Hamilton/Labree Roads Groundwater Contamination Superfund Site

Draft Final Feasibility Study

Prepared for

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CERTIFICATION

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.

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ACRONYMS

AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
Breen	S.C. Breen Construction Company
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm/s	centimeters per second
COPC	chemical of potential concern
CSM	conceptual site model
cy	cubic yard
DNAPL	dense nonaqueous-phase liquid
DNR	Department of Natural Resources
E&E	Ecology and Environment, Inc.
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation/cost analysis
EFH	Essential Fish Habitat
EPA	U.S. Environmental Protection Agency
ERH	electrical resistance heating
ESA	Endangered Species Act
Farallon	Farallon Consulting.
FRTS	Federal Remediation Technologies Roundtable
FS	feasibility study
ft	foot
ft/d	feet per day
ft/ft	foot per foot
GCL	geosynthetic clay liner
gpm	gallon per minute
HRIA	Hamilton Road Impact Area
I-5	Interstate 5
ICs	institutional controls
ISCO	In-Situ Chemical Oxidation
kg	kilogram
MCL	maximum contaminant level

ACRONYMS (CONTINUED)

$\mu g/m^3$	microgram per cubic meter
µg/kg	microgram per kilogram
µg/L	microgram per liter
mg/kg	milligram per kilogram
MRL	method reporting limit
MTCA	Model Toxics Control Act
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
O&M	operation and maintenance
PCE	tetrachloroethene
POTW	publicly owned treatment work
PRB	permeable reactive barrier
PUD	public utility district
QA	quality assurance
QAPP	quality assurance project plan
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RG	remediation goal
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
scfm	standard cubic feet per minute
SAIC	Science Applications International Corporation
START	Superfund Technical Assistance and Response Team
SWCAA	Southwest Clean Air Agency
TCLP	toxicity characteristic leaching procedure
TCE	trichloroethene
TEG	Transglobal Environmental Geosciences Northwest, Inc.
TMP	temperature monitoring point
URS	URS Group, Inc.
USFWS	U.S. Fish and Wildlife Service

ACRONYMS (CONTINUED)

VOC	volatile organic compound
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington State Department of Health

1. INTRODUCTION

This report presents the feasibility study (FS) completed by EPA for the Hamilton/Labree Roads Groundwater Contamination Superfund Site (Site) in Chehalis, Washington. The FS was completed under the EPA Region 10 Architect and Engineering Services (Small Business) Contract No. 68-S7-03-04.

1.1 PURPOSE

The FS was prepared by EPA Region 10 to identify and evaluate potential remedial alternatives for cleanup of contaminated groundwater and creek bed sediment/soil related to historical spills and releases of hazardous materials to the ground and Berwick Creek, in order to allow EPA to select a preferred alternative.

This FS report was prepared in accordance with *Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response, Compensation, and Liability Act* [CERCLA] (Interim Final, October 1988).

1.2 ORGANIZATION

This report is divided into eight major sections including:

- Section 1: Introduction – describes Site information including, but not limited to, site description and history, historical investigations, and previous remedial actions.
- Section 2: Applicable and Relevant Appropriate Requirements – discusses the potential applicable and relevant appropriate requirements (ARARs) that could impact the type of remedial action selected and extent of treatment required at the Site.
- Section 3: Remedial Action Objectives/General Response Actions – describes the remedial action objectives (RAOs) for each media of concern and general remedial response actions.
- Section 4: Identification and Screening of Technologies – identifies potential remedial technology options by media.
- Section 5: Development and Screening of Alternatives – describes potential remedial alternatives which may include a combination of several technologies presented in Section 4.
- Section 6: Detailed Analysis of Alternatives – presents the results of the analysis of each of the alternatives in which the performance and attributes of each alternative is described with regards to specific evaluation criteria.
- Section 7: Comparative Analysis of Alternatives – provides a comparison and ranking of the developed remedial alternatives based on the evaluation criteria established under CERCLA.
- Section 8: References.

1.3 BACKGROUND

This section presents site background information including, but not limited to, a description of the Site and history, a summary of previous investigation, the nature and extent of contamination, baseline risk assessment results, and a description of the fate and transport process affecting contaminant migration.

1.3.1 Site Description and History

The Hamilton/Labree Site is located near the intersection of Hamilton Road and Labree Road, west of Interstate 5 (I-5), about 2 miles south of the city of Chehalis, Washington (Figure 1-1). The Hamilton/Labree Site includes the S.C. Breen Construction Company (Breen) Property, Hamilton Road Impact Area (HRIA), and the geographic area underlain by groundwater containing chemicals of potential concern (COPCs). This geographic area encompasses the area between and around the Breen property and the HRIA and extends to the northwest to MW-28 (Figure 1-2).

The boundary between the City of Chehalis and unincorporated Lewis County bisects the Hamilton/Labree Site roughly north to south along the western side of Labree Road. The HRIA and the Breen property are both within the city limits of Chehalis. This entire portion of the site within the city of Chehalis is zoned for commercial use. The portion of the site located in Lewis County is zoned rural development district, and includes agricultural uses (predominately dairy) and residential uses (Farallon 2003).

The Site is located within the Newaukum River valley and has a relatively flat topography. Berwick Creek traverses the site from southeast to northwest. Overall, the site slopes to the northwest. Groundwater and surface water flow is generally northwest toward the Chehalis River.

On October 31, 2001, an Administrative Order on Consent (AOC) between the EPA and Breen was signed (U.S. EPA Docket No. CERCLA 10-2002-0002). In accordance with the AOC, Breen (through their consultant, Farallon Consulting) conducted remedial investigation (RI) activities under EPA oversight to investigate the COPCs in the shallow aquifer at the Breen Property, primarily tetrachloroethene (PCE) and associated degradation products. In addition, EPA conducted an investigation within the HRIA to further evaluate contamination within Berwick Creek and the shallow aquifer.

Breen Property

The Breen Property is located in the northeast quarter of the southeast quarter of Section 9, Township 13 North, Range 2 West, Willamette Baseline and Meridian in Lewis County, Washington.

The Breen Property has been previously discussed as two geographic areas: the western and eastern portions (Figure 1-3). The western portion consists of approximately 6.5 acres containing three wood-framed, steel-clad buildings with concrete floors. The Bulldog Trailer Company occupies the northern building (Building A), a building located in the center portion of the property is unoccupied (Building B), and a building located on the southern portion of the property is also unoccupied (Building C). A concrete wash-down pad approximately 24 feet by 38 feet is located southeast of Building C.

The eastern portion of the Breen Property is approximately 4.5 acres and contains the Chehalis Livestock Auction. The eastern portion is no longer owned by Breen (Farallon 2003). Two buildings are located on the portion of the Property: a large wood-framed building is located on the northeast portion and a smaller wood-framed building is located along the southeastern boundary and Berwick Creek. Most of the eastern portion of the Breen Property is an unpaved parking area.

HRIA

The HRIA is located southeast of the Breen Property (see Figure 1-3). The HRIA is shown in the AOC as a roughly rectangular area approximately 3 acres in size, located immediately east of the United Rentals building and extending eastward to the western edge of I-5. This area includes a portion of the United Rentals property and small portions of properties owned by Mr. Reggie Hamilton and Mr. Willard Warren. The area is crossed in a north-south direction by Hamilton Road and Berwick Creek. The portion of the HRIA located between Hamilton Road and I-5 consists of grassy open land that includes Berwick Creek, which flows north; overhead power lines; and a wire field fence preventing access to I-5. An unnamed ditch passes underneath I-5 and discharges to Berwick Creek within the HRIA.

1.3.2 Historical Site Investigations

Both the Breen Property and the HRIA have been identified as sources of PCE in shallow groundwater beneath the Site. This groundwater occurs in a “shallow” aquifer occurring from roughly 5 feet to approximately 50 feet below ground surface (bgs). Regional groundwater flow in the shallow aquifer is to the northwest along the Newaukum River valley.

During late 1993 and early 1994, Washington State Department of Health (WDOH) sampled 18 private water-supply wells in the vicinity of the Hamilton/Labree Site as part of a routine sampling program. PCE was detected in six of the 18 water-supply wells. These six wells were screened in the shallow aquifer and contained PCE at concentrations ranging from 3.3 micrograms per liter (µg/L) to 2,165 µg/L (Ecology 1999). The maximum contaminant level (MCL) for PCE is 5 µg/L. Lewis County Public Services informed affected well owners of the sampling results and advised them to obtain alternative sources of drinking water.

In 1996, WDOH re-sampled five of the six water-supply wells that previously exhibited PCE concentrations and found that concentrations had increased slightly from those measured in 1993 and 1994. Also in 1996, Ecology learned from a confidential source that drums containing solvents might have been buried on the Breen Property. Ecology initiated an investigation that included a geophysical survey by Geo-Recon International and a subsurface investigation by Science Applications International Corporation (SAIC). Between October 1997 and July 1998, Ecology performed quarterly sampling of monitoring wells installed by SAIC and some private water-supply wells. In spring 1998, Ecology contracted Transglobal Environmental Geosciences (TEG) Northwest, Inc. to conduct an additional subsurface investigation.

In June 1999, Ecology installed seven additional monitoring and recovery wells within the HRIA study area and contracted GeoPotential to conduct an additional geophysical survey. In August 1999, Breen entered into an Agreed Order with Ecology and contracted for additional investigation on the Breen Property. This investigation included a geophysical survey by Northwest Geophysical Associates in August 1999 and additional subsurface investigation by GeoEngineers, Inc. In September 1999, 70 drums and a number of pails and cans were removed from beneath Building B on the Breen Property. PCE was detected in the contents of some drums and in water in the drum excavation (GeoEngineers 2001).

On July 27, 2000, the Hamilton/Labree Site was added to the EPA National Priorities List (NPL). The same year the EPA Superfund Technical Assistance and Response Team (START) contractor began a phased removal assessment including installing soil borings and new groundwater monitoring wells, and collecting subsurface soil and groundwater samples in and near the HRIA. The assessment resulted in the expansion of the City of Chehalis municipal water-supply system to include those residences at the Site with contaminated water-supply wells.

Beginning in July 2002, Farallon, under contract to Breen, conducted Phase I RI activities. Farallon installed and sampled temporary borings and conducted a soil gas investigation on the Breen Property, collected surface water and stream-bed soil samples from Berwick Creek, and sampling groundwater from existing monitoring and private water-supply wells within the overall Hamilton/Labree Site.

In 2003, URS began additional field investigations in the HRIA to support completion of an Engineering Evaluation/Cost Analysis (EE/CA). The purpose of the field investigations was to better define the extent of soil and groundwater contamination including defining the extent of dense non-aqueous phase liquid (DNAPL) in the Berwick Creek bed and the shallow aquifer. URS also evaluated potential alternatives for remediation of contamination in the HRIA.

Beginning in late 2003, Farallon conducted Phase II RI sampling and analysis to better define the nature and extent of contamination at the Breen Property and to determine potential sources on areas of the property. This included conducting soil and groundwater sampling, monitoring well installation and sampling, surface water sampling, pump testing, and various other activities. This data was collected, but was not reported.

The history of investigations conducted at the Hamilton/Labree Site is summarized in Table 1-1.

1.3.3 Site Geology, Hydrogeology, and Surface Water Hydrology

Geology

The overall soil-type distribution from ground surface to approximately 47 feet bgs of the site is silt and clay underlain by water-bearing sand and gravel, underlain by a silt and clay aquitard. These soil types are consistent with regional geologic mapping by Weigle and Foxworthy (1962) and a regional study for the Chehalis Generation Facility (Dames and Moore 1994). These regional studies classify the upper 50 feet of soil in the area of the site as recent alluvium and glaciofluvial sediments. The aquitard found at approximately 50 feet bgs is widespread, is often described as a blue-gray, clayey silt, and is reported to be more than 100 feet thick (Dames and Moore 1994).

The low permeability silt cap of the aquifer was found to be continuous within the Site, ranging in thickness from less than 1 foot beneath Berwick Creek to 15 feet at the Breen Property. The silt cap creates locally confined groundwater conditions in the shallow aquifer. In some cases, the silt grades to a silty sand or silty gravel at its contact with the underlying sand and gravel of the shallow aquifer.

The sand and gravel of the shallow aquifer underlies the silt cap and extends to a depth of about 50 feet bgs. Soil types within the sand and gravel typically range from fine-grained, poorly sorted sand to coarse gravel, with cobbles prevalent. The silt content of the sands and gravels varies substantially throughout the shallow aquifer, with some zones classified as silty sands and silty gravels and other zones classified as clean sands or gravels. The degree of correlation in soil types between nearby borings is poor, indicating a high degree of grain size and silt content variation within the shallow aquifer. In general, laterally continuous beds or zones of particular grain sizes or silt content are not apparent. A somewhat laterally extensive bed of poorly sorted sand was identified in borings beneath and around Berwick Creek at a depth of about 30 feet bgs. However, this bed does not appear to be a substantial barrier to downward contaminant migration. Silt lenses have been reported within the sand and gravel shallow aquifer by previous investigators.

The silt and clay aquitard that forms the base of the shallow aquifer was present at all sampling locations drilled sufficiently deep. The aquitard appears to be continuous beneath the Site, which is consistent with regional geologic information (Dames and Moore 1994 and Ecology 2005).

Hydrogeology

The groundwater flow direction beneath the HRIA/Berwick Creek source area is to the southwest, but becomes westerly downgradient of the United Rentals building. The flow direction becomes northwesterly downgradient of the Breen Property and on a regional scale.

Regional investigations conducted by others (Dames and Moore 1994 and Ecology 2005) have categorized the shallow aquifer in the area as an unconfined aquifer or semi-confined. However, in the HRIA, the shallow aquifer exhibits the characteristics of a confined or semi-confined aquifer, primarily due to the low permeability silt cap immediately above the aquifer. The mean vertical hydraulic conductivity of the silt capping the shallow aquifer was measured as 6.3×10^{-7} centimeters per second (cm/s). The silt cap of the shallow aquifer exhibits vertical hydraulic conductivities less than the 8×10^{-6} cm/s rule-of-thumb value published as representative of confining layers (Fetter 1980).

START estimated the horizontal hydraulic conductivity in the area of the HRIA at 4.4×10^{-2} cm/s or 125 feet per day (ft/d). The horizontal hydraulic conductivity estimated based on long-term pumping tests completed in the HRIA during the EE/CA (URS 2004) ranged from 1.7×10^{-3} to 4.9×10^{-2} cm/s (4.8 to 135 ft/d). The average hydraulic conductivity was calculated at 4.9×10^{-3} cm/s (13.5 ft/d). Calculated hydraulic conductivity for pump testing completed at the Breen Property showed a value between 5.1×10^{-3} to 6.4×10^{-3} cm/s (14.5 and 18 ft/d).

The overall groundwater gradient beneath the HRIA is 0.0063 foot per foot (ft/ft) (URS 2004). A localized steeper gradient (approximately 0.016 ft/ft) is apparent immediately downgradient of Hamilton Road. START previously calculated an average groundwater gradient of 0.0032 ft/ft for the entire Site (EPA 2001). The average regional gradient in the area of the Site is 0.0055 ft/ft (Ecology 2005).

Surface Water Hydrology

There are three surface water features in the immediate vicinity of the release: Berwick Creek and two unnamed ditches that flow into Berwick Creek. Both ditches pass under I-5, with flow from east to west. Both ditches are intermittent drainages, and discharge and frequency data are not available. Berwick Creek drains into Dillenbaugh Creek, which flows into the Chehalis River.

Surface water monitoring on Berwick Creek was completed as part of the site-wide RI/FS investigation. Monitoring between August and November of 2002 indicated that the surface water had the potential to discharge to groundwater at the majority of the stations monitored. A comparison of surface water and groundwater elevations for corresponding monitoring points measured in September and November 2002 indicated that surface water elevations were at or above the potentiometric surface of the shallow aquifer during both events

(Farallon 2003). These data indicate that there is a potential for surface water to seasonally discharge to groundwater in areas where the creek bed is permeable.

During the EE/CA investigation, groundwater elevations in monitoring wells within the HRIA and adjacent to Berwick Creek were above the approximate surface water elevation. This indicates a potential for groundwater to seasonally discharge to surface water in this reach of Berwick Creek. However, at all exploration locations near the creek, the low permeability silt was found to be present between surface water and groundwater. The low vertical hydraulic conductivity (6.3 x 10^{-7} cm/s) of the silt layer probably minimizes the groundwater and surface water interaction within the HRIA.

1.3.4 Nature and Extent of Contamination

Based on the results of the baseline risk assessment, the primary contaminant of potential concern (COPC) is PCE. Degradation products including trichloroethylene (TCE), cis-1,2-dichloroethylene (cis-1,2-DCE), and vinyl chloride have been detected in soil and groundwater samples collected at the Site, but less frequently and at much lower concentrations than PCE. TCE and other breakdown products are also coextensive with PCE at the Hamilton/Labree Site. Therefore, for the purpose of discussing the nature and extent of contamination at the site, PCE will be considered the contaminant of concern for the Site. A summary of the results of the baseline risk assessment is presented in Section 1.3.6.

