparging system was installed. Only one site (Swift Cleaners) reporting achieving remediation goals. Other sites reported that contaminant concentrations were not significantly reduced or that cleanup goals were not met.	In situ chemical oxidation (ISCO): At the Butler Cleaners #1, Butler Cleaners #2, Former Quick-N-Easy Wash-O-Mat, and Former Artistic Cleaners sites, solutions of potassium permanganate were injected into the subsurface to oxidize contaminants. At two sites the solutions were mixtures of potassium permanganate with water, with potassium permanganate making up 8% to 15% of the solution. At one site, the solution was heated and tertiary butyl alcohol was added to help mobilize the contaminants. The solutions were injected through from one to 45 wells, and injection volumes ranged from 1,000 to 2,200 gallons. At two of the sites SVE was also used to remove contaminants from the soil. At the Hanner's Cleaners and Swift Cleaners sites, solutions of water, hydrogen peroxide (12 to 25%), and an unspecified catalyst were injected into the subsurface to oxidize contaminants. The solutions were injected through from 6 to 12 wells, and volumes ranged from 1,700 to 20,000 gallons. SVE was also used at both sites to remove contaminants from the soil. At the Paul's Classic Dry Cleaners site, a field demonstration of an ozone in-well air sparging system was conducted. The treatment system consisted of a single well where sequential sparging and groundwater recirculation functions were performed in the sparge well. The system delivered an air and ozone gas mixture (the composition of the mixture was not specified) at a rate of 1.7 to 2.2 cfm first to the lower sparge point, then the in-well sparge point, each for a specified period of time. In-well pumping was then performed. This process was repeated in a cycle over a period of 16-18 hours/day. Multi-phase extraction was also conducted at the site.	**Regulatory Requirements/Cleanup Goals:** Cleanup goals were based on state regulatory goals or EPA MCLs. Specified cleanup goals included 0.005 to 0.014 mg/L for PCE and 0.012 mg/L for TCE. **Results:** Only one site (Swift Cleaners) reported achieving remediation goals. Other sites reported that contaminant concentrations were not significantly reduced or that cleanup goals were not met.	• Butler Cleaners #1 - ongoing (dates not specified) • Butler Cleaners #2 - October, 1999 • Former Quick-N-Easy Wash-O-Mat and Former Artistic - Cleaners - 1999 • Hanner's Cleaners - June to September, 2000 • Paul's Classic Dry Cleaners - Not specified • Swift Cleaners - July 1999	Potassium permanganate systems $105,000 to $230,000 Hydrogen peroxide $110,000 to $170,000 Ozone sparging Not specified

TABLE C-11

EXAMPLE APPLICATION OF SIX-PHASE THERMAL TREATMENT FOR CHLORINATED SOLVENTS IN SOIL AND GROUNDWATER AT A FORMER ELECTRONICS MANUFACTURING SITE

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Former manufacturing facility (confidential commercial client) **Location:** Skokie, Illinois **Contaminants:** Chlorinated Solvents • TCE and TCA, as well as degradation products cis-and trans-1,2- dichloroethene, 1,1-dichloroethene, 1,1-dichloroethane, vinyl chloride and chloroethane • Concentrations in groundwater at start of SPH remediation (June 1998) – TCE (130 mg/L maximum; 54.4 mg/L average), TCA (150 mg/L maximum; 52.3 mg/L average) and DCE (160 mg/L maximum; 37.6 mg/L average) • - DNAPL present **Type/Quantity of Media Treated:** Source zone (saturated and unsaturated) • Initial source zone area - approximately 23,100 cubic yards of soil and groundwater, based on a treatment area of 26,000 square feet and a depth of 24 ft bgs. Additional source zone area - 11,500 cubic yards of soil and groundwater • Soil at site - heterogeneous silty sands with clay lenses to 18 ft bgs (hydraulic conductivity -10-4 to 10-5 cm/sec); underlain by dense clay till aquitard (hydraulic conductivity -10-8 cm/sec) • Depth to groundwater- 7 ft bgs **Description:** This site is a former electronics manufacturing facility located in Skokie, Illinois. From 1958 to 1988, manufacturing operations included machining and electroplating. Soil and groundwater at the site were found to be contaminated with solvents (TCE and TCA), including large pools of dense nonaqueous phase liquids (DNAPL). The site is being remediated under Illinois' voluntary Site Remediation Program. From 1991 to 1998, steam injection combined with groundwater and vapor extraction reduced the area of contamination from about 115,000 square feet to about 23,000 square feet. As of early 1998, the remaining area to be remediated represented four source locations where manmade subsurface features limited the effectiveness of the previously used steam-based remediation system. To complete the remediation, the site owner selected SPH. The SPH process operated at the Skokie site from June 4, 1998, to November 20, 1998, to remediate the initial estimated 23,000 cubic yards of contaminated soil and groundwater. Based on the results of sampling conducted in December 1998 that indicated there was a potential for vinyl chloride to be produced outside the initial treatment area at levels in excess of the cleanup levels, a decision was made to expand the SPH system to cover an additional 11,500 cubic yard treatment area. The SPH system restarted in December 1998 and operated until April 30, 1999, when cleanup goals were achieved in the additional area. The unit cost for this technology was $32 per cubic yard for the initial 23,000 cubic yards of contaminated soil and groundwater and also for the additional 11,500 cubic yards of contaminated media.	Electrical Resistive Heating - Six-Phase Heating (SPH), and air stripping for extracted groundwater condensate. • Initial network of 107 electrodes (85 beneath the floor of a warehouse building) operated from June to November 1998; 78 electrodes added (185 total) and operated from December 1998 to April 1999 to treat additional area of contamination. • Electrodes designed to be electrically conductive throughout a depth interval of 11 to 21 feet bgs and to increase the subsurface temperature in the depth interval of 5 to 24 feet bgs to the boiling point of water. • Electrical power input - 1,775 megawatt hours (MW-hrs.) consumed from June 4 to November 20, 1998; information not provided for Dec. 1998/Jan. 1999 through May 1999. • Temperature - 100°C; operating pressure/vacuum - 7.5 inches of mercury (Hg). • Network of 37 soil vapor extraction wells, screened to 5 feet bgs, were used to capture vapors. • Off-gas was condensed and sent through an air stripper prior to discharge to the atmosphere.	**Regulatory Requirements/Cleanup Goals**: Tier III cleanup criteria for groundwater; developed by ENSR and approved by Illinois EPA as the cleanup goals for the site. Tier III goals were TCE (17.5 mg/L); TCA (8.85 mg/L); and DCE (35.5 mg/L). No criteria established for soil. **Results:** Results for the remediation of the initial 23,000 cubic yards of contamination: By December 1998 (6 months of operation), the Tier III cleanup goals were achieved for TCE, TCA, and DCE in all wells in the initial area of contamination. During this time, average groundwater concentrations were reduced by more than 99% for TCE (54.4 mg/L to 0.4 mg/L); more than 99% for TCA (52.3 mg/L to 0.2 mg/L), and more than 97% for DCE (37.6 mg/L to 0.8 mg/L). Results for the remediation of the additional 11,000 cubic yards of contamination: By April 1999 (5 months of operation), the Tier III cleanup goals were achieved for TCE, TCA, and DCE in all wells in the additional area of contamination. During this time, average groundwater concentrations were reduced by more than 96% for TCE (4.16 mg/L to 0.15 mg/L); more than 92% for TCA (14 mg/L to 1 mg/L); and more than 90% for DCE (2.39 mg/L to 0.24 mg/L).	• June 4, 1998, to November 20, 1998 (initial area treated); • December 1998 to April 30, 1999, (additional area treated).	Initial Source Zone: The unit cost for this technology of $32 per cubic yard is based on a calculated treatment volume of 23,100 cubic yards, or a treatment area of 26,000 square feet and a depth of 24 ft bgs $739,200 Additional source area: The unit cost for the treatment from December 1998 through May 1999 also was $32 per cubic yard, based on a calculated treatment volume of 11,500 cubic yards $368,000 TOTAL $1,107,200