Soil

Currently, the only identified surface/near surface soil source for PCE concentrations to groundwater is creek bed sediment/soil in the HRIA (see below). Only minor surface soil contamination has been identified at the Breen Property and in areas downgradient of the HRIA/Berwick Creek source area in the HRIA.

Subsurface sampling results for the HRIA have indicated PCE concentrations ranging up to 3,220 milligrams per kilogram (mg/kg). These concentrations are directly related to PCE DNAPL, which has been observed in aquifer soils beneath the apparent PCE release area in Berwick Creek. Only minor subsurface concentrations of PCE have been detected in subsurface soils at the Breen Property. Soil contamination related to the leakage from drums buried beneath Building B was removed during remedial action to remove the drums in 2001.

Groundwater

The groundwater sampling results indicate that there are two distinct source areas within the HRIA. The southeastern hotspot at the HRIA is located in the area of monitoring wells MW-600 through 604 (see Figure 1-3). This hotspot is located beneath the assumed PCE release location into Berwick Creek. PCE concentrations in groundwater have been detected up to 2,720,000 µg/L at MW-602. PCE DNAPL has been detected in groundwater and aquifer soils from just beneath the silt layer in the bed of Berwick Creek to 30 feet bgs.

Dissolved PCE in groundwater at concentrations greater than 1,000 µg/L does not appear to have migrated southwest of the United Rentals building (see Figure 1-3). PCE dissolved at concentrations less than 1,000 µg/L has migrated substantially farther downgradient of this area and has commingled with the PCE plume originating from the Breen Property. PCE migrating downgradient beyond the United Rentals property is typically found at the highest concentrations at an intermediate depth in the shallow aquifer of approximately 30 to 35 feet bgs.

The northwestern hotspot is centered on monitoring well MWR-4, where PCE concentrations of 5,300 µg/Land 8,800 µg/L were detected in groundwater samples collected during

February and November 2003 sampling events, respectively (see Figure 1-3). Dissolved PCE in groundwater appears to have migrated northwest of the northwestern hotspot based on the most recent data collected by Farallon. A groundwater sample at MW-33, located west of the northwestern hotspot, contained a PCE concentration of 1,100 µg/L during April 2004 sampling.

The results of groundwater sampling conducted at the Breen Property indicate the presence of a confirmed source at the Building B former drum area and two potential source areas:

- A former wash-down pad area.
- An area between the southeast corner of Building C and the Torpedo Tube.

Groundwater sampling results from location downgradient of the former drum area contained PCE at a maximum concentration of 75 µg/L, indicating that the former drum area is only a minor contributor of PCE to shallow aquifer.

Historically, groundwater samples collected from RS-7 and SG2-15, located near the wash-down pad, contained PCE concentrations of 2,400 µg/L and 1,500 µg/L, respectively. Groundwater samples collected during February and November 2003 sampling events from monitoring well MW-8 and monitoring well pair MW-20/MW-21 detected concentrations of PCE ranging from 1,400 µg/L to 1,800 µg/L. These data indicate a suspected source of PCE to groundwater at or upgradient of the wash-down pad area (Farallon 2003). Groundwater samples collected from MW-30 and MW-34, located upgradient of the wash-down pad, had detected concentrations of PCE during 2003 and 2004 sampling events. MW-30 contained PCE ranging from 1,300 µg/L to 1,700 µg/L during fall 2003 sampling events. MW-34 contained a PCE concentration of 1,700 µg/L in April 2004. These results indicate a potential PCE source upgradient of the wash-down pad. However, the PCE source for this groundwater contamination has not been identified, if still present.

Groundwater samples collected from sampling points located in the suspected source area in the center of the Property between the southeast corner of Building C and the Torpedo Tube indicate a potential source of PCE to groundwater. PCE concentrations in groundwater samples collected from this area have historically ranged from 1,300 µg/L to 1,600 µg/L. These results indicate a potential localized PCE source somewhere between Building C and the Torpedo Tube. However, the PCE source for this groundwater contamination has not been identified, if still present.

An additional area of high PCE concentrations is located downgradient of HRIA and crossgradient (south) of Breen Property. Private well PW-9 showed PCE concentrations of 2,100 ug/L and 2,500 ug/L during the February and November 2003 sampling events, respectively. Historically, concentrations in PW-9 have ranged from 1,460 ug/L in June 1999 to 3,350 ug/L in June 2000. The source of the PCE in PW-9 is not known, but may be associated with an additional PCE release to Berwick Creek south of the Breen Property.

Currently, the overall PCE plume in groundwater extends to approximately 800 to 1,000 feet northwest of MW-25 or approximately 4,000 feet northwest of the Breen Property.

Surface Water

PCE concentrations in surface water within known areas of contamination within the HRIA (locations SW-3, SW-5, and SW-7) have ranged from not detected at a method detection limit (MRL) of 0.2 µg/L to 40 µg/L (location SW-5 in the unnamed ditch in November 2002). The detection of PCE in surface water samples at these three locations has varied considerably and no clear seasonal trend has been identified. However, by far the highest concentrations of PCE at locations SW-7 and SW-5 were detected during November (12 and 40 µg/L, respectively), typically a high precipitation month.

SW-1 and SW-2, located 800 to 1,200 feet downstream of the HRIA and sampled by Ecology in 1998, exhibited PCE concentrations ranging from 8.5 to 16 µg/L, similar to concentrations measured within the HRIA. Repeated sampling by Farallon in this same reach of stream (locations SW-8 and SW-9) in 2002 and 2003 found no PCE concentrations exceeding 1.0 µg/L. Farallon also found concentrations less than 1.0 µg/L in surface water samples from SW-10. These data indicate that there are currently no significant concentrations of PCE in surface water. The source of the PCE detected in surface water samples collected at several stations may be residual contamination in the creek bed sediment/soil.

Creek Bed Sediment

During EE/CA investigations, 39 shallow soil samples were collected from the bed and bank along Berwick Creek and the unnamed ditch (URS 2004) in the HRIA. The maximum PCE concentration detected was 5,220 mg/kg. The average PCE concentration of all 39 creek bed and bank samples (using half the detection limit for samples with no detectable PCE) was 195 mg/kg.

Creek channel samples CC-1 through CC-9 were collected by Farallon in September 2003 during Phase II RI/FS sampling. The samples were collected from various locations along Berwick Creek adjacent to the Breen Property. The samples were collected from the creek bed sediment/soil at approximately 1 foot bgs. No PCE was detected above laboratory detection limits in any of the samples collected.

PCE contamination within the creek bed sediment/soil appears to be confined primarily to the HRIA.

1.3.5 Fate and Transport

The two primary sources of contamination at the Hamilton/Labree Roads Site appear to be:

- Liquid PCE released directly into Berwick Creek within the HRIA.
- PCE leaked or spilled onto the soil at both the HRIA and Breen Property.

The fate of PCE in the subsurface at the HRIA study area can be summarized as follows:

- Continued dissolution of PCE DNAPL with continued expansion of the dissolved PCE plume.
- Continued increase in concentration of dissolved PCE downgradient HRIA/Berwick Creek source area.
- Physical advection of dissolved PCE in groundwater, chemical dispersion, and simultaneous dilution.
- Minor biodegradation of PCE to daughter products such as TCE.

Some minimal biodegradation is indicated by the presence of the daughter products TCE and cis-1,2-DCE in some groundwater samples. However the overall geochemistry of the aquifer is unfavorable for biodegradation (URS 2004).

The future fate and transport of PCE from the HRIA and the Breen Property was evaluated using a three-dimensional groundwater model. The modeling was used to estimate the maximum extent of the PCE plume downgradient of the HRIA and Breen Property in the absence of source control and to estimate the general effects of implementing source control.

The results of the groundwater modeling effort showed the following:

- Under current conditions (no source control), the PCE plume from the HRIA/Berwick Creek source area will continue to increase in concentration and will continue to migrate, potentially impacting drinking water sources located greater than three miles downgradient of the HRIA.

- If the source of dissolved-phase PCE is removed to the extent that practicable and dissolved concentrations are reduced by 85 percent or more at the HRIA/Berwick Creek source area, the maximum plume length in the shallow aquifer is unlikely to exceed three miles and will eventually be remediated through natural attenuation including physical advection of dissolved PCE in groundwater, chemical dispersion, and simultaneous dilution. Biodegradation was not considered a natural attenuation process occurring at the Site for the purposes of groundwater modeling.
- Source areas at the Breen Property appear to have been the main contributor of PCE to the leading edge of the plume. Modeling results showed that the PCE concentration detected in groundwater at MW-25 (located about 2,400 feet downgradient of the Breen Property) is not associated with the HRIA/Berwick Creek source area.
- The portion of the plume originating at the Breen Property will most likely be reduced through natural attenuation processes to concentrations below MCLs prior to reaching additional downgradient drinking water sources. This assumes no continuing source of dissolved PCE to groundwater is present at the Property.
- With or without source control, PCE-impacted groundwater may have the potential to discharge to surface water (Dillenbaugh Creek and the Newaukum River) downgradient and crossgradient of MW-25. Additional data may be necessary to determine if groundwater/surface water interaction is occurring in this area.

The results of the groundwater modeling effort are shown in Appendix A.

1.3.6 Baseline Risk Assessment Summary

The objectives of the baseline risk assessment were to:

- Evaluate potential effects of chemicals detected in soil and groundwater on human and ecological receptors at the HRIA and Breen Property source areas,
- Evaluate contaminants in groundwater at areas downgradient and cross-gradient of the source areas, and
- Evaluate surface water and sediment in Berwick Creek associated with the source areas.

Existing environmental data was reviewed to determine COPCs. Chemical concentrations were summarized for four exposure areas (areas upgradient of the HRIA, HRIA, Breen Property, and areas downgradient of the Breen Property) and compared to risk-based screening benchmarks for human and ecological health. The COPCs to human health at the HRIA, Breen Property, and downgradient areas identified from the risk screening and evaluated in the baseline risk assessment included:

- cis-1,2-DCE
- Methylene chloride
- PCE
- Tetrahydrofuran

- TCE
- Vinyl chloride

No COPCs were identified for the areas upgradient of the HRIA.

COPCs evaluated for ecological health included:

- cis-1,2-DCE
- PCE
- TCE

The overall results of the human health risk assessment indicate that current contaminant concentrations (predominantly PCE) in groundwater associated with the HRIA and Breen Property source areas represent a potential for elevated health risks to current or future site workers and downgradient residents if receptors were to use the groundwater for domestic purposes. Currently the affected receptors are connected to the municipal water system.

The overall results of the ecological risk assessment indicate that current contaminant concentrations (predominantly PCE) in sediment associated with the HRIA source area and PCE in subsurface soils may represent a potential for elevated risks to organisms encountering the HRIA/Berwick Creek source area. However, risks to ecological receptors are considered to be minimal since (1) highly conservative exposure estimates were utilized in the BRA and (2) the HRIA/Berwick Creek source area is confined to a small area within Berwick Creek and is not shown to be moving downstream.

The following are the general conclusions from the baseline risk assessment:

- PCE and associated VOCs were historically released from spills and leaks at the HRIA and Breen Property. These releases have lead to the contamination of soils and groundwater located at the HRIA and Breen Property and in downgradient groundwater wells. The primary source of the dissolved-phase PCE plume is the HRIA/Berwick Creek source area.
- The human health risk assessment concluded that drinking current or future groundwater concentrations of VOCs (particularly PCE) may potentially adversely affect the health of on-site workers and downgradient residents. However, the commercial and private properties within this area are connected to the municipal water system. Thus, current human populations are not drinking contaminated water. However, there are potential risks to human health if existing or future wells draw water from the shallow groundwater aquifer. Estimated risks from the volatilization of contaminants in groundwater to indoor air appear to be elevated above risk threshold levels only at the buildings present at the HRIA (i.e., United Rentals). Indoor air estimates are likely to be overestimated due to the nature of the Johnson and Ettinger volatilization model and limited air sampling results indicated low PCE concentrations (WDOH 2004). Recreational activities at Berwick Creek are anticipated to be of minimal concern if conducted away from the HRIA/Berwick Creek source area.
- The ecological risk assessment concluded that current concentrations of PCE in Berwick Creek sediment may adversely affect ecological receptors only at the HRIA/Berwick Creek source area. Additionally, VOC concentrations in soil at the HRIA and Breen Property may present risks to burrowing animals. Surface water

concentrations do not appear to pose a risk to aquatic receptors within Berwick Creek.

- Overall, PCE and associated VOC risks at the HRIA are localized in soil and sediment and groundwater. Domestic use of groundwater is the primary concern at the Site (i.e., HRIA, Breen Property and downgradient) and use of municipal water systems rather than groundwater sources for domestic purposes and institutional controls to restrict access to the source areas will reduce exposure to contaminants associated with the HRIA and Breen Property source areas.

1.3.7 Estimated Mass of PCE at the HRIA

During preparation of the EE/CA, the estimated mass of PCE as DNAPL, absorbed to soil, and dissolved in groundwater was calculated for the HRIA/Berwick Creek source area (URS 2004). Mass calculations were only completed for the HRIA since remediation is proposed for this area only. Within the HRIA/Berwick Creek source area, there appears to be approximately 2,100 kilograms (kg) of PCE present in the subsurface. The 90 percent confidence interval for this estimate is approximately 825 to 4,250 kg. Of this mass, 1,480 kg, or 70 percent, is estimated to be present as DNAPL. The calculated mass of PCE at the HRIA/Berwick Creek source area is only an estimate based on existing Site data and interpreted site condition. The actual mass of total PCE and PCE DNAPL may vary based on actual site conditions.

Table 1-2 presents estimates of the mass of PCE present at the HRIA. The estimated DNAPL zone at the HRIA/Berwick Creek source area is shown in Figure 1-4. PCE mass calculations are presented in the EE/CA (URS 2004).

1.3.8 Previous Remedial Action

In September 1999, sixty-six 55-gallon drums, four 30-gallon drums, and a number of pails and cans were removed from beneath Building B on the Breen Property. PCE was detected in the contents of some drums and in water in the drum excavation. In addition, approximately 600 tons of PCE and petroleum contaminated soil was removed from the drum excavation. Confirmation sampling results from samples collected from the final excavation were either non-detect or contained contamination below MTCA Method A and/or Method B cleanup levels (GeoEngineers 2001).

Approximately twenty-four private water-supply wells are located in the shallow aquifer downgradient of the HRIA. Of the properties supplied by these wells, all but seven were connected to the City of Chehalis municipal water supply during a removal action completed in 2002 (EPA 2003). The properties connected to the water-supply line are those located within an approximately 3,800-foot radius of the intersection of Hamilton and Labree Roads and roughly downgradient of the source areas. The location of the water-supply line is shown on Figure 1-5. PCE has not been detected in the private wells located downgradient of the intersection of Hamilton and Labree Roads that remain unconnected to the municipal water supply.

Expansion of the water main to service homes and businesses with contaminated or potentially contaminated drinking water wells was selected as the time-critical removal action to protect human health. The water main was extended across I-5 at Labree Road and was installed beside portions of Labree Road, Hamilton Road North, and Rice Road. The water main was extended along Rice Road approximately parallel to the direction of contaminated groundwater flow as far as 2296 Rice Road (see Figure 1-5). Along Hamilton Road North, the water-supply line extends southward to 269 Hamilton Road North.

2. APPLICABLE AND RELEVANT APPROPRIATE REQUIREMENTS

The potential ARARs for the Hamilton/Labree Road site include three types:

- Chemical-specific;
- Location-specific; and
- Action-specific.

Chemical-specific ARARs are typically health- or risk-based values that when applied to site-specific conditions represent cleanup standards. Location-specific ARARs are related to the geographical position and/or physical condition of the site and may affect the type of remedial action selected for the site. Action-specific ARARs are usually technology-based or activity-based requirements or limitations on actions or conditions taken with respect to specific hazardous substances. The action-specific requirements do not determine the selected remedial alternative, but indicate how or to what level a selected alternative must perform.

Potential ARARs were identified for each media of concern. These potential ARARs are shown in Table 2-1.

3. REMEDIAL ACTION OBJECTIVES

This section presents the proposed RAOs for impacted media at the Site.

3.1 REMEDIAL ACTION OBJECTIVES

RAOs consist of media-specific or operable-unit specific goals for protecting human health and the environment based on the COPCs, receptors, and exposure routes at the Site. For the Site, RAOs were evaluated for groundwater, aquifer soil (soil located in the shallow aquifer beneath the low permeability silt layer), creek bed sediment/soil, and surface water.

3.1.1 Groundwater

The RAOs for groundwater include:

- Prevent human exposure to groundwater containing PCE at concentrations exceeding the Ecology Model Toxics Control Act (MTCA) Method A and Federal/State maximum contaminant level (MCL) value of 5 µg/L.
- Prevent further migration of contaminated groundwater exceeding the PCE MCL of 5 µg/L to drinking water sources that are currently below the PCE MCL.
- Restore the groundwater quality of the shallow aquifer to Federal drinking water standards.

3.1.2 Aquifer Soil

The RAOs for the aquifer soil include:

- Reduce the mass of PCE DNAPL in aquifer soil to the extent practicable at the HRIA/Berwick Creek source area..

3.1.3 Creek Bed Sediment/Soil

The RAOs for Berwick Creek bed sediment/soil include:

- Reduce or eliminate human exposure through direct contact (incidental soil ingestion, skin contact with soil, and inhalation of vapors) with contaminated soils that exceed protective regulatory levels.
- Reduce or eliminate risks to ecological receptors from contaminated sediments in Berwick Creek at the HRIA.
- Reduce the mass of PCE DNAPL in creek bed sediment/soil to the extent practicable at the HRIA/Berwick Creek source area.

3.1.4 Surface Water

- Prevent human exposure to surface water in Berwick Creek containing PCE at concentrations exceeding protective regulatory levels.

4. IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section includes a discussion of the general response actions and the identification and screening of remedial technology types that could potentially be used at the Hamilton/Labree Site.

4.1 GENERAL RESPONSE ACTIONS

General response actions describe those actions that will satisfy the RAOs. These may include institutional controls, treatment, containment, excavation, extraction, or a combination of these. A discussion of possible general response actions for the Site is presented in the following sections.

4.1.1 No Action

No Action is retained throughout the FS process as required under 40 CFR 300.430(3)(6) and provides a baseline for comparison. No remedial action would be completed to reduce the toxicity, volume or mobility of the contaminated groundwater, aquifer soils, and creek bed sediment.

4.1.2 Institutional Control

Institutional controls (ICs) provide protection from exposure through the use of non-engineered or legal controls that limit land or resource use, such as access controls and property restrictions. Although ICs provide no reduction of toxicity, volume or mobility of contaminants, they can reduce or eliminate direct exposure pathways and resultant risk. Proprietary controls could include easements for site access to monitor onsite wells and promise to not use wells completed in the shallow aquifer as a drinking water source. Government controls could include state and local government restrictions on installing groundwater wells in the shallow aquifer within the existing footprint of the PCE plume plus some distance downgradient.

4.1.3 Containment

Containment is the use of a subsurface or surface barrier to isolate a contaminated media to reduce the likelihood of direct contact to the media. For groundwater at the Site, this could include either a physical or hydraulic barrier. This may also be combined with in-situ or ex-situ treatment to help reduce the volume and toxicity of the contaminants present.

4.1.4 Collection/Treatment

This action would include in-situ treatment using chemical, biological and/or physical treatment designed to reduce the toxicity, volume or mobility of contaminants. In some cases, this may include vapor extraction to collect volatilization products generated during in-situ treatment, and the ex-situ treatment of this vapor.

4.1.5 Removal/Disposal

The removal/disposal option consists of physically removing the contaminated media through excavation or a similar method, and disposing of the media at an off-site facility. For the Site, this action would be used for remediation of the PCE-contaminated sediment/soil in the bed of Berwick Creek.

4.2 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES

Screening of remedial technologies types and process options were completed using the on-line screening tool at the EPA's CLU-IN website, Federal Remediation Technologies Roundtable (FRTR) Remediation Technologies Screening Matrix and related websites, and information presented in the *Engineering Evaluation/Cost Analysis (EE/CA) Hamilton-Labree Impact Area Superfund Site* (URS 2004).

Potential remedial technologies are shown in Table 4-1.

5. DEVELOPMENT AND SCREENING OF ALTERNATIVES

Evaluation of existing soil and groundwater data including three-dimensional modeling was used to evaluate the fate and transport of PCE in groundwater. The results of the data evaluation and modeling showed the following:

- PCE in the bed of Berwick Creek is a constant source of PCE dissolving into the water of Berwick Creek and the shallow groundwater aquifer beneath the HRIA.
- The PCE DNAPL in the shallow aquifer at the HRIA/Berwick Creek source area is slowly dissolving, acting as a continuing source of dissolved PCE concentrations in groundwater.
- Hazardous material releases associated with historical waste handling activities conducted on the Breen Property are or were sources for contamination of the shallow aquifer and may have been the primary source of contamination at the current leading edge of the PCE plume. The existence or absence of potential existing source areas for shallow aquifer groundwater contamination at the Breen Property were not adequately confirmed during previous site investigations.
- PCE-impacted groundwater has a potential to discharge to surface water (creeks) downgradient of the Breen Property.
- If the source of dissolved-phase PCE is removed to the extent practicable, and dissolved concentrations are reduced by 85 percent or more at the HRIA/Berwick Creek source area, the maximum plume length in the shallow aquifer is unlikely to exceed three miles and will eventually be remediated through natural attenuation including physical advection of dissolved PCE in groundwater, chemical dispersion, and simultaneous dilution.

Based on these conclusions, source control at the HRIA/Berwick Creek source area, natural attenuation of the dissolved-phase PCE plume, establishment of institutional controls, and long-term monitoring of PCE plume was determined to be an effective strategy for achieving RAOs at the Site. The proposed treatment area at the HRIA is shown in Figure 1-4.

If the HRIA/Berwick Creek source area is removed and/or contained, the PCE groundwater plume will most likely not migrate beyond three miles and would not impact downgradient drinking water sources. Residences and businesses located within the portion of the plume exceeding MCLs that used the shallow aquifer as a drinking water were connected to the City of Chehalis municipal water supply during a removal action completed in 2002 (EPA 2003). Institutional controls would be implemented to protect human health by restricting the use of and access to PCE-contaminated groundwater of the shallow aquifer in areas downgradient of the HRIA/Berwick Creek source area. By completing these tasks, adequate protection of downgradient receptors is anticipated.

Long-term monitoring will be conducted following remedial action at the HRIA/Berwick Creek source area to assess migration of the dissolved-phase plume and to assess whether or not sufficient natural attenuation is occurring to achieve RAOs. If the results of long-term monitoring do not indicate that RAOs will be met, the need for additional investigation or remedial action will be evaluated. Needs could include additional evaluation of potential source areas at the Breen Property if dissolved PCE concentrations in groundwater do not appear to be decreasing through natural attenuation or increase over time on or immediately downgradient of the Property.

Based on this determination of remedial strategy, the selected preliminary remedial alternatives for the HRIA/Berwick Creek source area include the following:

- No Action
- Electrical Resistance Heating
- Chemical Oxidation with Creek Bed Silt Removal
- Permeable Reactive Barrier with Creek Bed Silt Removal
- Hydraulic Containment/Pump and Treat with Creek Bed Silt Removal

A brief description of these remedial alternatives is presented below.

No-Action. The No-Action alternative consists of allowing the Site to remain in its present condition, with no measures completed to reduce or monitor the PCE concentrations. This alternative is retained throughout the process of alternative development and analysis as a baseline for comparison of other alternatives.

Electrical Resistance Heating. This alternative allows for treatment of the shallow aquifer and the contaminated silt in the Berwick Creek bed together by applying a strong electric current to heat the soil and groundwater. The PCE in the soil and groundwater is volatilized by this process and collected by a vapor extraction system. The PCE and other vapors are then treated in an on-site treatment system. Since this technology uses heat for treatment, the water in Berwick Creek would also be heated, which could negatively impact in-creek life. The creek would have to be diverted prior to installation to allow for fish passage.

Chemical Oxidation. In this alternative, potassium permanganate or Fenton's Reagent would be repeatedly injected into the shallow aquifer to chemically break-down the PCE. Because this technology would not be effective in treating the PCE-impacted low permeability silt in the bed of Berwick Creek, this material would be excavated and disposed of off-site, and replaced with a low-permeability material layer and habitat material. The chemical oxidation process would take place prior to removal of the Berwick Creek bed silt. Berwick Creek would be diverted during silt removal.

Permeable Reactive Barrier Containment. This alternative would involve constructing a wall of iron filings or other reactive material downgradient of the PCE source area. The wall would allow groundwater to pass through, but the iron or other material would react with the PCE, chemically breaking it down. The wall would be installed to the full depth of the aquifer (approximately 48 feet deep) and 340 feet long. Because this technology would not be effective in treating the PCE-impacted low permeability silt in the bed of Berwick Creek, this material would be excavated and disposed of off-site, and replaced with a low-permeability material layer and habitat material. Berwick Creek would be diverted during silt removal.

Hydraulic Containment. In this alternative some of the wells installed near Berwick Creek during the various site investigations would be pumped continuously to create a hydraulic barrier. This pumping would minimize dissolved PCE moving with groundwater. The pumped water would be treated using air stripping and/or adsorption and discharged to Berwick Creek. Because this technology would not be effective in treating the PCE-impacted low permeability silt in the bed of Berwick Creek, this material would be excavated and disposed of off-site and replaced with a low-permeability material layer and habitat material. Berwick Creek would be diverted during silt removal.

For all alternatives (excluding the No-Action alternative), long-term groundwater monitoring would be conducted to monitor contaminant attenuation within the dissolved plume downgradient of the treatment area. In addition, ICs would be implemented restricting the use of and access to PCE-contaminated groundwater of the shallow aquifer in areas not treated.

6. DETAILED ANALYSIS OF ALTERNATIVES

This section presents a detailed description of the elected remedial alternatives for the HRIA/Berwick Creek source area, a general conceptual design for the alternative, and a detailed analysis of alternatives.

6.1 ALTERNATIVE DESCRIPTION/CONCEPTUAL DESIGN

This section presents a description of each of the five selected remedial alternatives and a general conceptual design for the alternative. Information sources for completing this detailed analysis included the Federal Remediation Technologies Roundtable (FRTR) website, EPA's CLU-IN website, *Engineering Evaluation/Cost Analysis Report, Hamilton Road Impact Area, Hamilton-Labree Roads Superfund Site, Chehalis, Washington* (URS 2004), and various vendors of remedial technologies.

6.1.1 Alternative 1 - No-Action

The No-Action alternative is retained throughout the alternative development and analysis process as a baseline for comparison to other alternatives. The no-action alternative consists of allowing the site to remain in its present condition, with no measures taken to reduce or monitor PCE concentrations.

6.1.2 Alternative 2 - Electrical Resistance Heating

Alternative 2, Electrical Resistance Heating (ERH) would consist of the following:

- ERH for treatment of contaminated creek bed silt and groundwater at the HRIA/Berwick Creek source area.
- Long-term monitoring of the migration and natural attenuation of PCE remaining in groundwater.
- Institutional controls for areas downgradient of the treatment area.

ERH is an in-situ, polyphase electrical heating technology that uses commonly available electricity and applies it into the ground through electrodes. This technology is equally effective in treating both soil and groundwater. The electrodes heat the soil and groundwater to over 100 degrees Celsius via resistive current. Contaminates are volatized and removed from the subsurface via a vapor extraction system.

ERH would be used to treat the contaminated silt in the Berwick Creek bed and banks concurrently with treatment of the aquifer soils. This is the only alternative that would provide in-situ treatment of the creek bed silt without physical removal through excavation. ERH at the Site would involve the installation of electrodes, temperature monitoring points (TMPs), vapor recovery wells below the silt, and horizontal vapor recovery piping above the silt. Prior to installation of the ERH system, four existing monitoring wells (MWR-1, -2, and -5, and MW-9) would be abandoned, because they are not constructed to withstand the induced heat.

The reach of Berwick Creek within the treatment zone would be isolated using earthen berms and dewatered. Fish within the isolated creek section would be "rounded-up" or moved from the work area to below the downstream net.

A one-year diversion of Berwick Creek would be required to provide fish passage to upstream habitat. The diversion would route Berwick Creek through a 48 inch-diameter HDPE pipe beneath Hamilton Road (Figure 6-1). The diversion would occur upstream of the treatment zone. The water from Berwick Creek would be diverted back into the existing creek channel at the downstream end of the treatment zone. The diversion would include 395 feet of 48 inch-diameter HDPE and earthen berms at the upstream and downstream ends of the treatment zone.

A diversion alignment between Berwick Creek and I-5 may also be feasible. This alternative alignment could be hindered by logistical construction difficulties related to access from I-5, stability issues with I-5 related to deep trenching close to the roadway, and deeper trenching because of the topography in this area. The costs for diversion alignments on either the western or eastern banks of Berwick Creek are likely to be similar, and selection of the best diversion alignment could be accomplished during design.

Due to the presence of the low permeability silt cap, the aquifer is slightly artesian, so penetrating the cap during installation of the diversion may result in the introduction of contaminated water into the work zone. If dewatering is needed, pumping would be from existing wells located near the alignment of the diversion and would utilize a temporary pumping and treatment system.

Once dewatering was complete, the creek bed would be filled to produce a level surface. The treatment zone in the creek would be sealed with a sheet of high temperature grade plastic, a layer of pumice gravel placed over the plastic for insulation, and a second top layer of plastic sheeting placed over the gravel. Once a level and insulated surface was constructed over the creek, the rest of the treatment area would need to be graded to provide a level area for the installation of the ERH system. Based on information provided by the vendor, the natural silt cap at the site will provide sufficient cover for the vapor extraction process.

Once site preparation is complete, drilling and installation of the electrodes, vapor extraction wells and TMP placement would commence. Based on vendor estimates (Appendix B), preparation for the thermal heating process would include the installation of 62 electrodes spaced approximately 19 feet apart and ranging in depth between 4 and 42 feet. There would be eleven TMPs. The approximate configuration of the electrodes and TMPs is shown on Figure 6-1.

The vapor recovery wells will be co-located next to the electrodes. Therefore, there would be 62 vapor recovery points at the site to extract the vaporized PCE. The vapor recovery air flow rate will be approximately 510 standard cubic feet per minute (scfm). Extracted vapor would be treated using granular activated carbon (GAC) and would be discharged to the atmosphere following treatment. Condensate is expected to be generated at a rate of approximately 6.5 gallons per minute (gpm). The condensate would be disposed of off-site or reused as drip water for electrode wetting.

Treatment system infrastructure and equipment would be assembled and staged on the northeast shoulder of Hamilton Road, requiring long-term traffic control. In addition, a new transformer would be installed at the treatment location to provide three-phase electrical power, and Lewis County Public Utility District (PUD) would run additional power supply lines. The treatment area and infrastructure would be fenced-in to prevent tampering and vandalism.

Once all electrodes and TMPs are in place, the system would be hooked up to the new electrical system, and the system would begin to heat the soil and groundwater. Raising the temperature of the contaminated soils to begin removal would require approximately 50 to 60 days. The total heating/treatment time is estimated at between 219 to 305 days in order to achieve RAOs for aquifer soil, creek bed sediment/soil, and groundwater. Sampling would be ongoing through the removal process to monitor groundwater and soil temperatures, as well as contaminant concentration in groundwater from existing wells. Once achievement of RAOs is confirmed through groundwater and vapor sampling, treatment would be discontinued and confirmation soil sampling would be conducted at nine locations within the treatment zone.

ERH vendor TRS has stated that vapor recovery performed as part of the treatment process will be sufficient to maintain hydraulic control of potentially mobilized PCE. The mass removal of vapor from the subsurface should limit the movement of the DNAPL.

According to TRS, hydraulic containment is normally not required when the average groundwater flow rate is less than 1 ft/d. The calculated average groundwater flow rate for the site is 0.36 ft/d. However, there is always uncertainty when dealing with subsurface lithology and the effect of this lithology on groundwater flow rates. Because of the uncertainty, hydraulic control has been included in the cost estimate for this alternative. The need for pumped hydraulic control would be further evaluated during the design phase.

Following treatment, the gravel and plastic would be removed from the creek bed and banks. The plastic would be disposed of and the gravel would be redistributed elsewhere at the site. The channel and habitat of Berwick Creek would be restored in the following in-stream construction season, and the water flow returned to the main channel.

Long-term groundwater monitoring would be performed semi-annually for 30 years in the HRIA/Berwick Creek area and along the entire plume length. Long-term groundwater monitoring is discussed in Section 6.1.6.

ICs would be established for the area within the entire plume length where concentrations still exceed groundwater criteria to insure protection of human receptors that could potentially access PCE-impact groundwater. ICs are discussed in Section 6.1.7.

6.1.3 Alternative 3 - Chemical Oxidation with Creek Bed Silt Removal

Alternative 3, Chemical Oxidation would consist of the following:

- In-situ chemical oxidation (ISCO) of PCE (dissolved phase and DNAPL) in groundwater at the HRIA/Berwick Creek source area.
- Excavation of contaminated silt from the creek bed.
- Long-term monitoring of the migration and natural attenuation of PCE remaining in groundwater.
- Institutional controls for areas downgradient of the treatment area.

ISCO would be used to treat the PCE-contaminated groundwater at an adjacent source area in Berwick Creek. ISCO involves injecting a chemical oxidant into the shallow aquifer and chemically degrading contaminants in groundwater into innocuous compounds (carbon dioxide and water). Contaminant concentration, general chemistry parameters, and environmental indicators are monitored prior to and following injection to assess the degradation process.

For this alternative, the PCE mass in groundwater would be treated using modified Fenton's Reagent. Treatment using modified Fenton's Reagent is based on the following chemical reactions:

$$C_2Cl_4Fe^{+2} + 3H_2O_2 \rightarrow 2CO_2^- + 2H_2O + 4Cl^- + 2H^+$$

A different oxidant or a combination of oxidants could be selected during the design phase based on the results of treatability testing.