TABLE C-12

EXAMPLE APPLICATION OF SIX-PHASE THERMAL TREATMENT FOR CHLORINATED SOLVENTS IN GROUNDWATER AT CHARLESTON NAVAL COMPLEX

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Charleston Naval Complex, AOC 607 **Location:** North Charleston, South Carolina **Contaminants:** Chlorinated Solvents: PCE Dense Non-Aqueous Phase Liquid (DNAPL), TCE, cis-1,2-DCE, 1,1-DCE, VC Initial maximum contaminant concentrations: • Total volatile organic compounds (VOCs): 18,000 µg/L • PCE: 8,090 µg/L **Type/Quantity of Media Treated:** Groundwater and DNAPL **Description:** Charleston Naval Complex area of concern (AOC) 607 consisted of a former dry cleaning facility. PCE was one of the primary chemicals that was used, stored, disposed of, and accidentally released at the site. A RCRA Facility Investigation conducted in 1996 and 1997 detected dissolved-phase chlorinated solvents in the saturated zone including PCE, TCE, cis-1,2-DCE, 1,1-DCE and VC. In addition, PCE in the form of DNAPL appeared to have migrated into the shallow saturated zone. Initial maximum contaminant concentrations included 18,000 µg/L of total VOCs and 8,090 µg/L of PCE. The site was remediated under the RCRA Corrective Action Program. Operation of the ERH system was initiated in October 2001 and continued until July 2002. Approximately 4,300 cubic yards of media were treated. This volume is based on a 7-foot deep (saturated zone: 4 feet bgs to 11 feet bgs treatment zone) over a 16,525 square feet (ft2) TTA. The objective of the ERH treatment was to reduce the amount of DNAPL present in the aquifer, thereby reducing its potential to act as a continuing source for dissolved-phase contamination. A quantifiable cleanup objective was not established during this remediation action. In general, ERH resulted in a decrease in the area of the plume and a decrease in the number of high concentration zones. PCE concentrations reduced by about 95 percent in concentration compared to the pre-treatment baseline. Total VOCs decreased by 83 percent. Total CVOCs and PCE mass recovered during ERH system operation was calculated at 247 and 234 lbs respectively. One of the main issues that arose during the ERH treatment at AOC 607 was that the treatment took longer than anticipated, mainly due to slower heating of the groundwater in deeper portions of the saturated zone. The ERH system was enhanced by using additional electrodes to achieve adequate heating.	• Electrical Resistive Heating - Six-Phase HeatingTM (SPH) for subsurface heating • Soil Vapor Extraction (SVE) system for vapor recovery • Above-ground treatment system to process vapor and liquid wastes generated by SVE • ERH system: • Two 500 kilowatt (kW) power control units (PCU) operating 101 electrodes. • Electrodes installed to a depth of approximately 10 to 10.5 feet below ground surface (bgs) with a lateral spacing of approximately 14 feet. • PCU 1 began operating on October 3, 2001 in the more contaminated southern portion of the Target Treatment Area (TTA). • PCU 2 began operating in the ı northern portion of the TTA on December 13, 2001. • From April 15 to May 15, 2002, the entire ERH system operated using 101 electrodes, twelve 8-inch diameter steel piles, six Geoprobe electrodes, and 310 ¾-inch diameter ground rods. • To optimize performance, both PCUs cycled with 50 minutes of operation followed by 10 minutes of shut-down, to allow re-wetting of the electrodes and prevent the drying of soils close to the electrodes. • The average weekly power input during the nine-month ERH operation was approximately 278 kilowatts (kW), with a maximum power input of 520 kW that occurred during the week immediately following the start-up of PCU-2. The ERH system was shut down on July 8, 2002. • A condenser (to remove water vapor), a cooling tower (to cool condensate), and granular activated carbon (GAC) adsorption units (to treat dry vapor prior to atmospheric release). • - Following completion of the ERH in July 2002, TTA monitoring continued until March 2004.	**Regulatory Requirements/Cleanup Goals:** The objective of the ERH treatment was to reduce the amount of chlorinated volatile organic compounds (CVOC) DNAPL present in the aquifer, thereby reducing its potential to act as a continuing source for dissolved-phase contamination. A quantifiable cleanup objective was not established during this remediation action. **Results:** In general, ERH resulted in a decrease in the area of the plume and a decrease in the number of high concentration zones. In March 2004 (22 months after ERH shutdown), PCE was detected in a monitoring well at a concentration of 283 µg/L. This suggested a 95 percent reduction in concentration compared to the pre-treatment baseline. Total volatile organic compounds concentration decreased by 83 percent. Total CVOCs and PCE mass recovered during ERH system operation was calculated at 247 and 234 lbs, respectively.	October 2001 to July 2002	Capital Costs $373,000 mobilization/de-mobilization $71,000 Operational Costs $473,000 Retrofit (electrode installation and well replacement) $60,000 Monitoring (laboratory analytical services) $50,000 Project Oversight $215,000 TOTAL $1,242,000

Geomatrix

TABLE C-13

EXAMPLE APPLICATION OF SIX-PHASE THERMAL TREATMENT FOR METHYLENE CHLORIDE IN SOIL

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Avery Dennison **Location:** Waukegan, Illinois **Contaminants:** Methylene chloride concentrations in the soil in this area averaged 1,900 mg/kg. **Type/Quantity of Media Treated:** Source zone- 16,000 yds^3 (based on an estimated soil density of 1.3 tons per yd^3, corresponds to 21,000 tons treated) The topography of the site is generally flat, with a slight manmade slope that drains toward stormwater collection drains. The geology underlying the site is predominantly heterogeneous silty-clay, glacial till to a depth of about 180 ft bgs. Discontinuous silty sand and sand lenses are present at some locations within the till. Bedrock (Niagaran dolomite) is encountered at depths ranging from 180 to 270 ft bgs. Depth to groundwater ranges from approximately 6 ft to 25 ft bgs. Approximately 17,000 ft^2 of soil along the north side of the building on the site was contaminated with MeCl to depths as great as 24 ft bgs, with concentrations as high as 40,000 mg/kg. **Description:** The Avery Dennison site is located in the Waukegan-Gurnee Industrial Park in Waukegan, Illinois. From 1975 through 1992 film coating operations were performed at the site. Methylene chloride (MeCl) used in these operations was unloaded in the northeast corner of the building, and transferred by underground piping to above-ground storage tanks in the northwest corner of the building. In May 1985, an inventory check indicated that approximately 1,585 gallons of MeCl was released from the underground pipe. Site investigations indicated that the released MeCl was present in the soil and groundwater beneath the loading area, the bulk storage tank area, the underground transfer pipe, and a former stormwater drainage system. Cleanup activities at the site performed from 1985 through 1998 included excavation, soil vapor extraction, groundwater pump and treat, and air sparging. The results of additional investigations indicated that DNAPL was present in soil at the site. ERH was used from December 1999 through November 2000 to address the DNAPL source in the unsaturated zone. The ERH system included 95 copper electrodes installed around the perimeter of 20 treatment cells, including six electrodes installed below an active street, and 16 installed inside the existing building. Thirty-four recovery wells were installed to extract of soil vapor and steam. Two thermocouples were installed in the center of each treatment cell, at the shallowest (4 ft) and deepest (24 ft) levels of contamination. ERH was performed in the western portion of the treatment zone starting in December 1999 and in the eastern portion of the treatment zone starting in June 2000. During the first 4 weeks of operation, the system did not achieve the target heating rate and power input to the subsurface. The vendor found that the electrodes had oxidized and that the down hole power cables had been damaged. System modifications included installing galvanized steel pipes around the electrodes and using aboveground power cables. The system was restarted and achieved the target heating rate and soil temperature, though the power input remained below the design level. With the exception of four treatment cells, the concentrations of methylene chloride were reduced to below cleanup goals by October 2000. Additional electrodes were added to these cells and the system was operated another month to meet the cleanup goals. No cost data were available for this application.	Electrical Resistive Heating (ERH) • 20 treatment cells; electrodes were installed around the perimeter of each cell to a depth of 24 feet; 2 thermocouples were installed in the center of each treatment cell, at the shallowest and deepest levels of contamination, 4 and 24 ft bgs. • Total of 95 copper electrodes, including six installed below an active street and 16 installed inside the existing building; designed power input - 610 kW ; design heating rate of 1°C per day until a temperature above 75°C was achieved. • 34 recovery wells at 20 locations to extract of soil vapor and steam • After 4 weeks of operation, the average soil temperature, heating rate, and input to the subsurface were below design targets; vendor determined that the copper electrodes had oxidized and downhole power cables to the electrodes were damaged. • One-inch galvanized steel pipes were installed around each electrode; the power cables were attached above ground. • Maximum temperature - 65°C to 100°C; average delivery of power to the subsurface was 320 kW, less than the expected delivery of 610kW.	**Regulatory Requirements/Cleanup Goals:** MeCl in the soil below 24 mg/kg, based on Illinois EPA's Tiered Approach to Corrective Action Objectives (TACO). **Results:** Results of soil samples taken from the treatment cells indicated that, with the exception of four treatment cells, concentrations of MeCl had been reduced to below the treatment goals by October 2000. Additional galvanized steel pipe electrodes were added to the four treatment cells, and the treatment system was operated in these cells for another month, with shut down in November, 2000. Average MeCl concentrations in soil were reduced to 2.51 mg/kg.	December 1999 to November 2000	No cost information was provided for this application.