An ISCO bench-scale treatability test would be conducted to help refine the full-scale injection approach. Results of the treatability test would also be used to determine if a pilot test is required before full-scale treatment is completed.

Modified Fenton's Reagent (3 to 12 percent hydrogen peroxide and iron-based catalyst) would be injected into the shallow aquifer via injection point clusters spaced approximately 30 feet apart throughout the treatment zone (based on the expected radius of influence of 12 feet). Approximately 75 injection locations (66 treatment and 9 polishing) consisting of three injection points would be installed using a hollow-stem auger rig. Each injection point cluster would be installed to allow oxidant injection at three different 10 foot depth intervals. The proposed injector scheme is shown in Figure 6-2. This preliminary injector scheme could be modified based on the pilot test results. Injection of a total of 249,000 pounds of hydrogen peroxide, or roughly 5,000 pounds per day, would be injected over a 50-day period to achieve the RAOs. Each injection event would partially overlap (approximately 50 percent) the previous event. Monitoring of PCE, oxidant concentrations, and other parameters (i.e., pH, iron concentration) in groundwater would be performed during and between injections.

ISCO would not be effective in treating the low permeability silt present in the bed and banks of Berwick Creek. Therefore, the contaminated low permeability silt would be excavated from the creek and disposed of off-site and the creek bed would be reconstructed. Excavation would be completed following ISCO treatment since the silt cap would contain the Fenton's Reagent within the aquifer for more effective treatment.

Prior to excavation, Berwick Creek would be temporarily diverted and the area to be excavated would be dewatered (Figure 6-3). Construction dewatering would be accomplished by pumping wells MW-600 through MW-603. Prior to dewatering of the work area, fish would be moved from the excavation area and relocated downstream. The pumped water would be treated using a portable GAC treatment system and discharged to Berwick Creek. Once dewatering is completed, the contaminated silt layer in the creek bed and banks would be removed using a tracked excavator or similar. Approximately 900 cubic yards of contaminated silt and creek bank soil would be removed from Berwick Creek and would be disposal of at an off-site facility.

Following excavation of the silt, the creek bed would be reconstructed to minimize discharge of contaminated groundwater into surface water in the creek. Reconstruction of the creek bed would include installation of a geosynthetic clay liner (GCL) or similar liner into the creek bed and replacement of fish habitat. Habitat restoration would include planting of native vegetation and installation of fish spawning habitat, such as spawning gravel.

Long-term groundwater monitoring would be performed semi-annually for 30 years in the HRIA/Berwick Creek area and along the entire plume length. Long-term groundwater monitoring is discussed in Section 6.1.6.

ICs would be established for the area within the entire plume length where concentrations still exceed groundwater criteria to insure protection of human receptors that could potentially access PCE-impact groundwater. ICs are discussed in Section 6.1.7.

The treatment time to achieve RAOs for groundwater and aquifer soil is only an estimate. Additional injection events after the proposed 50-day treatment event may be required to achieve the RAOs. In addition, there may be potential issues with ineffective treatment of low permeability materials in the aquifer soil and the potential for leaching of residual PCE and associated concentration "rebound" in groundwater. This could potentially greatly impact the project cost. A discussion on the estimated cost for this alternative is presented in Section 7.7.

6.1.4 Alternative 4 - Permeable Reactive Barrier with Creek Bed Silt Removal

Alternative 4, Permeable Reactive Barrier (PRB) would consist of the following:

- Installation of a PRB immediately downgradient of the Berwick Creek source area.
- Excavation of contaminated silt from the creek bed as described in Alternative 3.
- Long-term monitoring of the migration and natural attenuation of PCE remaining in groundwater.
- Institutional controls for areas downgradient of the treatment area.

Under this alternative, a PRB wall composed of reactive iron would be installed to contain and treat the highest groundwater PCE concentrations migrating from the Berwick Creek source area. Groundwater containing PCE and breakdown compounds such as TCE and cis-1,2-DCE would be remediated as it flowed through the wall. PCE and breakdown products would react with the iron in a process known as abiotic reductive dehalogenation. The concentration reduction that can be achieved is dependent on the groundwater flow velocity through the wall and the wall thickness.

The PRB has been conceptually designed to exceed the 85 percent source concentration reduction. Assuming a residence time of 1.7 days (based on the half life data for PCE) and a groundwater flow velocity of 0.36 ft/d (URS 2004), a 0.6-foot thick, 340-foot long, 48-foot deep wall would be installed immediately downgradient of the Berwick Creek source area (Figure 6-4). The PRB wall would be installed beneath the northeastern shoulder of Hamilton Road North and would include short alignment extensions toward Berwick Creek to help prevent contaminated groundwater flow around the ends of the wall. Successful design of Alternative 4 is likely to require a treatability study using groundwater from the site prior to final wall design and installation.

Prior to installation of the PRB wall, the contaminated creek bed silt would be excavated and disposed of off-site. This would include temporarily diverting Berwick Creek, dewatering the area to be excavated, and reconstructing the creek bed as described under Alternative 3.

Installation of the PRB wall would include:

- Excavation of a trench along the PRB alignment from ground surface to the aquitard.
- Stabilization of the open trench with biodegradable guar-based slurry.
- Placement of granular iron in the trench through the slurry.
- Restoration of the ground surface.

Trenching for wall installation would produce approximately 1,000 cubic yards of contaminated soil requiring off-site disposal. This assumes a 2-foot wide trench would be excavated for wall installation.

Performance monitoring of the PRB would include periodic sampling and water level measurement in wells near the treatment zone. The monitoring program would be designed to verify hydraulic control, verify a complete reaction within the PRB, and identify wall fouling. The results of the conventional chemistry analyses conducted at the HRIA (URS 2004) indicate the geochemistry of the site is favorable and indicates a low potential for precipitate fouling.

Based on information supplied by Environmental Technologies, Inc., a vendor of this technology, for most sites, rejuvenation of the treatment media will be required approximately every 15 years. Technologies for in-situ rejuvenation are not well developed.

Since the source area groundwater PCE concentration at the HRIA is not reduced using this remedial alternative, long-term groundwater monitoring would be performed semi-annually for 30 years in the HRIA/Berwick Creek area and along the entire plume length. Long-term groundwater monitoring is discussed in Section 6.1.6.

ICs would be established for the area within the entire plume length where concentrations still exceed groundwater criteria to insure protection of human receptors that could potentially access PCE-impact groundwater. ICs are discussed in Section 6.1.7.

6.1.5 Alternative 5 - Hydraulic Containment/Pump and Treat with Creek Bed Silt Removal

Alternative 5, Hydraulic Containment would consist of the following:

- Groundwater extraction using existing wells to remove and treat contaminated groundwater, and produce a hydraulic barrier at the HRIA/Berwick Creek source area.
- Excavation of contaminated silt from the creek bed.
- Long-term monitoring of the migration and natural attenuation of PCE remaining in groundwater.
- Institutional controls for areas downgradient of the treatment area.

This alternative consists of capturing groundwater with high dissolved PCE concentrations before it can migrate outside the treatment zone. Several existing monitoring wells installed along Berwick Creek would be pumped continuously to create a hydraulic barrier to contaminant migration. This alternative would contain the PCE in the area where it is present as DNAPL, cutting off the constant source area from the downgradient areas of the site.

Similar to Alternatives 3 and 4, the contaminated low permeability silt would be excavated from the creek and disposed of off-site and the creek bed replaced. Silt removal, construction dewatering and creek bed replacement is discussed under Alternative 3. Since construction dewatering would be accomplished using several of the wells proposed in groundwater extraction and treatment system described below, the system would be installed prior to silt removal.

Under the hydraulic containment alternative, continuous pumping would be performed from eight existing monitoring wells: MW-600 through MW-604, MWR-1, MWR-2, and MWR-5. Using calculations presented in the EE/CA (URS, 2004), the results of three-dimensional groundwater modeling, and an assumed pumping rate of approximately 8 gpm per well, the expected capture zone for this configuration would include most groundwater exhibiting PCE concentrations greater than 50,000 μg/L (Figure 6-5). This capture zone is based on an average hydraulic conductivity of 4.8 x 10^{-3} cm/sec and a local groundwater flow direction to the southwest.

The extracted groundwater would be treated by a system located in the area of monitoring well MW-5, and discharge to Berwick Creek. The aboveground treatment system would consist of a pre-manufactured, skid-mounted unit including sediment filtration, air stripping, and activated carbon polishing. The treatment system will be sized to accommodate approximately 85 gpm. The air stripper will consist of a stainless steel, low profile tray stripper with four 3-ft. by 6-ft. removable trays. Effluent from the air stripper would be treated using granular activated carbon for final polishing before discharging to Berwick Creek. The vapor from the stripper will be treated using granular activated carbon prior to release to the atmosphere.

Performance monitoring of the hydraulic containment system would include periodic monitoring of the system, and periodic sampling and water-level measurement in wells in the HRIA/Berwick Creek area. The monitoring program would be designed to verify hydraulic containment and to document mass removal over time.

Long-term groundwater monitoring would be performed semi-annually for 30 years in the HRIA/Berwick Creek area and along the entire plume length. Long-term groundwater monitoring is discussed in Section 6.1.6.

ICs would be established for the area within the entire plume length where concentrations still exceed groundwater criteria to insure protection of human receptors that could potentially access PCE-impact groundwater. ICs are discussed in Section 6.1.7.

6.1.6 Long-Term Monitoring

For Alternatives 2 through 5, long-term groundwater monitoring would be performed semi-annually for 30 years in the HRIA/Berwick Creek area and along the entire plume length to insure the permanence of the remedial alternative, that the downgradient edge of the PCE plume is not migrating, and to assess whether or not sufficient natural attenuation is occurring to achieve RAOs. The monitoring program would include the groundwater location along the full length of the plume downgradient of the HRIA/Berwick Creek source area. This monitoring would include surface water locations along Dillenbaugh Creek and the Newaukum River to determine potential discharge of PCE-impact groundwater to these water bodies. Potential discharge of PCE-contaminated groundwater is discussed in Section 1.3.5.

Currently, few monitoring wells are located downgradient of the Breen Property, especially at the leading edge of the PCE plume. Additional monitoring wells would need to be installed at and downgradient of the leading edge of the groundwater plume for monitoring plume migration and natural attenuation. An estimated three to five new monitoring wells would be installed between existing monitoring wells MW-25 and MW-28.

If the results of long-term monitoring do not indicate that RAOs will be met, the need for additional remedial action to protect human health and the environment will be evaluated.

6.1.7 Institutional Controls

For Alternatives 2 through 5, ICs would be implemented in areas downgradient of the HRIA/Berwick Creek source area to insure protection of human receptors that could potentially access PCE-impact groundwater. Anticipated ICs would include:

- Restrictions on installation of shallow aquifer drink water wells within one or more miles downgradient of the leading edge of the plume

- Restrictions on shallow aquifer groundwater use at locations within the PCE plume footprint, particularly for wells already completed in the aquifer.
- Easements with property owners for assessment of long-term groundwater monitoring.

The need for additional ICs will be evaluated during remedial design.

6.2 DETAILED ANALYSIS

A detailed analysis of alternatives was completed as described in Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA 1988). Each of the alternatives is to be evaluated against the following nine criteria:

- Overall Protection of Human Health and the Environment,
- Compliance with ARARs,
- Long-Term Effectiveness and Permanence,
- Reduction of Toxicity, Mobility, and Volume Through Treatment,
- Short-Term Effectiveness,
- Implementability,
- Cost,
- State Acceptance, and
- Community Acceptance

The last two criteria, State and Community Acceptance, are normally evaluated following comment on the RI/FS report and proposed plan, and included in the Record of Decision (ROD).

The detailed analysis of the alternatives discussed above is presented in Table 6-1.

7. COMPARATIVE ANALYSIS OF ALTERNATIVES

The purpose of the comparative analysis is to evaluate the relative performances of each HRIA remedial alternative in relation to each of the nine evaluation criteria. The comparative analysis also identifies the advantages and disadvantages of each alternative relative to one another to assist in selection of a final remedial alternative for the Site. Overall protection of human health and the environment and compliance with ARARs serve as threshold criteria, so they must be met by any alternative for it to be eligible for selection. Since the No-Action alternative does not meet these criteria, it will not be included in the detailed comparison.

7.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 2 (ERH) would provide the highest level of protection to human health and the environment by physically removing, through in-situ and ex-situ treatment, most of the dissolved PCE and PCE DNAPL in the creek bed silt, aquifer soil, and groundwater within the HRIA/Berwick Creek source area. Alternative 2 is the only alternative that would effectively remove the PCE DNAPL from all impacted media within the source area, thereby eliminating the source of dissolved PCE to groundwater and surface water and associated negative impacts to human health and the environment.

Alternative 3 (ISCO) would provide a level of protection to human health and the environment by reducing the mass of PCE in aquifer soil and groundwater. Reduction of PCE concentration in groundwater would effectively eliminate exposure pathways and the potential for migration to local production wells and the possible discharge of contaminates to downgradient surface waters. However, this alternative would not be effective at treating DNAPL within low permeability soil within the aquifer, thereby leaving a potential source of future contamination to groundwater and leaving a potential exposure pathway.

Alternative 4 (PRB) and Alternative 5 (Hydraulic Containment) would provide protection of downgradient receptors by containing PCE contaminated groundwater at the source area. However, the effectiveness of these alternatives would need to be monitored over the long term to ensure protection of downgradient receptors. The DNAPL within the aquifer soils at the source area would not be removed with these remedial alternatives, leaving a source of future contamination to groundwater and leaving a potential exposure pathway.

Alternative 5 (Hydraulic Containment) would provide some treatment of PCE DNAPL within groundwater, but pump-and-treat technology is not very effective in treating the DNAPL. Alternative 4 (PRB) would provide the lowest level of protection to human health and the environment since source area groundwater and aquifer soil contamination would not be treated.

Under Alternatives 3, 4, and 5, removal of contaminated creek bed silt would eliminate future pathways for human and ecology exposure to PCE-impacted creek bed sediment and surface water.

For all the alternatives, ICs would be implemented to protect human health by restricting the use of and access to PCE-contaminated groundwater of the shallow aquifer in areas downgradient of the HRIA/Berwick Creek source area.

In addition, for all alternatives, long-term monitoring will be conducted following remedial action at the HRIA/Berwick Creek source area to assess natural attenuation and migration of the dissolved-phase PCE plume and to assess whether or not sufficient natural attenuation is occurring to achieve RAOs. If the results of long-term monitoring do not indicate that RAOs will be met, the need for additional remedial action to protect human health and the environment will be evaluated.

7.2 COMPLIANCE WITH ARARS

Alternative 2 (ERH) would meet ARARs for groundwater, aquifer soil, and creek bed sediment/soil through physical treatment.

Alternative 3 (ISCO) would likely meet ARARs for groundwater and aquifer soil through physical treatment. ARARs may not be met if DNAPL cannot be adequately removed for low permeability aquifer soils.

Alternative 4 (PRB) would likely meet ARARs for groundwater downgradient of the wall through treatment of contaminated groundwater. This alternative would not meet ARARs within the HRIA source since no active treatment would be occurring. PCE DNAPL in aquifer soil and groundwater would not be removed and would continue to be a source of dissolved PCE to groundwater. Alternative 4 would not meet the ARARs for the aquifer soils at the site as it only addresses the groundwater.

Alternative 5 (Hydraulic Containment) may not meet all ARARs for groundwater through physically removal of contaminated groundwater from the subsurface, since DNAPL would not be fully removed and would continue to be a source of dissolved PCE to groundwater. This alternative would not meet the ARARs for the aquifer soils at the Site as it only addresses groundwater.

Alternatives 3, 4, and 5 would most likely meet the ARARs for creek bed sediment/soil by physically removing contaminated material through excavation and off-site disposal. However, because the extent of PCE DNAPL is estimated based on available data, there is a possibility for DNAPL to be present outside the proposed excavation area. A potential exists for residual DNAPL to remain in the low permeability silt and provide a continued source of dissolved-PCE to groundwater.

For all alternatives, ARARs for surface water quality would be met by removing the source of the dissolved PCE in Berwick Creek.

7.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 2 (ERH) would be expected to provide the highest degree of long-term effectiveness and permanence because the technology would achieve remediation goals by physically removing PCE from the aquifer soil, the groundwater and the creek bed sediment/soil. Alternative 2 is the only alternative that would effectively remove DNAPL from all media including low permeability soils within the aquifer.

Under Alternative 3 (ISCO), where effective, there would be little residual at source area. However, DNAPL within low permeability zones within the shallow aquifer may not be effectively treated and could provide a future source of dissolved PCE to groundwater.

Under Alternative 4 (PRB), replacement or rejuvenation of the PRB could be required after 10 to 15 years, if significant fouling or loss of reactivity occurs. Technologies for in-situ rejuvenation are not well-developed.

Alternative 5 (Hydraulic Containment) with pump and treat technology is not highly effective at removing DNAPL, although close well spacing maximizes its effectiveness. Based on historical information, the effectiveness of pump and treat may be reduced over time.