TABLE C-14

EXAMPLE APPLICATION OF STEAM-ENHANCED EXTRACTION

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Former Telecommunications Manufacturing Facility **Location:** Chicago, Illinois **Contaminants:** Volatile Organic Compounds: • TCE and daughter products (cis-1,2-DCE) • Mineral spirit constituents (toluene and xylene) • DNAPLs/LNAPLs **Type/Quantity of Media Treated:** Groundwater – steam injected into highly permeable glacial till up to 46 feet below grade. Steam injected across 10-ft zone. 25,900 lbs of volatile organic hydrocarbons removed. Soil – Approximately 63,000 tons of impacted soil were excavated and disposed off site. **Description:** Chlorinated solvents (TCE and cis-1,2-DCE) and mineral spirit components (toluene and xylene) were discovered in soil and groundwater in the vicinity of a former tank farm during the decommissioning of a former telecommunications facility. Over 63,000 tons of soil were excavated from the facility and disposed off site. DNAPL and LNAPL were identified in soil and groundwater at the facility. Bedrock is encountered beneath the site at depths of 60 to 90 feet bgs.	Excavation and off-site disposal (63,000 tons); Steam-Enhanced Extraction: • 186 shallow SVE wells • 76 dual-phase extraction wells • 65 steam injection wells • 2 deep groundwater extraction wells • Groundwater treated by an air stripper and carbon polishing prior to discharge	**Regulatory Requirements/Cleanup Goals:** Not identified. **Results:** • More thane 25,900 lbs of VOC removed (primarily TCE). • Mean TCE concentrations in groundwater reduced from 45,000 µg/L to 500 µg/L in 24 months. • Soil temperatures of 29 - 60°C and groundwater temperatures of 20 to 74°C observed. • Number of wells with DNAPL indicators (10 mg/L TCE) reduced from 13 to 1 in 21 months.	Study describes 29-month operation period.	No cost information provided.

TABLE C-15

EXAMPLE APPLICATION OF PUMP AND TREAT SYSTEM FOR VOLATILE ORGANIC COMPOUNDS AND DENSE NONAQUEOUS PHASE LIQUID IN GROUNDWATER

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Lawrence Livermore National Laboratory **Location:** Livermore, California **Contaminants:** Volatile Organic Compounds: • Trichloroethene (TCE) • DNAPLs **Type/Quantity of Media Treated:** Through July 1997: • Groundwater - a total of 93.8 million gallons of groundwater; 9.9 kg of VOC mass removed • Soil - 399,000 cubic feet of soil vapor; 30.5 kg of VOC mass removed **Description:** Lawrence Livermore National Laboratory Site 300 is a DOE experimental test facility located near Livermore, California. Craft shops and equipment fabrication and repair facilities in the General Services Area (GSA) used solvents as degreasing agents. In the eastern portion of the GSA, craft shop debris was buried in shallow trenches. In the central portion, rinse waters from operations were disposed of in dry wells. The results of site investigations, begun in 1982, identified VOC contamination in the soil and groundwater. Groundwater TCE concentrations have been detected as high as 74 ug/L in the eastern GSA and 240,000 mcg/L in the central GSA. Groundwater TCE plumes have been identified in both areas. The highest preremediation concentration of TCE in soil in the central GSA was 360,000 mcg/L. Remediation began in 1991 as a removal action. A Record of Decision was signed moving the cleanup to the remedial phase. The remedy at the eastern portion of the GSA, begun in 1991, involves groundwater extraction using three wells and treatment using carbon adsorption. The system originally used air sparging; however, as VOC concentrations in the groundwater decreased, air sparging was replaced with carbon adsorption. After 6 years of operation, the system has removed 5.1 kg of VOC mass, treated 93 million gallons of groundwater and reduced the maximum TCE concentration in groundwater to 13 mcg/L. The remedy for the central portion of the GSA included both groundwater extraction and treatment and SVE. The groundwater system, operated since 1993, had 19 extraction wells and includes air stripping for vapors and carbon adsorption for treatment of groundwater. After 4 years of operation, the system has removed 4.8 kg of VOC mass, treated 787,000 gallons of groundwater, and reduced maximum TCE levels to 33 mcg/L. The SVE system, operated since 1993, has removed 30.5 kg of VOC mass and reduced TCE concentrations in the soil vapor to 2 ppmv. Levels of VOC remained above the cleanup goals as of 1997. Cyclic pumping is used to maximize VOC mass removal efficiency from all three systems. Results of modeling used to predict the time frame for cleanup indicated that the SVE system would require 10 years and groundwater extraction and treatment 55 years.	Eastern GSA pump and treat (P&T) • Three extraction wells • Treatment includes 5-micron particulate filter and three aqueous phase GAC units in series with a 50 gpm capacity Central GSA pump and treat (P&T) • 19 extraction wells – extract groundwater and soil vapor simultaneously • Treatment includes shallow tray air stripper (50 gpm); 5-micron particulate filter; two vapor-phase GAC units; air emissions stack housed in a portable treatment unit Central GSA Soil Vapor Extraction (SVE) • Seven extraction wells • 2-hp vacuum pump • Four vapor-phase GAC units in series	**Regulatory Requirements/Cleanup Goals:** Groundwater - reduce VOC concentrations to MCLs in all contaminated groundwater, including a cleanup goal of 5 mcg/L for TCE. The discharge limit is 0.5 mcg/L for total VOCs. Soil - soil vapor of 0.36 ppmv; soil vapor remediation will continue until: 1) it is demonstrated that VOC removal from the vadose zone is no longer technically or economically feasible and 2) the VOC inhalation risk inside Building 875 is adequately managed. **Results:** Maximum TCE groundwater concentrations had been reduced from pre-remediation levels ranging from as high as 240,000 mcg/L at the site to levels of 13 mcg/L (eastern GSA) and 33 mcg/L (central GSA) as of May 1997. These levels are above the cleanup goal of 5 mcg/L. Maximum TCE soil vapor concentrations had been reduced from a preremediation level of 450 ppmv to 2 ppmv as of May 1997, above the cleanup goal of 0.36 ppmv. The discharge limits have been met while the system was operating.	6/91 - ongoing (Data reported through July 1997)	Total Central GSA P&T and SVE systems. $32,400,000 Eastern GSA P&T $6,200,000 TOTAL $38,600,000 These costs include preconstruction and construction activities and post-construction O&M