For all alternatives, long-term monitoring (30 years) would be required following installation to ensure effectiveness and to monitor the natural attenuation and migration of remaining site plume.

7.4 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT

Alternative 2 (ERH) would reduce the toxicity and volume of PCE by removing dissolved PCE and PCE DNAPL from creek bed silt, aquifer soil, and groundwater within the treatment zone. The mobility of dissolved PCE and PCE DNAPL would also be reduced through proper design of the vapor extraction system. ERH with vapor extraction is the only in-situ technology that would effectively reduce the toxicity and volume of PCE DNAPL within all media (including the creek bed sediment/soil) at the HRIA/Berwick Creek source area.

Alternative 3 (ISCO) would reduce the toxicity and volume of PCE in groundwater by chemically degrading dissolved PCE and PCE DNAPL within the treatment zone to innocuous compounds. However, this alternative would not directly affect the mobility of dissolved PCE or PCE DNAPL in groundwater.

Alternative 4 (PRB) and Alternative 5 (Hydraulic Containment) would directly reduce the mobility of PCE in groundwater by providing a barrier to groundwater flow. Alternative 5 would reduce the volume of PCE in groundwater at and downgradient of the HRIA/Berwick Creek source area, but would not directly affect the toxicity. Alternative 4 would reduce the volume and toxicity of PCE downgradient of the source area, but would not affect either volume or toxicity within the source area. Neither alternative would reduce the volume or toxicity of PCE DNAPL within the aquifer soil or groundwater at the source area.

Alternative 3 (ISCO), Alternative 4 (PRB), and Alternative 5 (Hydraulic Containment) would reduce the toxicity, mobility, and volume of PCE in Berwick Creek and the shallow aquifer by physically removing the contaminated silts from the creek bed that is a source of PCE to surface water and groundwater.

7.5 SHORT-TERM EFFECTIVENESS

For all alternatives, the community and the environment would be protected during completion by the use of site control and traffic control during construction, placement of the system infrastructure primarily on unused public land away from current public use, and fencing and/or burial of system infrastructure, as applicable. Health risk to workers performing remedial and monitoring activities would be mitigated through proper health and safety measures.

Alternative 2 (ERH) is anticipated to have the greatest short-term effectiveness with respect to meeting RAOs. Aquifer soils, groundwater and creek bed sediment RAOs would be met within 12 months.

Alternative 3 (ISCO) is anticipated to have the moderate short-term effectiveness with respect to meeting RAOs. Groundwater and creek bed sediment/soil RAOs would be met within 2 to 3 months. However, aquifer soils may require a longer timeframe based on the effectiveness of DNAPL treatment, especially in low permeability soils. Treatment of DNAPL in these soils may be difficult and potentially ineffective.

Alternative 4 (PRB) and Alternative 5 (Hydraulic Containment) would be effective in the short term since both would be effective within a short time of installation. Containment would be achieved within a few hours of installation and start-up. However, it is estimated that it may take over 30 years to achieve the RAOs using these technologies.

7.6 IMPLEMENTABILITY

Alternative 5 (Hydraulic Containment) could be easily implemented at the Site. Pump and treat technology is well established and has been used from groundwater cleanup at numerous sites throughout the country. Existing monitoring wells would be converted to extraction wells; no new wells would be required. The groundwater extraction system could also be expanded to allow capture of a larger portion of the site-wide plume, if necessary.

Alternative 3 (ISCO) could be easily implemented at the Site. ISCO is a well established technology, which has been successfully implemented at numerous sites. Although some preferential flow pathways clearly exist beneath the Site, the sand and gravel soils of the shallow aquifer are more homogeneous than soils at many sites. This indicates that the soil conditions beneath the site are generally favorable for chemical oxidation. A pilot test would be conducted in the source area as part of the overall treatment process to assist in designing the most efficient injection program.

Alternative 4 (PRB) could be implemented fairly easily at the Site. Excavation for wall installation would be deep, but could still be accomplished using standard techniques. PRB walls have been implemented at numerous locations around the world. The necessary materials and services for implementing this alternative are readily available, although the PRB technology is proprietary and a licensing fee is required. Trenching for wall installation would be deep, but installation could still be accomplished using standard techniques.

For Alternative 3, 4, and 5, excavation and off-site disposal of the contaminated silt can be accomplished using standard construction techniques and equipment.

Alternative 2 (ERH) is a relatively new technology that requires sophisticated equipment and skilled technical personnel. A limited number of vendors provide this proprietary technology. Implementation of Alternative 2 would require a 12 month diversion of Berwick Creek designed to accommodate fish passage. ERH has been successfully completed at nearby Fort Lewis. Per discussions with the vendor providing ERH services for Fort Lewis, it is predicted that the implementation would be similar at the Site.

7.7 COST

The cost estimates prepared for this FS are “order-of-magnitude” estimates having an accuracy range of -30 percent to +50 percent and are suitable for comparing costs, not as an estimate of construction costs. The actual cost for these remedial alternatives will depend on actual site and subsurface conditions, competitive bids, and market conditions at the time of implementation. Because of these factors and potential unforeseen issues, the actual cost and feasibility of these alternatives may vary. Detailed cost estimates for each of the four alternatives (excluding Alternative 1 – No-Action) and supporting information are presented in Appendix C.

Alternative 3 (ISCO) has the lowest present worth cost of the four alternatives evaluated at an estimated $3,270,000 to $4,410,000. A range of costs was presented because the cost for ISCO varied greatly between vendors. The actual cost is dependant primarily on the number of injection events and quantity of oxidant required to reduce aquifer soil and groundwater contamination below RAOs. Vendor 1 assumed that one 40-day injection event would be required to reach RAOs. Vendor 2 assumed that up to five short-term injection events would be required to meet the RAOs. The lowest cost presented in the FS assumes the one 40-day primary injection event. The exact number of injection events and quantity of oxidant can only be estimated at this time, but would be determined based on the results of pilot testing and the previous injection event. Therefore, there is uncertainty with the actual effort that is required for meeting RAOs using ISCO and a greater uncertainty with the overall cost of this alternative versus Alternative 2 (ERH).

Alternative 4 (PRB) has a second lowest present worth ($4,330,000) than Alternatives 2 and 3 primarily due to higher initial capital costs and the need for long-term monitoring. Based on the unknown long-term effectiveness of this remedial alternative and the long timeframe for attainment of RAOs, the certainty of the cost estimate for this alternative is lower than cost estimates for Alternatives 2 and 3.

Alternative 2 (ERH) has the next lowest present worth at an estimated $4,500,000. The cost for installing and operating the ERH system is based on experience at the nearby Fort Lewis site with similar stratigraphy. This alternative is anticipated to be more effective than Alternative 3 (ISCO). The cost effectiveness of this alternative may be considered better based on the high effectiveness versus ISCO.

Alternative 5 (Hydraulic Containment) has the highest present worth ($5,070,000) primarily because of the long-term operation and maintenance (O&M) cost for the pump and treat system and the long-term semi-annual groundwater monitoring costs. The cost effectiveness is considered low as compared to other alternatives based on the high present worth value, long timeframe for attainment of groundwater RAOs, and ineffectiveness for treating DNAPL in groundwater and aquifer soil.

Detailed cost estimates for each alternative are presented in Appendix C.

7.8 STATE ACCEPTANCE

To be addressed in the ROD.

7.9 COMMUNITY ACCEPTANCE

To be addressed in the ROD.

8. REFERENCES

Farallon Consulting. 2003. *Remedial Investigation/Feasibility Study Work Plan, Hamilton/Labree Roads Groundwater Contamination Superfund Site, Chehalis, Washington*. Prepared for S.C. Breen Construction Company. July.

Federal Remediation Technologies Roundtable. 2005. Remediation Technologies Screening Matrix and Reference Guide, Version 4.0. www.frtr.gov/matrix2.

Fetter, Jr., C.W. *Applied Hydrogeology*. Bell & Howell Company. 1980.

GeoEngineers. 2001. *Interim Remedial Action Report, S.C. Breen Construction Company Property, Chehalis, Washington*. Prepared for S.C. Breen Construction Company. March.

Geo-Recon International (Geo-Recon). 1996. *Geophysical Investigation of the Hamilton-LaBree Properties, Chehalis, Washington*. Prepared for Washington State Department of Ecology. October.

Parametrix. 2005. Technical Memorandum: Breen Property Surface Soil Data Review. Prepared by Parametrix for EPA Region 10. November 7.

Parametrix. 2006. Technical Memorandum: Hamilton/Labree Groundwater Contamination Site: Data Validation/Data Usability Review. Prepared by Parametrix for EPA Region 10. January 9.

SAIC. 1997. *Phase I and II Data Presentation Report for Hamilton/Labree Roads Perchloroethylene (PCE) in Groundwater Site*. Prepared by Science Applications International Corporation for Washington Department of Ecology under Ecology Contract C9300048, SAI019. June.

United States Environmental Protection Agency. 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*. Interim Final. October.

United States Environmental Protection Agency. 2000. BIOCHLOR: Natural Attenuation Decision Support System, User's Manual, Version 1.0. Office of Research and Development. EPA/600/R-00/008. January.

United States Environmental Protection Agency (EPA). 2000. *Removal Assessment Report, Hamilton-Labree Site, Chehalis, Washington*. Prepared by Ecology and Environment, Inc. for EPA Region 10 under START Contract 68-W6-0008. TDD: 00-01-0015. December.

United States Environmental Protection Agency (EPA). 2001. *Hamilton-Labree Phase III Removal Assessment Report, Chehalis, Washington*. Prepared by Ecology and Environment, Inc. for EPA Region 10 under START-2 Contract 68-S0-01-01. TDD: 01-01-0010. April.

United States Environmental Protection Agency (EPA). 2002. *Hamilton-Labree Phase IV Removal Assessment, Chehalis, Washington*. Prepared by Ecology and Environment, Inc. for EPA Region 10 under START-2 Contract 68-S0-01-01. TDD: 01-09-0006. January.

United States Environmental Protection Agency (EPA). 2003. *Hamilton-Labree Removal Action Report, Chehalis, Washington*. Prepared by Ecology and Environment, Inc. for EPA Region 10 under START-2 Contract 68-S0-01-01. TDD: 01-09-0006. May.

United States Environmental Protection Agency (EPA). 2006. CLU-IN Website. www.clu-in.org.

URS. 2004. *Draft (Revision 1) Engineering Evaluation/Cost Analysis Report, Hamilton Road Impact Area, Hamilton-Labree Roads Superfund Site, Chehalis, Washington*. Prepared for EPA Region 10 under RAC Contract 68-W-98-228. August.

Washington State Department of Ecology (Ecology). 1999a. *Source Investigation Report for Hamilton/Labree Roads Chlorinated Solvent Site.* January.

Washington State Department of Ecology (Ecology). 1999b. *Hamilton/Labree Roads PCE Site Ground Water Monitoring, October 1997 – July 1998*. April.

Washington State Department of Ecology (Ecology). 2000. *Hamilton/Labree Roads PCE Site Ground Water Monitoring, February and July 1999*. September.

Washington State Department of Ecology (Ecology). 2005. *Hydrology and Quality of Groundwater in the Centralia-Chehalis Area Surficial Aquifer*. Washington State Groundwater Assessment Program. Publication No. 05-03-040. December.

TABLES

Table 1-1. Summary of Historical Investigations Conducted at the Hamilton/Labree Roads Groundwater Contamination Superfund Site

Dates	Investigated By	Scope of Investigation	Data Sources
1993-94	Washington State Department of Health (WDOH)	Sampled 18 private water-supply wells in the Hamilton/Labree Roads area.	Ecology 1999a
1996	WDOH	Re-sampled 5 of 6 wells previously exhibiting tetrahloroethylene (PCE).	Ecology 1999a
1996	Geo-Recon and SAIC (for Washington Department of Ecology [Ecology])	Geophysical reconnaissance investigation on the Breen property for sources, sampled private water-supply wells, and installed monitoring wells in the upper aquifer.	SAIC 1997
1997-2000	Ecology	Quarterly sampling of monitoring wells and private water-supply wells. Installed 7 wells intended for monitoring and remediation, all within the HRIA study area. Sampling of surface water in Berwick Creek.	Ecology 1999b, 2000
1998	Transglobal Environmental Geosciences Northwest, Inc. [TEG] (for Ecology)	Sampled soil and groundwater from 28 temporary borings in the Hamilton/Labree Roads area.	Ecology 1999a
1999	Northwest Geophysical Associates and GeoEngineers (for Breen)	Located and removed 70 drums and several small containers, and contaminated soil from beneath a building on the Breen property.	GeoEngineers 2001
2000-02	START Contractor - Ecology and Environment, Inc. (for EPA)	Four phases of work as part of a time-critical removal action. Installed and sampled temporary borings, monitoring wells, and combined monitoring and recovery wells. All temporary and permanent sampling locations assessed the shallow aquifer, with various sampling and screen depths. Evaluated removal action alternatives.	EPA 2000, 2001, 2002b
2002-03	Farallon Consulting (for Breen)	Phase I investigation work for preparation of a site-wide remedial investigation/feasibility study. Within the HRIA study area, collected surface water from Berwick Creek and groundwater from existing monitoring and private water-supply wells. Outside of HRIA study area, installed and sampled temporary borings and permanent monitoring wells, collected stream-bed soil samples from Berwick Creek, collected soil gas samples on Breen property.	Farallon 2003
2003	RAC Contractor - URS Group (for EPA)	Engineering evaluation/cost analysis (EE/CA) investigation for HRIA study area. Performed geophysical survey to look for targets and characterize subsurface. Collected soil gas samples, stream bed and bank soil samples from Berwick Creek, sampled soil and groundwater from borings to 50 feet bgs, installed and sampled permanent monitoring wells, and performed two constant-discharge aquifer performance tests.	URS 2004
2003-04	Farallon Consulting (for	Collected soil, groundwater, and surface water data to support the RI/FS on the Breen property. Data	_

Table 1-1. Summary of Historical Investigations Conducted at the Hamilton/Labree Roads Groundwater Contamination Superfund Site

Dates	Investigated By	Scope of Investigation	Data Sources
	Breen)	collected but not reported.	

Table 1-2. Estimated Mass of PCE at the HRIA

	Mass of PCE DNAPL (kg)			Mass of PCE Sorbed and Dissolved (kg)		
Zone Name	**Best Estimate**	**95%LB**	**95%UB**	**Best Estimate**	**95%LB**	**95%UB**
Aquifer Treatment Zone	1,300	480	2,700	170	88	290
Silt Cap Treatment Zone	180	34	490	80	35	150
Remainder Zone >1,000 contour	0	-	-	300	160	490
Remainder Zone <1,000 contour	0	-	-	66	28	120
Total	1,480	514	3,190	616	311	1,050

Source: URS (2004)

95%LB = 95 percent confidence lower bound
95%UB = 95 percent confidence upper bound
kg = kilogram
DNAPL = dense nonaqueous-phase liquid
PCE = tetrachloroethene

Table 2-1. Potential Applicable or Relevant and Appropriate Requirements (ARARs)