TABLE C-16

EXAMPLE APPLICATION OF PUMP AND TREAT SYSTEMS FOR GROUNDWATER AT DRY CLEANERS SITES

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Multiple (5) Dry Cleaner Sites **Location:** - Former Big B Cleaners, Warrington, Florida • Former Sta-Brite Cleaners, Sarasota, Florida • Johannsen Cleaners, Lebanon, Oregon • Koretizing Cleaners, Jacksonville, Florida • Nu Way II Cleaners, Oregon **Contaminants:** Chlorinated Solvents • Three of four sites contaminated with PCE and TCE in soil and groundwater; one contaminated with PCE only. • Concentrations in groundwater varied by site ranging from 3 to 3,400 mg/L for PCE and 1 to 42 mg/L for TCE. • DNAPLs were present or likely to be present at four sites; LNAPL reported at one site. • Three sites also had soil contamination, with concentrations of PCE ranging from 76 to 37,000 mg/L. Contamination of soil with other chlorinated VOCs, such as TCE, and VCE, was also reported. **Type/Quantity of Media Treated:** Groundwater and Soil • Groundwater plume areas ranged from 0.27 to 17 acres. The deepest reported plume went to 92 ft bgs. Actual treatment areas ranged from 6,000 to 150,000 cubic feet for groundwater treatments. **Description:** Multi-phase extraction was conducted at four drycleaner sites and pump and treat at one drycleaner site to remediate soil and groundwater contaminated with chlorinated solvents. The amount of contaminant removed from the subsurface varied by site, with as much as 215 lbs of PCE removed at the Former Big B Cleaners site.	Multi-phase extraction: • Multi-phase extraction was applied at Former Big B Cleaners; Former Sta-Brite Cleaners; Johannsen Cleaners; and Koretizing Cleaners • At the Former Big B Cleaners site, the treatment system consisted of two soil vapor extraction (SVE) wells installed in horizontal trenches 1.5 ft in depth and one groundwater capture well. A vacuum of 73 inches of water was applied to the SVE wells, resulting in an extracted air flow rate of 102 cfm. The groundwater well design pumping rate was 10 gpm. The groundwater treatment system was a packed tower air stripper. Residual VOCs were treated with a granular activated carbon system. • At the Former Sta-Brite Cleaners site, the treatment system consisted of 8 recovery wells installed to depths of 17 to 19 ft bgs. The design vacuum of the system was 10 inches of mercury and 70 cfm. • At the Johannsen Cleaners Site, the treatment system consisted of two horizontal headers with vertical wells to the groundwater table. The system removed soil vapor and groundwater treated them using air stripping or direct discharge to the atmosphere. • At the Koretizing Cleaners Site, the treatment system consisted of seven extraction wells to remove groundwater and soil vapor. Groundwater and soil vapor removed rates were 2 gpm and 175 scfm, respectively. Extracted vapors were treated using granular activated carbon and extracted groundwater was treated using a low-profile air stripper.	**Regulatory Requirements/Cleanup Goals:** At three sites, the reported cleanup goal for groundwater was the drinking water MCL for PCE or TCE (less than 0.003 mg/L). For soil the cleanup goals were reported as leachability-based levels for PCE (less than 0.03 mg/kg). No cleanup goals were reported for the Johannsen Cleaners site. At the Nu Way II Cleaners site, no numeric cleanup goals were reported, but the goals removal of the contaminant source and protection or mitigation of threats to human health and the environment were reported. **Results:** At the Former Big B Cleaners site, 215 lbs of PCE were removed from the unsaturated zone, and post-treatment PCE levels were below detection limits 9 of 14 samples. Post-treatment PCE concentrations in groundwater were not specified. At the Former Sta-Brite Cleaners site, an estimated 150 lbs of contaminant mass was removed during the first 3 months of operation. Additional performance data are not provided. Treatment results were not provided for the Johannsen Cleaners site. At the Koretizing Cleaners site, 24 lbs of contaminant were removed, and the concentrations of chlorinated ethenes were reduced by approximately 2 orders of magnitude. At the Nu Way II Cleaners site, 40 lbs of VOCs and 50 lbs of petroleum hydrocarbons were removed.	• Former Big B Cleaners: March to August, 2000 and November, 2000 to January, 2001 • Former Sta-Brite Cleaners: June to August, 2001 • Johannsen Cleaners: Not provided • Koretizing Cleaners: March to October, 2001 • Nu Way II Cleaners: Three years (remediation reported to be ongoing, specific dates not specified).	Reported design and implementation costs: Former Big B Cleaners $61,000 Former Sta-Brite Cleaners $130,000 Johannsen Cleaners $60,000 to $85,000 Koretizing Cleaners $245,000 Nu Way II Cleaners not specified

TABLE C-17

EXAMPLE APPLICATIONS OF PUMP AND TREAT SYSTEM FOR CHLORINATED SOLVENTS IN GROUNDWATER AT SOLID STATE CIRCUITS SUPERFUND SITE

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Solid State Circuits Superfund Site **Location:** Republic, Missouri Chlorinated solvents • Contaminants of greatest concern at this site are TCE, 1,1-DCA, 1,1-DCE, methylene chloride, 1,1,1-TCA, and vinyl chloride • Maximum concentration of TCE was 290,000 µg/L **Type/Quantity of Media Treated:** Groundwater • 257 million gallons treated as of March 1997 • DNAPL suspected in groundwater on site • Extraction wells are located in three aquifers, which are influenced by a nearby surface water • Groundwater is characterized as a leaky artesian system occurring in karst formations, with three units identified at the site • Hydraulic conductivity ranges from <0.01 to 1.62 ft/day **Description:** From 1968 through November 1973, Solid State Circuits manufactured circuit boards and used TCE as a cleaning solvent in portions of its manufacturing process. Since 1973, the site was occupied by a number of tenants, including Micrographics, Inc., a photographic processing firm. In November 1979, a fire partially destroyed the building, and the debris was pushed into the basement under the remaining portion of the building. In June 1982, the Missouri Department of Natural Resources (MDNR) collected samples of water from the city's three municipal wells and detected elevated concentrations of TCE in one well located 500 ft from the site. In 1984, MDNR investigated the site and found elevated levels of TCE in the fill dirt and rubble from the basement, in a 540 ft deep well in the basement, and in shallow groundwater outside the building. The site was placed on the NPL in June 1986 and a ROD was signed in September 1989. The groundwater is characterized as a leaky artesian system occurring in karst formations, with three units identified at the site, with shallow and deep bedrock zones extending up to 1,500 ft bgs. The groundwater extraction system consists of seven wells, one of which is a municipal well. Extracted groundwater is treated using air stripping. After 9 years of operation, cleanup goals for TCE have not been achieved. Site operators are evaluating innovative technologies to enhance the remedial effort, such as air sparging using a horizontal well.	Pump and Treat • Groundwater is extracted using seven wells, four located on site and three located off site, at an average total pumping rate of 34 gpm. • Three wells have depths of 90 ft bgs, two wells of approximately 300 ft bgs, one of 600 ft bgs, and one of 985 ft bgs. • Groundwater extracted from on-site wells is treated with air stripping and discharged to a POTW. • Groundwater extracted from off-site wells is discharged without treatment to a POTW.	**Regulatory Requirements/Cleanup Goals:** The remedial goals for this site are to reduce the TCE concentration in groundwater to 5 µg/L and maintain hydraulic control over the groundwater contaminant plume. Performance goals were that TCE levels in individual discharge points to the POTW were below 200 µg/L, and that average water levels and pump rates from specific wells be within specified ranges; these latter requirements were to ensure hydraulic containment. **Results:** TCE concentrations in some of the wells have decreased from 1987 to 1996, and are below the cleanup goal in one well; however, TCE concentrations in most wells remain well above the cleanup goal. From March 1988 through March 1997, 2,754 lbs of TCE were removed from the groundwater. Plume containment has been achieved for this site.	Status: Ongoing Report covers: 1993 - 3/97	Capital Cost $893,700 O&M $1,616,700 TOTAL $2,510,400 The capital cost does not include the cost for installation of the four deeper wells; these costs were accounted for as part of the RI/FS.

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TABLE C-18

EXAMPLE APPLICATION OF PUMP AND TREAT SYSTEM FOR CHLORINATED SOLVENTS IN GROUNDWATER AT SYLVESTER/GILSON ROAD SUPERFUND SITE

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Sylvester/Gilson Road Superfund Site **Location:** Nashua, New Hampshire **Contaminants:** • Chlorinated solvents; volatiles - nonhalogenated; and heavy metals (selenium) Maximum concentrations detected in 1980 included methylene chloride (122,500 mcg/L), chloroform (81,000 mcg/L), tetrahydrofuran (1,000,000 mcg/L), methyl ethyl ketone (80,000 mcg/L), and toluene (140,000 mcg/L) **Type/Quantity of Media Treated:** Groundwater • 1.2 billion gallons treated as of December 1996 • LNAPL (toluene) observed in several monitoring wells on site • Depth to groundwater was not provided for this site • Extraction wells are located in three hydrogeologic units which are influenced by a nearby surface water • Hydraulic conductivity in the upper unit ranges from 30 to 50 ft/day **Description:** The Sylvester/Gilson Road site is a 2-acre site. Approximately 6 acres of the site were used as a sand borrow pit for an undetermined number of years. Illegal dumping was first discovered in 1970. Although the total amount of hazardous waste disposed at the site had not been determined, documents show that approximately 900,000 gallons of hazardous waste were discarded at the site during a 10-month period in 1979. It was estimated that the site was used for hazardous waste disposal for 5 years. In 1981, initial remedial investigations by the state showed high concentrations of heavy metals and organic compounds in the groundwater under the site. A ROD for this site was signed in July 1982 and a supplemental ROD in September 1983. ESDs for this site were signed in July 1990 and September 2002. The remedial application at this site consisted of a pump and treat system, vertical barrier wall, cap, and soil vapor extraction system. Groundwater was extracted using 14 wells, located on site, and treated with addition of chemicals, flocculation, clarification, mixed-media pressure filtration, air stripping, and biological treatment. A slurry wall encloses the 20-acre site, and a HDPE synthetic cap covers the area inside the slurry wall. To address an area with LNAPL (toluene) that was identified partway through the application, a SVE system was installed that included 66 extraction wells. ACLs have been attained for all contaminants except chlorobenzene, which is expected to achieve its ACL in the near future. According to the third 5-year review for the site, the current concern is the presence of arsenic in groundwater, surface water, and sediments. Arsenic was not an original contaminant of concern and was not part of the sampling strategy during pump and treat operation. The review recommended expanding the boundaries of existing institutional controls to encompass all areas where groundwater is contaminated with arsenic. Ecological risks due to elevated arsenic concentrations in sediments are being evaluated.	Pump and Treat; Vertical Barrier Wall; Cap; and Soil Vapor Extraction • Groundwater was extracted using 14 wells, located on site, at an average total pumping rate of 265 gpm. • Extracted groundwater was treated with addition of chemicals (lime slurry), flocculation, clarification, mixed-media pressure filtration, air stripping [at elevated temperature (175°F)], and biological treatment (biological treatment was used for only 50 of the 265 gpm extracted). • Treated groundwater was reinjected on- and off-site through recharge trenches. • A slurry wall, 4 ft wide, 4,000 ft long, and as much as 100 ft deep, encloses the 20-acre site. • A 40-mil HDPE synthetic cap covers the area inside the slurry wall. • The SVE system included 66 wells and a boiler/incinerator for destruction of VOCs.	**Regulatory Requirements/Cleanup Goals:** The remedial goals for this site were set as alternate concentration limits (ACLs) within the containment structure. ACLs were set at 10% of the maximum concentration detected and consisted of the following: vinyl chloride (95 mcg/L), benzene (340 mcg/L), chloroform (1,505 mcg/L), 1,1,2-TCA (3 mcg/L), MEK (8,000 mcg/L), chlorobenzene (110 mcg/L), methylene chloride (12,250 mcg/L), toluene (2,900 mcg/L), 1,1-DCA (81 mcg/L), trans-1,2-DCA (1,800 mcg/L), 1,1,1-TCA (200 mcg/L), methyl methacrylate (350 mcg/L), selenium (2.6 mcg/L), and phenols (400 mcg/L). Risk-based concentration levels were set for groundwater outside of the containment structure. A performance goal for the remedial system was to prevent the contaminant plume from further migration. **Results:** As of December 1996, the remedial action appeared to have attained ACLs for all contaminants except 1,1-DCA and 1,1,2-TCA. In 2002, the ACL for 1,1-DCA was adjusted to 81 µg/L and 1,1,2-TCA was adjusted to 3 µg/L. Following this adjustment, all ACLs had been attained. As of spring 2004, ACLs for all contaminants continued to be met with the exception of chlorobenzene, which was detected slightly above its ACL of 110 ppb. According to the most recent 5-year review (September 2004), chlorobenzene levels are declining and are expected to reach their ACL in the near future. From 1986 through 1996, the system removed approximately 430,000 lbs of contaminants from the groundwater. A net inward flow into the containment structure has been maintained, thus reducing downward migration of contaminants. Status: Completed.	Period of Operation: December 1981 through December 1996 (1981 through 1986 for hydraulic control and 1986 through 1996 for remediation), followed by monitored natural attenuation. Performance data collected through December 1995.	Capital Cost $9,100,000 O&M $20,600,000 TOTAL $29,700,000

TABLE C-19

EXAMPLE APPLICATION OF PUMP AND TREAT SYSTEM FOR CHROMIUM IN GROUNDWATER

Site Description	Remediation Activities	Reduction Achieved	Time Frame	Cost
Site Name: Odessa Chromium II Superfund Site, South Plume, OU2 **Location:** Odessa, Ector County, Texas **Contaminants:** Heavy Metals (Chromium) Maximum concentration of chromium detected during 1986 sampling event was greater than 50 mg/L (perched zone aquifer) **Type/Quantity of Media Treated:** Groundwater • Groundwater is found at 30-45 ft bgs • Extraction wells are located in 2 aquifers, which are influenced by production wells in the area • Hydraulic conductivity ranges from 1.6 to 5.1 ft/day • 121 million gallons treated as of December 1997 **Description:** Basin Radiator & Supply operated a radiator repair facility at this site from 1960 to the early 1970s. Wastewater containing chromium was discharged to unlined ponds, and waste radiator sludge containing chromium corrosion inhibitors was buried on the site. In 1977, the TNRCC discovered elevated levels of chromium in the groundwater during investigations conducted in response to citizen complaints of contaminated well water. This site later became known as the Odessa II South (S) site. The Odessa IIS site was placed on the NPL in June 1986, and a ROD was signed for the site in March 1988. The extraction system used at this site consisted of six extraction wells constructed in the Trinity Sand Aquifer and four extraction wells in the Ogallala Formation. Extracted groundwater was treated with ferrous iron (produced on site in an electrochemical cell), pH adjustment and aeration, clarification, and multi-media and cartridge filtration. By December 1997, all of the recovery wells had met the cleanup goal with the exception of PRW-20 and PRW-28, located in the Perched Zone. Ferrous sulfate was injected into PRW-20 and PRW-28 on December 4, 1998. The wells were restarted on December 10, 1998, and sampled on a regular basis. Based on the results of the samples showing chromium concentrations below the cleanup goal, well PRW-20 was shut off on February 20, 1999. After 90 days of data showing chromium concentrations remaining below the cleanup goal, the well was treated with ferrous sulfate a second time, then plugged and abandoned. In Well PRW-28, chromium concentrations initially decreased to levels below the cleanup goal then increased to levels above the cleanup goal. On April 30, 1999, the well was treated a second time with ferrous sulfate. On December 10, 1999, after all wells in the Perched Zone and Trinity Aquifer had met the cleanup goals, the Closure Phase began. This phase included decommissioning and pressure washing the treatment building; plugging the remaining wells; and disconnecting the utilities. There were several startup problems that delayed full-scale operation of the P&T system at this site, including clogging of injection wells and encrustation of the multimedia filter by iron and calcium. These problems were solved by modifying the P&T system.	• Pump and treat (P&T) with electrochemical precipitation of chromium using ferrous ion • The extraction system consisted of four recovery wells at a depth of 70 ft and six recovery wells at a depth of 165 ft. • Extracted groundwater was treated using ferrous ions (produced on site in an electrochemical cell) followed by pH adjustment, flocculation, precipitation, and multimedia and cartridge filtration. • Treated water was injected using nine injection wells. • 121 million gallons of groundwater treated. • 141 lbs of chromium removed from groundwater. • In situ ferrous sulfate addition • Two wells that did not meet cleanup goals using P&T were treated using ferrous sulfate.	**Regulatory Requirements/Cleanup Goals:** Remediate groundwater so that chromium levels are less than the maximum contaminant level (MCL) or primary drinking water standard. Prior to 1990, the drinking water standard for chromium was 0.05 mg/L; in 1990, EPA revised the drinking water standard to 0.10 mg/L. Treated effluent that is injected into the aquifer must have a chromium level of less than 0.10 mg/L. The remedial system was required to create an inward gradient toward the site to contain the plume. **Results:** Groundwater P&T As of December 1997, all six wells in the Trinity Aquifer and two wells in the Perched Zone had achieved chromium concentration less than 0.10 mg/L. The P&T system removed a total of 141 lbs of chromium from the groundwater. Effluent chromium levels met the required performance standard of 0.1 mg/L. Therefore, injection of effluent occurred throughout system operation. The site operators concluded that the plume had been contained in both aquifers. In Situ Ferrous Sulfate Treatment The two wells, PRW-20 and PRW-28 that did not meet cleanup goals using P&T were treated with two rounds of ferrous sulfate. The ferrous sulfate treatment reduced chromium concentrations to below the cleanup goal in both wells.	• Electrochemical Groundwater Pump and Treat, December • 1993 to December 1997 • In Situ Chemical Treatment, December 1998 to April 1999	Groundwater P&T: Capital costs of remedial construction $1,927,502 O&M from 1993 to 1996 $560,232 TOTAL $2,487,734 In Situ Ferrous Sulfate Treatment: The combined cost of two treatments with ferrous sulfate and plant operations for three months was approximately $42,600 In 1999 dollars.