ARAR	Description	Applicability
Groundwater		
Clean Water Act, Section 304, National Recommended Water Quality Criteria, EPA Office of Science and Technology (4304T, 2004).	There are no ambient water quality criteria for PCE for protection of freshwater organisms.	Surface water quality criteria are potentially relevant and appropriate to ambient surface water quality in and point-source discharges to Berwick Creek.
Safe Drinking Water Act, Primary Drinking Water Regulations (40 CFR 141.61(a))	These regulations protect the quality of public drinking water supplies through regulation of chemical parameters and constituent concentrations as maximum concentration limits (MCLs).	MCLs and are potentially relevant and appropriate at the site where groundwater is a potential source of drinking water.
Surface Water		
Clean Water Act, National Pollutant Discharge Elimination System (40 CFR Part 122) and Washington State National Pollutant Discharge Elimination System Permit Program (WAC 173-220).	The National Pollutant Discharge Elimination System (NPDES) program requires that permits be obtained for point-source discharges of pollutants to surface water. Under this regulation, a point-source discharge to a surface water body cannot cause an exceedance of water quality standards in the receiving water body outside the mixing zone.	Although permits would not be required for on-site actions under CERCLA, the substantive regulatory requirements of the NPDES permit program are potentially applicable to the direct discharge of treated groundwater to a surface water body such as Berwick Creek (or to the unnamed or small ditches, since they have a connection to Berwick Creek).
Clean Water Act, General Pretreatment Regulations (40 CFR Part 403).	The regulations limit pollutants in wastewater discharges to sanitary sewer systems to protect publicly owned treatment work (POTWs) from accepting wastewater that would damage their system or cause them to exceed their NPDES permit discharge limits.	These regulations are potentially applicable to the discharge of treated groundwater to City of Chehalis POTWs. The City of Chehalis pretreatment ordinance would be potentially applicable as well.
Washington Surface Water Quality Standards, Short-Term Modifications (WAC 173-201A-410)	Washington State provides for short-term modifications of standards for specific water bodies on a short-term basis when necessary to accommodate essential activities, respond to emergencies, or to otherwise protect the public interest.	The substantive requirements of this regulation are potentially applicable for in-water work at Berwick Creek.
Washington State Water Quality Standards for Surface Waters (WAC 173-201A)	Washington State water quality standards protect freshwater aquatic life by specifying protection criteria by stretch of surface waters. WAC 173-201A provides limitations on other parameters such as turbidity, temperature, dissolved oxygen, and pH for protection of organisms. Tributaries of waters whose uses are designated salmon and trout spawning, core rearing and migration, or extraordinary primary contact recreation are protected at the same level as the waters themselves.	These would be potentially applicable to remedial actions within or impacting Berwick Creek.
Washington Hydraulics Project Approval (WAC 220-110)	This regulation requires Washington Department of Fish and Wildlife (WDFW) approval for projects that will use, divert, obstruct, or change the natural flow or bed of waters of the state. WDFW typically issues in stream work windows under the authority of this program.	Substantive technical provisions written for freshwater hydraulic projects covered in WAC 220-110-040 through -224 are potentially applicable to work within or effecting Berwick Creek
Clean Water Act, Section 404, Dredge or Fill Requirements (33 CFR Parts 320 to 330; 40 CFR Part 230)	EPA guidelines for discharge of dredged or fill materials in 40 CFR Part 230 specify consideration of alternatives that have less adverse impacts; prohibit discharges that would result in exceedance of surface water quality standards, exceedance of toxic effluent standards, and jeopardy of threatened or endangered species; and provide for evaluation and testing of fill materials before placement.	These requirements are potentially applicable to remedial actions in or near navigable waters, which include wetlands, establishing requirements that limit the discharge of dredged or fill material to these waters.
Air		
Washington Clean Air Act and Implementing Regulations (WAC 173-400; WAC 173-460; WAC 173-490)	WAC 173-400 requires air emissions at the site boundary fall below the acceptable source impact limit (ASIL). WAC 173-400 also requires control of fugitive dust emissions during construction and defines general emission discharge treatment requirements. WAC 173-460 requires systemic control of new sources emitting air pollutants. WAC 173-490 sets emission standards and source control for volatile organic compounds.	Applicable for air stripping/sparging remedial technology.
Southwest Clean Air Agency [SWCAA] Regulation (SWCAA 400 and 490)	Air regulations applicable to Lewis, Cowlitz, Clark, Skamania, and Wahkiakum Counties. SWCAA 400 are the general air pollution regulations. SWCAA 490 sets emission standards and source control for volatile organic compounds	Applicable for air stripping/sparging remedial technology.
All Media		
Model Toxics Control Act (WAC 173-340)	Model Toxics Control Act (MTCA) regulates the investigation and cleanup of releases to the environment that may pose a threat to human health or the environment. Establishes cleanup levels for soil, air, groundwater, and surface water.	MTCA is applicable at the site for soil, air, groundwater, and surface water.
Miscellaneous		
Protection of Wetlands, Executive Order 11990 (40 CFR Part 6, Appendix A)	This executive order mandates that response actions taken by federal agencies must be designed to avoid long- and short-term impacts to wetlands. If remediation activities are located near/in wetlands, the activities must be designed to avoid adverse impact to the wetlands wherever possible, including minimizing wetlands destruction and preserving wetland values.	This Act would be potentially applicable to remedial activities at the site.
Endangered Species Act (50 CFR Parts 17, 402)	Section 7 of the Endangered Species Act (ESA) and 40 CFR Part 402 require that federal agencies consider the effects of their proposed actions on federal listed species. It requires consultation between the agency proposing the action and the U.S. Fish and Wildlife Service (USFWS) or National Oceanic and Atmospheric Administration (NOAA) Fisheries, as appropriate. Preparation of a biological assessment is conducted, addressing the potential effects to listed species in the area and ways to minimize those effects.	The ESA is potentially applicable to remedial actions at the site because the USFWS has determined that federal threatened species (bald eagle and bull trout) may use the project area. Therefore, they could potentially be affected by these actions.

Table 2-1. Potential Applicable or Relevant and Appropriate Requirements (ARARs)

ARAR	Description	Applicability
Native American Graves Protection and Repatriation Act (43 CFR Part 10)	Native American Graves Protection and Repatriation Act regulations protect Native American burials from desecration through the removal and trafficking of human remains and "cultural items," including funerary and sacred objects.	This Act is potentially applicable to remedial actions at the site because it is possible that the disturbance of Native American materials could occur as a result of work in the stream bed or subsurface excavations elsewhere at the site. Such materials are not known to be present at the site, but could be inadvertently uncovered during soil or sediment removal.
National Historic Preservation Act (36 CFR Parts 60, 63, and 800)	National Historic Preservation Act (NHPA) regulations require federal agencies to consider the possible effects on historic sites or structures of actions proposed for federal funding or approval. Historic sites or structures as defined in the regulations are those on or eligible for the National Register of Historic Places, generally at least 50 years old.	This Act is potentially applicable to stream bed or other subsurface work at the site. No such sites are known to be present in the area.
Washington Hazardous Waste Management Act (WAC 173-303)	Establishes standards for the generation, transport, treatment, storage, or disposal of designated dangerous waste in the state.	This regulation is potentially applicable to alternatives that would involve handling of contaminated media on-site. The area of contamination policy allows contaminated media to be consolidated within the same area of a site without triggering Resource Conservation and Recovery Act or Washington dangerous waste regulations.
Washington Solid Waste Handling Standards (WAC 173-350)	Establishes standards for handling and disposal of solid non-hazardous waste in Washington.	These regulations are potentially applicable to solid nonhazardous wastes and are potentially relevant and appropriate to on-site remedial actions governing contaminated media management.

Table 4-1. Remedial Technology Screening

Media	Preliminary Remedial Action Objectives	General Response Actions	Remedial Technology Type	Process Options	Effectiveness	Implementability	Cost
Groundwater	Prevent ingestion of groundwater containing PCE at concentrations exceeding the Ecology MTCA Method A and Federal/State MCL value of 5.0 µg/L. Prevent downgradient migration of PCE to drinking water sources. Restore aquifer groundwater quality.	No Action/Institutional Control	Proprietary Controls Government Controls	NA	This technology would not be effective at meeting the RAOs. The PCE source would remain. Institutional Controls would provide short-term effectiveness. Migration of PCE to downgradient drinking water sources would not be prevented.	The No Action alternative would be easy to implement because no action would be required. Implementing Institutional Controls can be difficult.	There is no cost for the No Action alternative. The cost for applying Institutional Controls can be high.
		Containment	Vertical Barriers	**Slurry Wall** – a physical barrier used to contain contaminated groundwater or divert it from a downgradient receptor.	This technology would be effective at meeting the groundwater RAOs. Would prevent downgradient migration of PCE. Containment only, would not treat groundwater or provide source removal. Degradation of the slurry wall over time may occur. This technology does not guarantee that additional remedial action will not be required since no treatment is occurring.	Slurry walls have been used for decades. Contaminated soil would be generated during wall installation and would require off-site disposal. Long-term operation (>30 years) would be required if source areas were not removed and treatment of source area contamination is not completed.	The cost for this technology is high. This cost would include the off-site disposal of soil excavated during installation.
			Hydraulic Containment	**Pumping** – use of groundwater pumping to form a barrier and extract groundwater for treatment.	This technology would be effective at meeting the groundwater RAOs when combined with a treatment technology. The downgradient migration of PCE would be prevented. This technology is normally not effective at removing DNAPL.	Pumping is a well established technology. Additional extraction wells may be required to effectively contain the PCE plume. A performance monitoring program is required to assess the effectiveness of this technology.	The cost for this technology is low to medium. This assumes this technology is used in conjunction with an ex situ treatment method.
		Collection/Treatment	Ex Situ Physical Treatment (pump and treat)	**Air Stripping** - volatile organics are removed from water by greatly increasing the surface area of the contaminated water exposed to air and inducing volatilization.	This technology would be effective at meeting the groundwater RAOs when combined with hydraulic containment (pumping). Historically effective in treating PCE.	Air stripping is a common and well established technology, and relatively easy to implement.	The cost for this technology is medium. This assumes this technology is used in conjunction with pumping.
				Adsorption/Absorption – contaminated water flows through a media such as granular activated carbon (GAC) or a synthetic resin to remove contaminants.	This technology would be effective at meeting the groundwater RAOs when combined with hydraulic containment. Effectiveness of this technology known to decrease over time. Not always effective at treating DNAPL.	The use of adsorption/absorption, especially GAC, is a common and well established technology, and is relatively easy to implement. Turnkey treatment systems are available and plumbed into a pumping system at the site (see Pumping above).	The cost for this technology is medium to high. This assumes this technology is used in conjunction with pumping.
			In Situ Treatment	**Permeable Reactive Barrier (PRB)** – a permeable barrier composed of a reactive material that treats contaminated groundwater as it flows through it.	This technology would be effective at meeting the groundwater RAOs. The downgradient migration of PCE would be prevented. The long-term effectiveness of PRBs has not been fully verified. Loss of reactive capacity may occur over time and reactive medium may require replacement.	PRBs have been implemented at over 100 sites. Contaminated soil would be generated during wall installation and would require off-site disposal. Long term operation (>30 years) would be required if source areas were not removed or additional treatment of source area contamination is not completed.	The cost for this technology is high. This cost would include the off-site disposal of soil excavated during installation.
				Monitored Natural Attenuation (MNA) – natural subsurface processes such as dilution, volatilization, biodegradation and	MNA would not be effective at meeting the groundwater RAOs. Based on previous studies at the site, the	MNA is easy to implement since little to no action is required. A long-term groundwater monitoring system	The cost for this technology is low.

Table 4-1. Remedial Technology Screening

Media	Preliminary Remedial Action Objectives	General Response Actions	Remedial Technology Type	Process Options	Effectiveness	Implementability	Cost
				other physical and/or chemical processes are allowed to reduce contaminant concentrations in the aquifer.	potential for natural degradation of PCE in groundwater is low. The PCE may migrate before it degrades to acceptable concentrations.	would be required to verify the effectiveness of this technology.	
				Electrical Resistance Heating (ERH) – use of electrical current to heat soil and groundwater so contaminants are vaporized and collected for ex situ treatment.	ERH would be effective at meeting the groundwater RAOs. A large percentage of the PCE would be removed from shallow groundwater within the treatment area preventing downgradient migration. This technology would also treat the PCE source (creek bed silt) to groundwater. ERH has proved effective at nearby Fort Lewis within similar type aquifer materials. ERH has also been combined with steam injection.	ERH is a newer technology that very few companies provide. This technology would be challenging to implement at the site. Berwick Creek would need to be diverted prior to installation and during treatment. Numerous borings would be required for equipment installation. An additional electricity source would be required to power the vapor extraction system.	The cost for this technology is high.
				In Situ Chemical Oxidation (ISCO) – an oxidant such as permanganate is injected into the aquifer causing rapid degradation of organic compounds.	This technology would be effective at meeting the groundwater RAOs. A large percentage of the PCE would be removed from shallow groundwater within the treatment area preventing downgradient migration. Effectiveness limited by low-permeability soils and rapid groundwater flow.	ISCO is a well established technology. A treatability study and reaction transport modeling is normally required to access feasibility. Migration of oxidant, which is toxic to fish, from groundwater to Berwick Creek could occur. Installation of numerous borings would be required for oxidant injection.	The cost for this technology is medium to high.
				Air Sparging – air is injected through the contaminated aquifer creating a "stripper" that removes contaminants by volatilization.	Air sparging may be effective at meeting the groundwater RAOs. The effectiveness of this technology can be impacted by very small changes in soil permeability which can lead to localized treatment around the sparge point. Effectiveness limited by low-permeability soils. Often limited to about 30-foot aquifer thickness. Would remove DNAPL slowly as it dissolves.	The difficulty of implementing this technology would be moderate. Installation of numerous sparge points would be required for air injection into the aquifer. Potential for uncontrolled migration of PCE vapors due to non-uniform air flow in the aquifer.	The cost for this technology is medium.
Creek Sediment/Soil	Prevent ingestion of sediment containing PCE at concentrations exceeding the Ecology MTCA Method B carcinogenic value for soil of 1.9 mg/kg (ingestion). Prevent migration of PCE to surface water and groundwater.	No Action/Institutional Control	Proprietary Controls Government Controls	NA	This technology would not be effective at meeting the sediment RAOs. The PCE source would remain. Institutional Controls would provide short-term effectiveness.	The No Action alternative would be easy to implement because no action would be required. Implementing Institutional Controls can be difficult.	There is no cost for the No Action alternative. The cost for applying Institutional Controls can be high.
		Removal	Excavation	**Excavation** – mechanical removal of contaminated material from the creek bed.	This technology would be effective at meeting the sediment RAOs when combined with a treatment technology or offsite disposal. The PCE source to surface water and groundwater would be removed.	The difficulty of implementing this technology would be moderate. Berwick Creek would require rerouting during excavation. Replacement of impermeable layer may be required at site.	The cost for this technology is medium to high.
		Treatment	Ex Situ Treatment	**Chemical Oxidation** - ex situ treatment of contaminated sediment/soil following	This technology would be effective at meeting the sediment RAOs when	Implementation of this technology would be moderate to difficult. The	The cost for this technology is medium. This assumes the cost

Table 4-1. Remedial Technology Screening

Media	Preliminary Remedial Action Objectives	General Response Actions	Remedial Technology Type	Process Options	Effectiveness	Implementability	Cost
				excavation using an oxidant such as ORC.	combined with excavation. This alternative would require combination with excavation for removal of the contaminated silt in the creek bed. See excavation above.	excavated material will require physical mixing with the oxidant. This process would most like require an offsite location.	for excavation is included.
				Thermal Treatment (Incineration) – ex situ treatment of contaminated sediment/soil following excavation.	This technology would be effective at meeting the sediment RAOs when combined with excavation. This alternative would require combination with excavation for removal of the contaminated silt in the creek bed. See excavation above.	Implementation of this technology is easy to moderate. Contaminated sediments would be transported to an offsite facility for thermal destruction. Acceptance by the disposal facility would be required prior to transportation. Availability of local treatment facility would need to be determined.	The cost for this technology is medium to high. This assumes the cost for excavation and transportation to a disposal facility is included.
			In Situ Treatment	**Electrical Resistance Heating (ERH)** - see description above.	This technology would be effective at meeting the sediment RAOs. The PCE source in the sediments would be removed preventing migration of PCE to groundwater and surface water.	See description under groundwater above.	The cost for this technology is medium to high.
				In Situ Chemical Oxidation (ISCO) - an oxidant such as permanganate is injected into the sediment/soil causing rapid degradation of organic compounds.	This technology would not be effective at meeting the sediment RAOs. Chemical Oxidation would not be effective in treating PCE in the low permeability silts in the Berwick Creek bed.	Implementation of ISCO would be difficult. Berwick Creek would need to be diverted because of the toxicity of permanganate to fish. May require numerous injection point and several injection events because of the low permeability of the silt in the creek.	The cost for this technology is high.