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TABLE C-20

ESTIMATED REMEDIATION TIME FRAMES FOR HCIM ALTERNATIVES PER COC WATER TABLE AND SHALLOW GROUNDWATER DEPTH INTERVALS

PSC Georgetown Facility
Seattle, Washington

Constituent[1]	Final SWFS Cleanup Level (µgL)	Maximum Detected Concentration (µgL)	Half Life[2] (yr)	Estimated Remediation Time[3] (years)					
				Alternative HA-1	Alternative HA-2	Alternative HA-3	Alternative HA-4	Alternative HA-5	Alternative HA-6
Chloroethane	461	1,530	1.0	15 - 20	10 - 20	7 - 20	7 - 20	3 - 5	3 - 5
Chloroform	28	82	2.4	10 - 25	5 - 25	5 - 25	5 - 25	1 - 25	1 - 25
1,1-Dichloroethane	47	2,040	0.31	10 - 20	7 - 20	5 - 20	5 - 20	3 - 20	3 - 20
1,1-Dichloroethene	25	106	0.58[4]	10 - 20	7 - 20	5 - 20	5 - 20	3 - 20	3 - 20
1,2-Dichloroethane	30.6	1,100	0.31	10 - 20	7 - 20	5 - 20	5 - 20	3 - 20	3 - 20
cis-1,2-Dichloroethene	165	14,500	0.58[4]	225 - 250	225 - 250	200 - 250	200 - 250	150 - 250	150 - 250
trans-1,2-Dichloroethene	1,691	7,120	0.5	200 - 250	200 - 250	175 - 250	175 - 250	125 - 250	125 - 250
Tetrachloroethene	0.2	282	5.3	100 -150	75 -150	50 -150	50 -150	30 -150	30 -150
Trichloroethene	0.8	612	7.2	200 - 300	200 - 300	175 - 300	175 - 300	125 - 300	125 - 300
1,1,1-Trichloroethane	11	1,980	0.83	10 - 20	7 - 20	5 - 20	5 - 20	3 - 20	3 - 20
Vinyl chloride	2.04	15,400	3	300 - 350	275 - 350	250 - 350	225 - 350	175 - 350	175 - 350
Benzene	11.7	103	1.1	5 - 10	3 - 10	2 - 10	1 - 10	39092.0	39092.0
Benzo(a)anthracene	0.02	0.0212	Biodeg[5]	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5
Benzo(b)fluoranthene	0.019	0.0417	Biodeg	5 - 10	3 - 10	3 - 10	3 - 10	3 - 10	3 - 10
Benzo(k)fluoranthene	0.018	0.0938	Biodeg	10 - 30	7 - 30	7 - 30	7 - 30	7 - 30	7 - 30
Benzoic acid	42	649	0.015[5]	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5
Chrysene	0.018	0.0741	Biodeg	3 - 10	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10
Cumene	7.3	76	1.6[4]	10 - 20	7 - 10	7 - 10	7 - 10	7 - 10	7 - 10
Dibenzo(a,h)anthracene	0.016	77.6	Biodeg	15 - 25	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25
Diesel	500	224,000	Biodeg	30 - 60	25 - 60	20 - 60	20 - 60	20 - 60	20 - 60
Ethylbenzene	7.3	21,900	1.6	30 - 60	25 - 60	20 - 60	15 - 60	15 - 60	15 - 60
Gasoline	800	161,000	Not. Det.[7]	20 - 60	15 - 60	15 - 60	10 - 60	5 - 60	5 - 60
2-Hexanone	99	523	26[4]	65 - 150	60 - 150	60 - 150	60 - 150	45 - 150	45 - 150
Indeno(1,2,3-cd)pyrene	0.02	0.0592	Biodeg	10 - 50	7 - 50	7 - 50	7 - 50	7 - 50	7 - 50
1-Methyl naphthalene	2.1	2.82	4.4	5 - 20	5 - 20	5 - 20	5 - 20	5 - 20	5 - 20
2-Methylnaphthalene	2.1	21.7	4.4[4]	15 - 50	10 - 50	10 - 50	10 - 50	10 - 50	10 - 50

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TABLE C-20

ESTIMATED REMEDIATION TIME FRAMES FOR HCIM ALTERNATIVES PER COC WATER TABLE AND SHALLOW GROUNDWATER DEPTH INTERVALS

PSC Georgetown Facility
Seattle, Washington

Constituent[1]	Final SWFS Cleanup Level (µgL)	Maximum Detected Concentration (µgL)	Half Life[2] (yr)	Estimated Remediation Time[3] (years)					
				Alternative HA-1	Alternative HA-2	Alternative HA-3	Alternative HA-4	Alternative HA-5	Alternative HA-6
Lube Oil	500	1,490	Not Det.	50 - 75	45 - 75	45 - 75	45 - 75	30 - 75	30 - 75
Methyl isobutyl ketone (MIBK)	170	806	26	60 - 100	55 - 100	50 - 100	50 - 100	40 - 100	40 - 100
Naphthalene	12	362	0.53	3 - 10	3 - 10	3 - 10	3 - 10	1 - 10	1 - 10
n-Hexane	1	4.21	Biodeg	5 - 15	3 - 15	3 - 15	3 - 15	1 - 15	1 - 15
Propylbenzene	7.3	172	1.6[4]	10 - 25	7 - 25	7 - 25	5 - 25	3 - 25	3 - 25
sec-Butylbenzene	4.6	202	1.6[4]	10 - 25	7 - 25	7 - 25	5 - 25	3 - 25	3 - 25
Styrene	0.5	47.4	1.6[4]	10 - 50	10 - 50	10 - 50	10 - 50	7 - 50	7 - 50
Toluene	9.8	66,900	0.98	25 - 50	20 - 50	15 - 50	12 - 50	7 - 50	7 - 50
1,2,4-Trimethylbenzene	78	951	ND[8]	100 - 150	100 - 150	75 - 150	75 - 150	50 - 150	50 - 150
1,3,5-Trimethylbenzene	55.7	755	ND	100 - 150	100 - 150	75 - 150	75 - 150	50 - 150	50 - 150
Xylenes (Total)	141	15,900	1.2	15 - 20	10 - 20	10 - 20	7 - 20	5 - 20	5 - 20
Carbon disulfide	0.92	9.76	Not Det.	5 - 10	5 - 10	5 - 10	5 - 10	1 - 5	1 - 5
Cyanide	10	48.9	Biodeg	5 - 10	3 - 10	5 - 10	5 - 10	1 - 5	1 - 5
1,2-Dichlorobenzene	14	51.5	ND	100 - 150	100 - 150	75 - 150	75 - 150	50 - 150	50 - 150
1,4-Dichlorobenzene	2.5	25	ND	100 - 150	100 - 150	75 - 150	75 - 150	50 - 150	50 - 150
1,4-Dioxane	94.9	207	ND	100 - 150	100 - 150	75 - 150	75 - 150	20 -150	15 - 150
2,4-Dimethylphenol	28.5	921	0.11[4]	5 - 10	5 - 10	5 - 10	5 - 10	3 - 10	3 - 10
2-Methylphenol	13	282	0.11	5 - 10	5 - 10	5 - 10	5 - 10	3 - 10	3 - 10
4-Methylphenol	108	1,930	0.08	5 - 10	5 - 10	5 - 10	5 - 10	3 - 10	3 - 10
Methylphenol	1,650	2,680	0.11[4]	5 - 10	5 - 10	5 - 10	5 - 10	3 - 10	3 - 10
Pentachlorophenol	2.5	48.7	ND	100 - 150	100 - 150	75 - 150	75 - 150	50 - 150	50 - 150
Phenol	118	6,630	0.11	5 - 10	5 - 10	5 - 10	5 - 10	3 - 10	3 - 10
Arsenic	0.051	16.7	ND	---	---	---	---	---	
Barium	4	32.9	ND	---	---	---	---	---	
Chromium	10	12.5	ND	---	---	---	---	---	
Copper	3.1	7.35	ND	---	---	---	---	---	

TABLE C-20

ESTIMATED REMEDIATION TIME FRAMES FOR HCIM ALTERNATIVES PER COC WATER TABLE AND SHALLOW GROUNDWATER DEPTH INTERVALS

PSC Georgetown Facility
Seattle, Washington

Constituent[1]	Final SWFS Cleanup Level (µgL)	Maximum Detected Concentration (µgL)	Half Life[2] (yr)	Estimated Remediation Time[3] (years)					
				Alternative HA-1	Alternative HA-2	Alternative HA-3	Alternative HA-4	Alternative HA-5	Alternative HA-6
Iron	1,000	79,400	ND	---	---	---	---	---	
Lead	2.5	10.1	ND	---	---	---	---	---	
Nickel	8.2	9.14	ND	---	---	---	---	---	
Aroclor 1016	0.005	15.4	ND	---	---	---	---	10 - 15	
Aroclor 1232	0.005	25.9	ND	---	---	75 - 150	---	10 - 15	

Notes:
1. Only constituents that have been detected in the water table/shallow groundwater depth interval above the final SWFS cleanup level in the HCIM Area are listed in the table.
2. When available, half lives are as used for modeling fate and transport of COCs. For COCs not modeled, half lives are the average values for anaerobic biodegradation taken from Aronson, 1997.
3. Remediation time frames estimated considering: (1) COC half lives (when available); (2) ratio of maximum detected concentration to cleanup level; (3) expected performance of remediation technologies at sites similar to the HCIM Area.
4. No available half life data. Half lives are estimated based on available data for similar compound.
5. Biodeg. = literature sources indicate constituent biodegrades under anaerobic conditions; however, biodegradation rates were available only for aerobic conditions.
6. Calculated from data taken from the CHEMFATE web site (Syracuse Research Corporation, esc.syrres.com/scripts/CHFcgi.exe).
7. Not Det. = Not determined. No suitable data identified; degradation rate could not be determined.
8. ND = No degradation.

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TABLE C-21

ESTIMATED REMEDIATION TIME FRAMES FOR HCIM ALTERNATIVES PER COC
INTERMEDIATE GROUNDWATER DEPTH INTERVAL

PSC Georgetown Facility
Seattle, Washington

Constituent	SWFS CUL (µgL)	Maximum Detected Concentration (µgL)	Half Life (years)	Estimated Remediation Time Frames (years)[1] HA-1	HA-2	HA-3	HA-4	HA-5	HA-6
1,1-Dichloroethane	47	1,040	0.31	3 - 10	3 - 10	3 - 10	3 - 10	1 - 10	1 - 10
1,1-Dichloroethene	25	1,380		3 - 10	3 - 10	3 - 10	3 - 10	1 - 10	1 - 10
cis-1,2-Dichloroethene	165	85,400	0.58	225 - 250	225 - 250	225 - 250	225 - 250	200 - 250	200 - 250
trans-1,2-Dichloroethene	1,691	12,800		200 - 250	200 - 250	200 - 250	200 - 250	175 - 250	175 - 250
Tetrachloroethene	0.20	40.3	5.3	50 -75	50 -75	50 -75	50 -75	30 -75	30 -75
Trichloroethene	0.79	143,000	7.2	200 - 250	200 - 250	200 - 250	200 - 250	150 - 250	150 - 250
1,1,1-Trichloroethane	11	16.5	0.83	1 - 5	1 - 5	1 - 5	1 - 5	0 - 5	0 - 5
Vinyl chloride	2.04	67,200	3.0	250 - 300	250 - 300	250 - 300	250 - 300	200 - 300	200 - 300
Benzene	11.7	73.6	1.1	5 - 10	5 - 10	5 - 10	5 - 10	1 - 10	1 - 10
Diesel	500	1,500	Biodeg[2]	30 - 60	30 - 60	30 - 60	30 - 60	20 - 60	20 - 60
Ethylbenzene	7.3	2,200	1.6	20 - 30	20 - 30	20 - 30	20 - 30	15 - 30	15 - 30
Lube Oil	500	516		50 - 100	50 - 100	50 - 100	50 - 100	30 - 100	30 - 100
Styrene	0.5	6.1	1.6[3]	10 - 25	10 - 25	10 - 25	10 - 25	7 - 25	7 - 25
Toluene	9.8	3,520	0.98	10 - 15	10 - 15	10 - 15	10 - 15	7 - 15	7 - 15
1,2,4-Trimethylbenzene	78	475	ND[4]	100 - 150	100 - 150	100 - 150	100 - 150	75 - 150	75 - 150
Xylenes (Total)	141	884	1.2	5 -10	5 -10	5 -10	5 -10	1 -10	1 -10
Carbon disulfide	0.92	46.6	Not Det.[5]	5 - 10	5 - 10	5 - 10	5 - 10	1 - 5	1 - 5
Cyanide	10	64.9	Biodeg	5 - 10	5 - 10	5 - 10	5 - 10	1 - 10	1 - 10
1,2-Dichlorobenzene	14	197	ND	100 - 150	100 - 150	100 - 150	100 - 150	75 - 150	75 - 150
2,4-Dimethylphenol	28.5	444	0.11	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10
2-Methylphenol	13	302	0.11	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10
4-Methylphenol	108	2,230	0.08	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10
Phenol	118	4,670	0.11	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10	1 - 10
Arsenic	0.051	17.8	ND	---[6]	---	---	---	---	---
Barium	4	64	ND	---	---	---	---	---	---
Chromium	10	76	ND	---	---	---	---	---	---
Copper	3.1	25.3	ND	---	---	---	---	---	---
Iron	1,000	75,000	ND	---	---	---	---	---	---
Lead	2.5	7.13	ND	---	---	---	---	---	---
Manganese	100	268		---	---	---	---	---	---
Nickel	8.2	67.2	ND	---	---	---	---	---	---
Vanadium	20	41		---	---	---	---	---	---

Notes:

1. Remediation time frames estimated based on: (1) COC half lives (when available); (2) ratio of maximum detected concentration to CUL; (3) performance of remediation technologies at sites similar to the HCIM Area
   Only constituents that have been detected in the water table/shallow groundwater depth interval above the cleanup level in the HCIM Area are listed in the table.
2. Biodeg. = literature sources indicate constituent biodegrades under anaerobic conditions; however, biodegradation rates were only identified for aerobic conditions.
3. No available half life data. Half lives are based on available data for similar compound.
4. ND = No degradation
5. Not Det. = Not determined. No suitable data identified; degradation rate could not be determined.
6. --- = limited or no mass reduction, cleanup levels unlikely to be obtained

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APPENDIX D

Monitored Natural Attenuation of Metals

APPENDIX D
MONITORED NATURAL ATTENUATION OF METALS UNDER MTCA
PSC Georgetown Facility
Seattle, Washington

1.0 INTRODUCTION

Under the Model Toxics Control Act (MTCA), monitored natural attenuation (MNA) is considered an active remedial measure if certain conditions are met. MNA, either as a stand-alone measure or in combination with other remedial measures, is a component for the Outside Area of all remedial alternatives for organic and inorganic (metals) constituents of concern (COCs) evaluated in Technical Memorandum No. 5. This appendix evaluates the application of MNA to metals COCs in the context of MTCA requirements.