Table 6-1. Detailed Analysis of Alternatives

Criterion	Remedial Alternatives				
	1 - No Action	2 - Electrical Resistance Heating (ERH)	3 - In-Situ Chemical Oxidation (ISCO)	4 - Permeable Reactive Barrier (PRB)	5 - Hydraulic Containment
Overall Protection of Human Health and the Environment	• The No Action alternative provides a baseline for comparing other alternatives. • Under this alternative, future pathways for human and ecology exposure to PCE-impacted creek sediment, surface water, and groundwater exist. • Under this alternative there would be no reduction in risk to human health and the environment. • The potential exists for migration of contaminants in groundwater to downgradient drinking water sources.	• ERH would reduce baseline risk and provide level of protection to human health and environment by reducing the mass of PCE in aquifer soil, the contaminated groundwater and the creek sediments. • Removal of source area contamination would eliminate future pathways for human and ecology exposure to PCE-impacted creek sediment and surface water. • Reduction of PCE concentration in groundwater would effectively eliminate exposure pathways and the potential for migration to local production wells and the possible discharge of contaminates to downgradient surface waters. • Institutional controls would be implemented to protect human health by restricting the use of and access to PCE-contaminated groundwater of the shallow aquifer in areas downgradient of the HRIA/Berwick Creek source area.	• Alternative 3 would reduce baseline risk and provide level of protection to human health and environment by reducing the mass of PCE in aquifer soil and groundwater. • Removal of contaminated silt would eliminate future pathways for human and ecology exposure to PCE-impacted creek sediment and surface water. • Alternative 3 would also reduce the leaching of PCE from creek bed soil to surface water by removal of contaminated silt in Berwick Creek. • Reduction of PCE concentration in groundwater would effectively eliminate exposure pathways and the potential for migration to local production wells and the possible discharge of contaminates to downgradient surface waters. • Institutional controls would be implemented to protect human health by restricting the use of and access to PCE-contaminated groundwater of the shallow aquifer in areas downgradient of the HRIA/Berwick Creek source area.	• The PRB wall would reduce baseline risk and provide a level of protection to human health and environment by mass of PCE in downgradient groundwater. • Removal of contaminated silt would eliminate future pathways for human and ecology exposure to PCE-impacted creek sediment and surface water. • Containment of the source area groundwater contamination would reduce the potential migration of contaminants to drinking water sources. • Alternative 4 would also reduce the leaching of PCE from creek bed soil to surface water by removal of contaminated silt in Berwick Creek. • Groundwater and aquifer soil PCE concentration in the source area would not be reduced by this technology. • Institutional controls would be implemented to protect human health by restricting the use of and access to PCE-contaminated groundwater of the shallow aquifer in areas downgradient of the HRIA/Berwick Creek source area.	• Hydraulic containment would provide adequate protection of human health and the environment through the reduction of dissolved PCE in the groundwater and containing the migration of the contaminated water downgradient. • Removal of contaminated silt would eliminate future pathways for human and ecology exposure to PCE-impacted creek bed soil and surface water. • Alternative 5 would also reduce the leaching of PCE from creek bed soil to surface water by removal of contaminated silt in Berwick Creek. • Groundwater and aquifer soil PCE concentration in the source area would not be reduced by this technology. • Institutional controls would be implemented to protect human health by restricting the use of and access to PCE-contaminated groundwater of the shallow aquifer in areas downgradient of the HRIA/Berwick Creek source area.
Compliance with ARARs	• Would not meet project ARARs.	• ERH and the long-term diversion of Berwick Creek would be designed to comply with all action-specific and location-specific ARARs. • ERH would meet chemical-specific ARARs for groundwater, aquifer soils, and creek bed sediment/soil through physical treatment of contamination. • ARARs for surface water quality would be met by removing the source of the dissolved PCE in Berwick Creek. • Diversion of Berwick Creek would occur within the in-stream work window.	• The ISCO injections, the temporary diversion of Berwick Creek, and the silt removal would be designed to comply with all action-specific and location-specific ARARs. • ISCO would likely meet chemical-specific ARARs for groundwater through chemical treatment of contaminated groundwater. • This alternative would meet the chemical-specific ARARs for the aquifer soils at the site. • The removal of the contaminated silt would meet the chemical-specific ARARs for the creek bed soil. • Diversion of the creek and creek bed silt removal would occur within the in-stream work window. • ARARs for surface water quality would be met by removing the source of the dissolved PCE in Berwick Creek.	• The PRB-containment system the temporary diversion of Berwick Creek, and the silt removal would be designed to comply with all action-specific and location-specific ARARs. • Alternative 4 would likely meet chemical-specific ARARs for groundwater downgradient of the wall through treatment of contaminated groundwater. This alternative would not meet ARARs within the HRIA source area. • This alternative would not meet the chemical-specific ARARs for the aquifer soils at the Site as it only addresses the groundwater. • The removal of the contaminated silt would meet the chemical-specific ARARs for the creek bed soil.	• The hydraulic containment system the temporary diversion of Berwick Creek, and the silt removal would be designed to comply with all action-specific and location-specific ARARs. • Alternative 5 would likely meet chemical specific ARARs for groundwater through physically removal of contaminated groundwater from the subsurface. • This alternative would not meet the chemical-specific ARARs for the aquifer soils at the Site as it only addresses groundwater. • The removal of the contaminated silt would meet the chemical-specific ARARs for the creek bed soil. • Diversion of the creek and creek bed silt removal would occur within the in-

Table 6-1. Detailed Analysis of Alternatives

Criterion	Remedial Alternatives				
	1 - No Action	**2 - Electrical Resistance Heating (ERH)**	**3 - In-Situ Chemical Oxidation (ISCO)**	**4 - Permeable Reactive Barrier (PRB)**	**5 - Hydraulic Containment**
				• Diversion of the creek and creek bed silt removal would occur within the in-stream work window. • Removal of the contaminated silt would also help achieve surface water ARARs by removing the source of the dissolved PCE in Berwick Creek.	stream work window. • Removal of the contaminated silt would also help achieve surface water ARARs by removing the source of the dissolved PCE in the surface water.
Long-Term Effectiveness and Permanence	• Since no remedial action would be completed, this alternative would not be effective in the long term.	• ERH would be expected to provide the highest degree of long-term effectiveness and permanence because the technology would achieve remediation goal by removing PCE from the aquifer soil, the groundwater and the creek bed sediment/soil. • ERH is the only alternative that would effectively remove DNAPL from all media including low permeability soils within the aquifer and creek bed. This would greatly reduce or eliminate the PCE source to groundwater. • The ERH alternative would meet the RAOs by removing the constant source of PCE dissolving to groundwater and surface water and maximizing the PCE mass removal. • ERH has been proven to be effective in several full-scale projects involving PCE and similar contaminants. • It is anticipated that the removal of contaminants within this remediation zone would be permanent and is anticipated to result in no treatment residuals. • This alternative would be effective in the long term, because it would remove 85 percent of the PCE in aquifer soil and groundwater within the treatment zone. • Groundwater modeling predicts that the result would be stabilization of the plume and protection of downgradient drinking water receptors. • Removing the constant source of PCE to groundwater and the highest concentrations in groundwater would reduce the time for overall aquifer restoration.	• The ISCO alternative would meet the RAOs by removing the constant source of PCE dissolving to groundwater and surface water, and maximizing the PCE mass removal. • Removing the constant source of PCE to groundwater and the highest concentrations in groundwater would reduce the time for overall aquifer restoration. • The ISCO alternative would be effective in the long term because it would remove 100 percent of the PCE in the creek bed silt within the treatment zone through excavation and 85 percent of the PCE in the sand and gravel shallow aquifer within the treatment zone. • Where effective, little residual at Berwick Creek source area. However, DNAPL within low permeability zones within the shallow aquifer may not be effectively treated and could provide a future source of dissolved PCE to groundwater. • Periodic groundwater and system sampling together with follow-up soil sampling could be used to readily monitor effectiveness. • Short-term (2 to 5 years) post-treatment monitoring would be required to insure that treatment was successful and to monitor the migration of remaining site plume.	• The PRB containment alternative would meet the RAO of preventing the downgradient migration of PCE in groundwater. • Alternative 4 would meet the RAOs by removing the constant source of PCE dissolving to groundwater and surface water. • Containment under Alternative 4 would be effective in the long term, because it would cut off the constant source of PCE dissolving to downgradient groundwater. • Alternative 5 would not effectively treat aquifer soils that contain DNAPL. These soils would be a continuing source of PCE into the groundwater. • Because PCE would remain untreated at HRIA source area, the PRB wall would have to remain in place and functional for the foreseeable future (at least 30 years). • Replacement or rejuvenation of the PRB could be required after 15 years, if significant fouling or loss of reactivity occurs. Technologies for in-situ rejuvenation are not well developed. • The results of the conventional chemistry analyses indicate the geochemistry of the site is favorable and indicates a low potential for precipitate fouling. • Containing the constant source of PCE would reduce the time for overall aquifer restoration downgradient of the PRB wall. • DNAPL in groundwater and aquifer soil would not be effectively treated.	• Hydraulic containment would meet the RAOs by minimizing the downgradient migration of PCE in groundwater and reducing the leaching of PCE from creek bed silt to surface water and groundwater. • Alternative 5 would meet the RAOs by removing the constant source of PCE dissolving to groundwater and surface water. • Alternative 5 would not effectively treat aquifer soils that contain DNAPL. These soils would be a continuing source of PCE into the groundwater. • Pump and treat technology is not highly effective at removing DNAPL, although close well spacing maximizes its effectiveness. • Periodic groundwater sampling would be used to readily monitor effectiveness of the hydraulic containment. Monitoring would be necessary to ensure that containment was maintained. • Containing the constant source of PCE would reduce the time for overall aquifer restoration downgradient of the PRB wall. • With no additional remedial action, it is estimated that it may take over 30 years to treat the contamination using hydraulic containment and ex-situ treatment. • Alternative 5 would contribute to the probable future remedial actions since DNAPL would not be effectively treated. • Long-term monitoring (30-years)

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		• Periodic groundwater and system sampling together with follow-up soil sampling could be used to monitor the effectiveness of this alternative. • Short-term (2 to 5 years) post-treatment monitoring would be required to insure that treatment was successful and to monitor the migration of remaining site plume.		• With no additional remedial action, it is estimated that it may take over 30 years to treat the contamination PRB technology. • Long-term monitoring (30-years) would be required following PRB installation to ensure effectiveness and to monitor the migration of remaining site plume.	would be required during operation of the hydraulic containment system to ensure effectiveness and to monitor the migration of remaining site plume.
Reduction of Toxicity, Mobility, or Volume Through Treatment	• Since no remedial action would occur, there would be no reduction in toxicity, mobility, or volume of PCE in affected media.	• Alternative 2 would reduce the toxicity and volume of PCE by removing dissolved PCE and PCE DNAPL from creek bed silt, aquifer soil, and groundwater within the treatment zone. • ERH with vapor extraction is the only in-situ technology that would effectively reduce the toxicity and volume of PCE NAPL within all media at the HRIA/Berwick Creek source area. • The mobility of dissolved PCE and PCE DNAPL would also be reduced through proper design of the vapor extraction system. ERH may temporarily increase PCE mobility if vapor extraction is not properly designed or implemented. • ERH could potentially increase the toxicity in the short term by enhancing the chemical breakdown of PCE to TCE and vinyl chloride, which are more toxic. • This alternative would reduce the toxicity, mobility, and volume of PCE in Berwick Creek by physically removing the contaminated silts from the creek bed/banks that as a source of PCE to surface water.	• Alternative 3 would reduce the toxicity and volume of PCE in groundwater by 1) chemically degrading dissolved PCE and DNAPL within the treatment zone to innocuous compounds, and 2) excavating and off-site disposal of contaminated silt that is leaching PCE to groundwater. • ISCO would not directly affect the mobility of PCE in groundwater. • Potential for residual contamination in low-permeability materials (i.e., silt/clay) where present in the aquifer, leaving a potential PCE source material untreated. • This alternative would reduce the toxicity, mobility, and volume of PCE in Berwick Creek by physically removing the contaminated silts from the creek bed that is a source of PCE to surface water. If any PCE-impact silt is missed during excavation, a potential source of PCE to groundwater would remain.	• Alternative 4 would reduce the mobility and volume of PCE in groundwater by 1) cutting off the migration of groundwater containing dissolved PCE, 2) treating PCE-contaminated groundwater in-situ, 3) excavating and off-site disposal of contaminated silt that is leaching PCE to groundwater. • Alternative 4 would reduce the toxicity of PCE passing through the PRB wall by inducing chemical breakdown. • Dissolved PCE and PCE DNAPL immediately upgradient of the PRB wall would remain and would not be reduced in toxicity or volume. • The reaction occurring in the wall has the potential to create more toxic breakdown compounds. Design or construction errors, however, could result in more toxic breakdown products migrating downgradient of the wall. • The wall thickness would be designed to achieve nearly complete breakdown of the PCE passing through it. • Alternative 4 would reduce the toxicity, mobility and volume of PCE in Berwick Creek by physically removing the contaminated silts from the creek bed that is a source of PCE to surface water.	• Alternative 5 would reduce the mobility and volume of PCE in groundwater by 1) cutting off the migration of groundwater containing dissolved PCE, 2) treating PCE-contaminated groundwater, 3) excavating and off-site disposal of contaminated silt that is leaching PCE to groundwater. • This alternative would not reduce the toxicity of PCE remaining in the subsurface. • Alternative 5 would be only moderately effective at PCE mass reduction, especially related to DNAPL. • This alternative would reduce the volume of PCE in the groundwater through the physical removal of PCE followed by ex-situ treatment. • Alternative 5 would reduce the toxicity, mobility and volume of PCE in Berwick Creek by physically removing the contaminated silts from the creek bed that is a source of PCE to surface water. • Potential for residual contamination in low-permeability materials (i.e., silt/clay) if present in subsurface.
Short-Term Effectiveness	• Since no remedial action would occur, there would be no short-term risks.	• The community and the environment would be protected during completion by the use of site control and traffic control during construction, placement of the system infrastructure primarily on unused public land away from current public use, and fencing of treatment area and	• The community and the environment would be protected during completion by the use of site control and traffic control during construction, placement of the system infrastructure primarily on unused public land away from current public use, below ground installation of the injection wells where necessary.	• The community and the environment would be protected during completion by the use of site control and traffic control during construction. • The PRB alternative would be effective in the short term. Containment would	• The community and the environment would be protected during completion by the use of site control and traffic control during construction, placement of the system infrastructure primarily on unused public land away from current public use, burial of system

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		infrastructure. • The ERH system is anticipated to have the greatest short-term effectiveness with respect to meeting remedial action objectives. Aquifer soils, groundwater and creek bed sediment RAOs would be met within 4 to 6 months. • Health risk to workers performing remedial and monitoring activities can be mitigated through proper health and safety measures such as traffic control, worker PPE, air monitoring, and limited access to the aboveground treatment system/power delivery stations. • Moderately effective in the short term. The full benefit of treatment using ERH would not be realized for approximately 6 months after beginning of on-site action. • ERH could potentially increase the toxicity in the short term by enhancing the chemical breakdown of PCE to TCE and vinyl chloride, which are more toxic.	• ISCO would be moderately effective in the short term. The full benefit of treatment using ISCO would not be realized immediately because multiple injection events may be required to address the PCE DNAPL. • Health risk to workers performing remedial and monitoring activities can be mitigated through proper health and safety measures. • ISCO is anticipated to have the moderate short-term effectiveness with respect to meeting remedial action objectives. Groundwater and creek bed sediment RAOs would be met within 3 to 4 months. Aquifer soils may require a longer timeframe based on the effectiveness of DNAPL treatment, especially in low permeability soils.	begin immediately after the wall construction was completed, with treatment beginning following full degradation of the trench slurry. • Construction of the wall would require approximately 1 month, including breakdown of the bioslurry. • Health risk to workers performing remedial and monitoring activities can be mitigated through proper health and safety measures. • It is estimated that it may take over 30 years to achieve remedial action objectives using PRB technology.	infrastructure, and fencing of treatment infrastructure. • The hydraulic containment alternative would be effective in the short term. Hydraulic containment would be achieved within a few hours of starting the pumping system. • Health risk to workers performing remedial and monitoring activities can be mitigated through proper health and safety measures. • It is estimated that it may take over 30 years to to achieve remedial action objectives using hydraulic containment and ex-situ treatment.
Implementability	• Since no remedial action would occur, there would be no technical, administrative, or other obstacles to implementability.	• ERH is technically and administratively feasible. However, very few vendors are able to provide this proprietary technology. • Implementation would require a 12-month diversion of Berwick Creek designed to accommodate fish passage. • ERH technology has been successfully completed at nearby Fort Lewis. Per discussions with the vendor providing ERH for Fort Lewis, it is predicted that the implementation would be similar (though on a smaller scale) for the Hamilton/Labree Site. • The necessary electric power and wires are located near the site. A new transformer would need to be installed to supply the necessary power for soil heating. • A pilot test would be conducted in the source area as part of the overall treatment process. • Short-term (2 to 5 years) monitoring would	• ISCO is technically and administratively feasible. Chemical oxidation technology is well established and could be implemented at the site. • Multiple injection events will be required because of presence PCE as DNAPL. • Although some preferential flow pathways clearly exist beneath the site, the sand and gravel soils of the shallow aquifer are more homogeneous than soils at many sites. This indicates that the soil conditions beneath the site are generally favorable for chemical oxidation. • Generation of gas resulting from oxidation of PCE vapor may be an issue due to the presence of the silt layer above the shallow aquifer • The density of the sand and gravel aquifer may present a challenge to a large-scale Geoprobe program. A hollow-stem auger rig may be required to install injection points. • A source of water needed for injection of oxidant would bee to be determined.	• PRB containment is technically and administratively feasible. PRB technology has been implemented at over 100 sites around the world and performance data are available for PRB walls as old as 10 years. • Excavation and off-site disposal of the contaminated silt can be accomplished using standard construction techniques and equipment. • The necessary materials and services for implementing Alternative 4 are available, although the PRB technology is proprietary and a license fee is required. • Although trenching for wall installation would be deep at the HRIA, the installation depth would not be unprecedented. • The competent aquitard at the base of the shallow aquifer provides a laterally continuous low permeability stratum to key into at the base of the PRB wall.	• Hydraulic containment is technically and administratively feasible. Pump and treat technology is well established and could be readily implemented at the site. • Recovery wells currently exist at the site in excellent locations for implementation of hydraulic containment, and no new wells would are expected to implement this alternative. • Detailed design would be required to assess the level of uncertainty with the expected capture zone and confirm the adequacy of the existing well network. • Excavation and off-site disposal of the contaminated silt can be accomplished using standard construction techniques and equipment. • URS previously completed design of a hydraulic containment system for the