2.0 MTCA REQUIREMENTS AND DEFINITIONS

Natural attenuation is defined in Chapter 173-340-200 Washington Administrative Code (WAC) as follows: "natural attenuation means a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of hazardous substances in the environment. These in situ processes include: Natural biodegradation; dispersion; dilution; sorption; volatilization; and, chemical or biological stabilization, transformation, or destruction of hazardous substances." This chapter goes on to state that "a cleanup action that includes natural attenuation and conforms to the expectation in WAC 173-340-370(7) can be considered an active remedial measure."

Chapter 173-340-370 (7) WAC sets forth conditions under which MNA may be considered as part of a remedial action. Specifically, "(t)he department expects that natural attenuation of hazardous substances may be appropriate at sites where: (a) Source control (including removal and/or treatment of hazardous substances) has been conducted to the maximum extent practicable; (b) Leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health or the environment; (c) There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and (d) Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected."

It is also important to note that Ecology does not consider MNA a “model remedy” under Chapter 173-340-390 WAC. As such, selection of MNA as a component of remedial action at the site requires completion of a feasibility study under Chapter 173-340-350(8) WAC, including screening and evaluation of alternatives.

3.0 NATURAL ATTENUATION OF METALS

In comments on Technical Memorandum No. 4, Ecology requested an explanation of the mechanism by which MNA would reduce metals COC concentrations to cleanup levels and an estimate of the associated remediation time frame. Technical Memorandum No. 1 provided a lengthy discussion of the geochemical processes (primarily oxidation-reduction [redox] reactions) that are affecting the fate and transport of metals downgradient of the facility. Redox conditions in the area are controlled partially by the natural aquifer geochemistry and this naturally reducing condition is increased by the biodegradation of organic COCs released from the PSC facility and other downgradient sources. Biodegradation of organic COCs results in stronger reducing conditions than occur under natural aquifer conditions. These reducing conditions result in the mobilization and transport of metals and, therefore, stronger reducing conditions resulting from COC biodegradation increase the mobility of the metals. The metals most sensitive to redox conditions are arsenic, iron, and manganese, which are also the metals with the most wide-spread distribution within the SWFS study area at concentrations greater than cleanup levels.

Downgradient of the PSC facility (the source area for releases of organics), concentrations of COCs are decreasing due to biodegradation, dilution, and sorption of the organic source materials. As the organic COC concentrations decrease, the effects of biodegradation on redox conditions also decrease. In these areas, redox conditions rebound toward natural aquifer conditions (more oxidizing conditions0, which in turn results in a decrease in metals mobility. As discussed in Technical Memorandum No.1, under moderately oxidizing conditions iron will form insoluble oxide and oxyhydroxide compounds, which precipitate on aquifer mineral surfaces. Metals such as arsenic, chromium, copper, lead, selenium, and zinc are strongly adsorbed to the iron oxides and oxyhydroxides, with near complete adsorption occurring at pH values in the range of 6 to 8.

The redox-controlled precipitation and coprecipitation reactions are the primary mechanisms by which natural attenuation of metals is expected to occur downgradient of the facility. More oxidizing conditions necessary to support natural attenuation of metals COCs will be achieved by decreasing the concentrations of organic COCs that are currently biodegrading and producing reducing redox conditions. Since metals in the area downgradient of the PSC facility are not a result of a release of metals but are a result of the change (increase) in reducing conditions related to breakdown of organic COCs, the remediation of metals COCs through natural attenuation is directly dependent on remediation of the organic COCs. As such, the remediation time frame for the metals is expected to generally coincide with the remediation time frame for organic COCs. Technical Memorandum 1 outlined the remediation time frames for organic COCs based on biodegradation modeling.

4.0 MNA OF METALS UNDER MTCA

Ecology has also requested a discussion of the suitability of MNA for inorganic COCs under MTCA. As discussed above, application of MNA as a remedial measure at a site may be appropriate if the following conditions specified in Chapter 173-340-370 (7) WAC are met:

- a feasibility study is completed under Chapter 173-340-350(8) WAC;
- source control is conducted to the maximum extent practicable;
- contaminants left on site during the restoration time frame do not pose an unacceptable threat to human health or the environment;
- natural biodegradation or chemical degradation is occurring and will continue to occur; and
- monitoring is conducted to ensure that the natural attenuation is taking place and that human health and the environment are protected.

Each of these requirements is addressed in the following sections.

4.1 FEASIBILITY STUDY

Technical Memoranda Nos. 1 through 5 address the requirements specified in Chapter 173-340-350(8) WAC for completing a feasibility study, including screening and evaluation of alternatives. Ecology approved Technical Memorandum No. 4 which proposed final alternatives for the SWFS. Based on the Technical Memorandum No. 4 feasibility study screening and evaluation, MNA of metals and organic COCs was identified as an applicable remedy at the site.

4.2 SOURCE CONTROL

Based on site history and use, releases of metals-containing wastes may have occurred at the PSC facility; however, the available soil analytical data do not indicate any apparent soil source areas for metals. As discussed in Technical Memorandum No. 1, the metals (arsenic, iron, manganese) with the most wide-spread distribution in groundwater at concentrations above cleanup levels appear to occur partially or entirely due to dissolution from the aquifer matrix, rather than as a result of a metals release at the facility. This "release" of metals from aquifer materials is due to geochemical conditions in the aquifer resulting from biodegradation of organic COCs.

Source area controls for metals COCs in groundwater that may be derived from potential metals releases at the facility include capping/cover of soils at the facility and maintenance of the HCIM barrier wall. Remedial actions that decrease organic COC concentrations in groundwater and, in turn, alter the geochemical conditions that result in "releases" of metals from the aquifer matrix, would serve effectively as source area controls for arsenic, iron, and manganese.

4.3 UNACCEPTABLE THREAT TO HUMAN HEALTH OR THE ENVIRONMENT

The only current exposure pathway for metals-impacted groundwater is discharge to the Duwamish Waterway. As discussed in Technical Memorandum No. 1, groundwater monitoring data indicate that, with the exception of arsenic, iron, and manganese, metals are currently attenuated to below cleanup levels by approximately 6th Avenue South and all metals are unlikely to reach the Duwamish Waterway at concentrations greater than cleanup levels. Arsenic, iron, and manganese concentrations exceed cleanup levels farther downgradient than the other metals, and elevated concentrations generally correspond to reducing geochemical conditions associated with the organic COC plumes. The concentration and mobility of arsenic, iron, and manganese are strongly affected by geochemical conditions, with higher concentrations and greater mobility associated with reducing conditions. Under oxidizing conditions, iron will precipitate out of solution as insoluble oxide and oxyhydroxide compounds, while arsenic and other metals will co-precipitate with the iron minerals, effectively immobilizing these metals. High concentrations of arsenic, iron, and manganese are not expected to persist downgradient of the reducing conditions associated with the organic COC plumes. MNA and other remedial actions designed to address organic COC concentrations will shrink the associated area of reducing conditions downgradient from the facility, limiting further downgradient migration of metals toward the waterway. Based on this, MNA of metals will be protective of human health and the environment.

4.4 EVIDENCE NATURAL BIODEGRADATION OR CHEMICAL DEGRADATION

Biodegradation is generally not considered in evaluating natural attenuation of metals species. The term “chemical degradation” is not defined in MTCA; however, the definition of natural attenuation processes in Chapter 173-340-200 WAC includes chemical “stabilization, transformation, or destruction of hazardous substances”. As discussed in Technical Memorandum No. 1 (Geomatrix, 2006a), chemical transformation and stabilization of metals from more mobile (e.g., ferrous iron) and toxic (e.g., arsenite or $H_2AsO_3^-$) reduced metals species to less mobile (e.g., ferric iron) and less toxic (e.g., arsenate or $H_2AsO_4^-$) oxidized metals species is occurring downgradient of the facility in response to changes in geochemical conditions. Under more oxidizing conditions, metals such as iron, manganese, and arsenic are far less mobile and, in the case of arsenic species, less toxic. Additionally, under moderately or highly oxidizing conditions, dissolved iron will precipitate as insoluble oxide and oxyhydroxide compounds. Other metals such as arsenic, chromium, copper, lead, selenium, and zinc co-precipitate with the iron-containing minerals and are effectively immobilized.

4.5 APPROPRIATE MONITORING

All alternatives include comprehensive groundwater quality monitoring programs to ensure the effectiveness of the final selected remedial alternatives. Monitoring will be maintained until aquifer conditions meet cleanup levels for all COCs.