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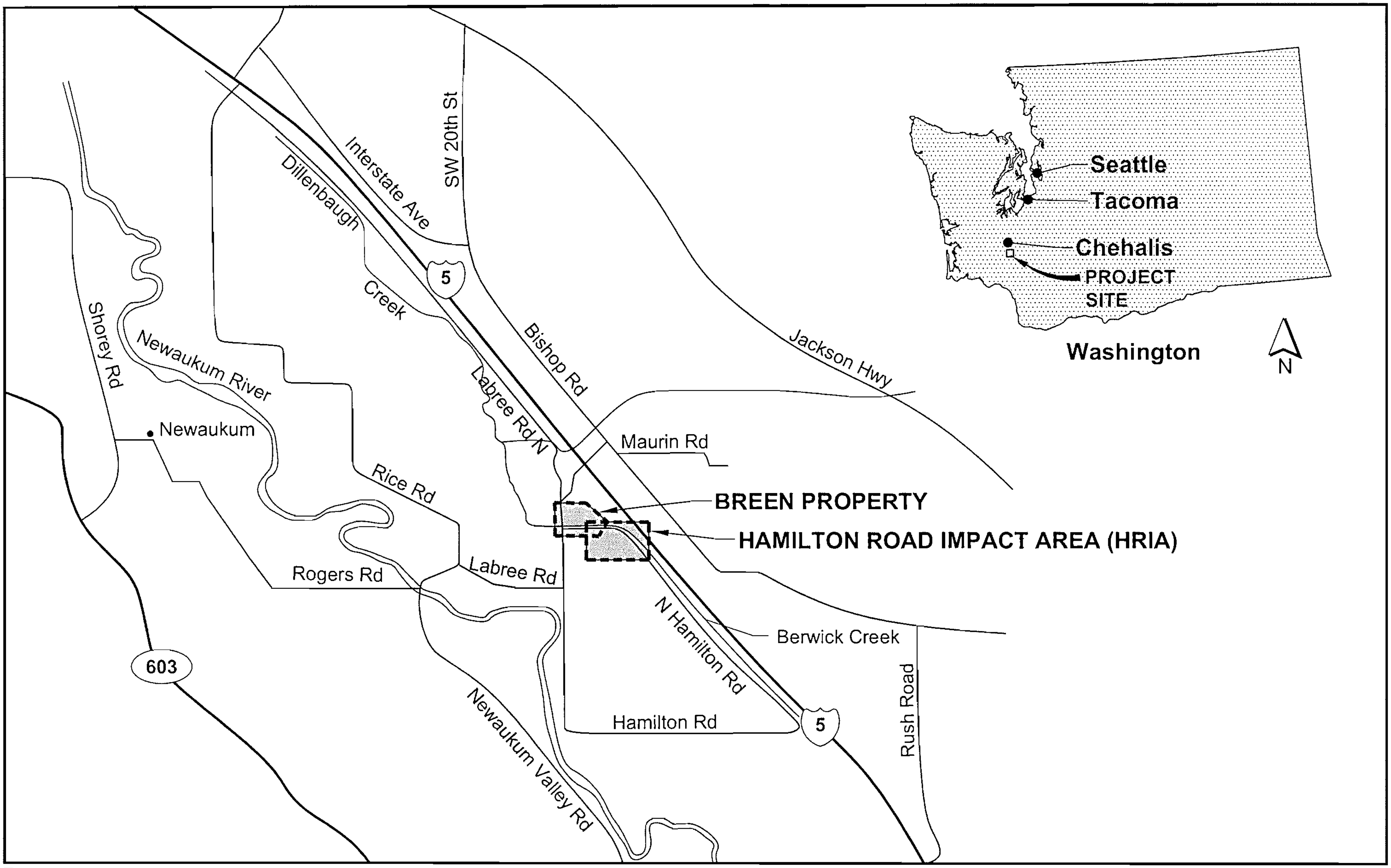
		be required following completion of ERH.	• Excavation and off-site disposal of the contaminated silt can be accomplished using standard construction techniques and equipment. • A pilot test would be conducted in the source area as part of the overall treatment process. • Short-term (2 to 5 years) monitoring would be required following ISCO treatment.	• Long-term monitoring (30-years) would be required following PRB installation.	HRIA. • The groundwater extraction system could also be expanded to allow capture of a larger portion of the site-wide plume, if necessary. • Long-term monitoring (30-years) would be required during operation of the hydraulic containment system.
Cost	• There is no cost associated with this remedial alternative.	Total Capital Cost = $2,140,000 Total Implementation Cost = $3,790,000 TOTAL PRESENT WORTH = $4,500,000	Total Capital Cost = $1,960,000 Total Implementation Cost = $2,560,000 TOTAL PRESENT WORTH = $3,270,000	Total Capital Cost = $3,420,000 Total Implementation Cost = $3,500,000 TOTAL PRESENT WORTH = $4,330,000	Total Capital Cost = $1,600,000 Total Implementation Cost = $1,820,000 TOTAL PRESENT WORTH = $5,070,000
State Acceptance	• The No Action alternative is not anticipated to meet State acceptance. • To be addressed in the ROD.	• To be addressed in the ROD.	• To be addressed in the ROD.	• To be addressed in the ROD.	• To be addressed in the ROD.
Community Acceptance	• The No Action alternative is not anticipated to meet community acceptance. • To be addressed in the ROD.	• To be addressed in the ROD.	• To be addressed in the ROD.	• To be addressed in the ROD.	• To be addressed in the ROD.

FIGURES



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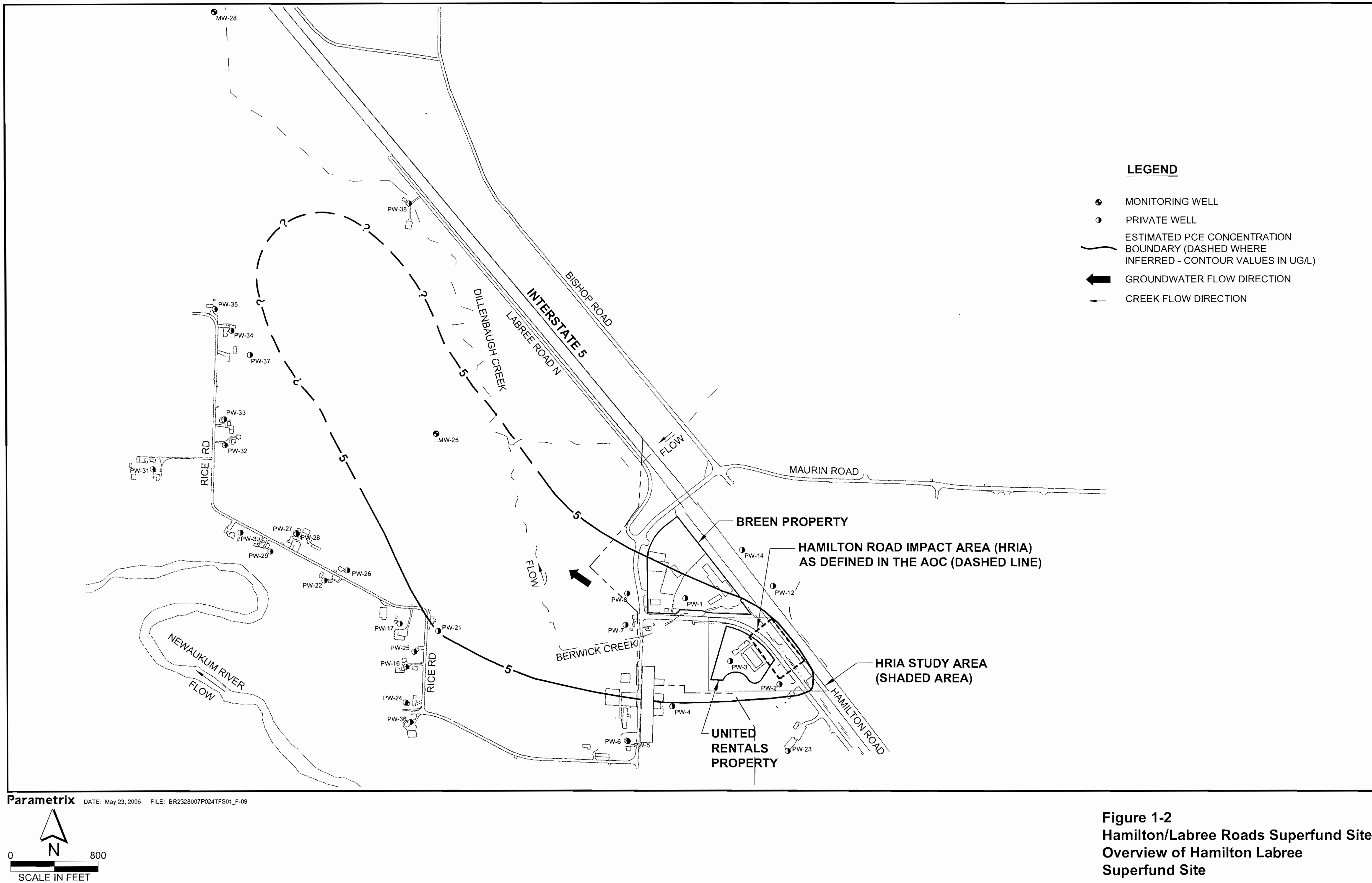
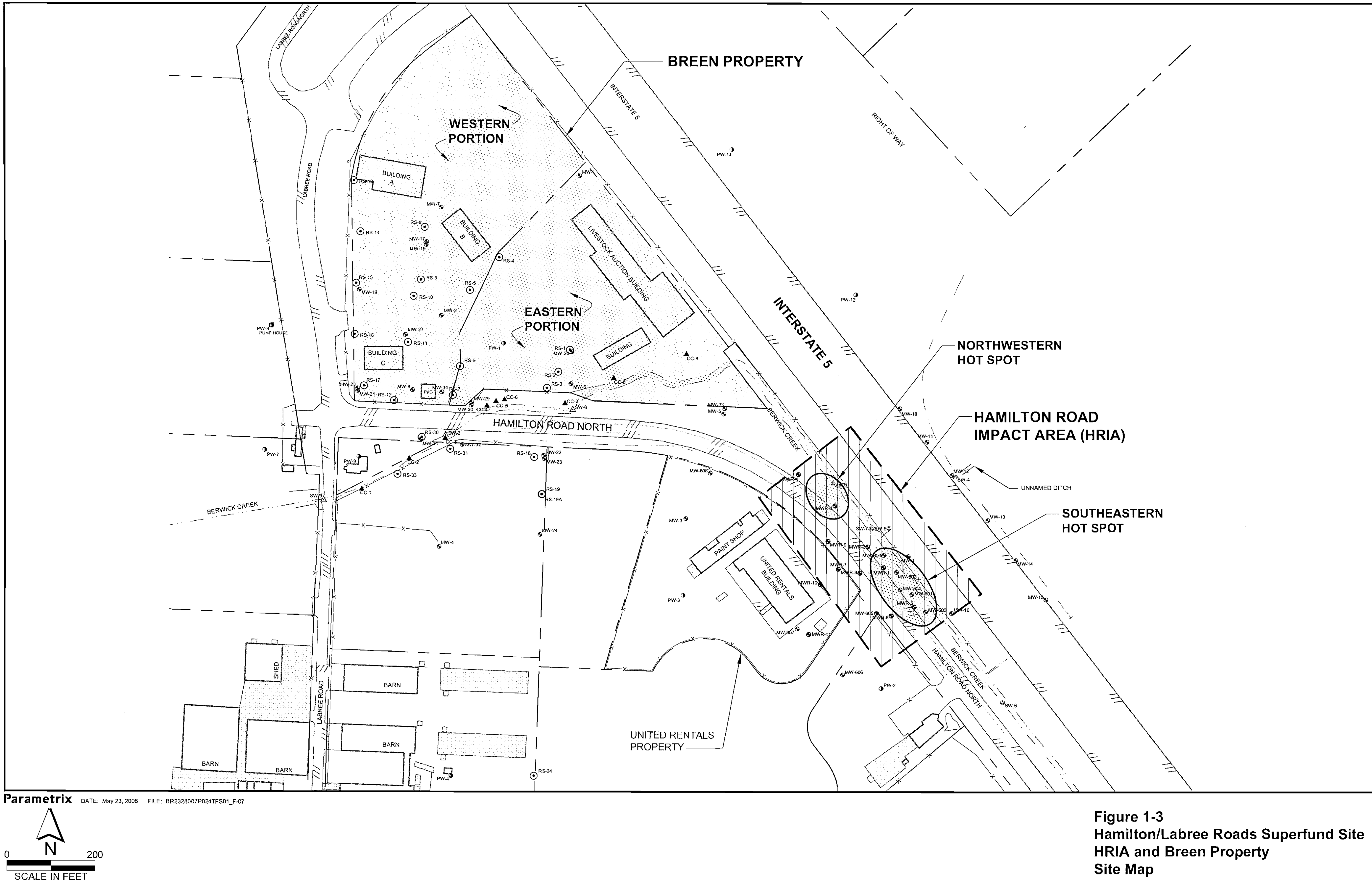
SCALE IN FEET

Figure 1-1
Hamilton/Labree Roads Superfund Site
Site Location Map



Parametrix DATE: May 23, 2006 FILE: BR2328007P024TFS01_F-09

Figure 1-2
Hamilton/Labree Roads Superfund Site
Overview of Hamilton Labree Superfund Site



Parametrix DATE: May 23, 2006 FILE: BR2328007P024TFS01_F-07

Figure 1-3
Hamilton/Labree Roads Superfund Site
HRIA and Breen Property
Site Map

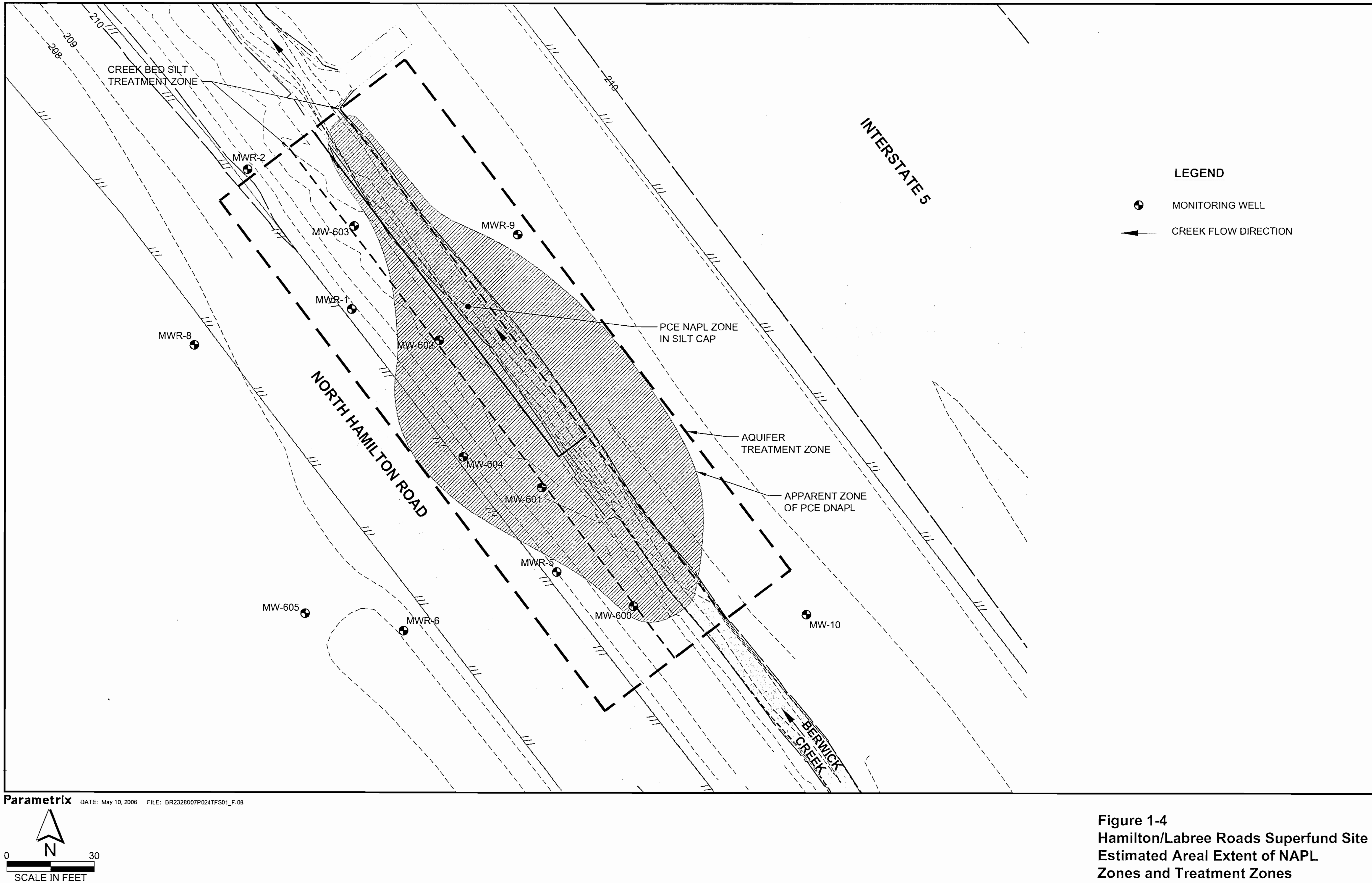
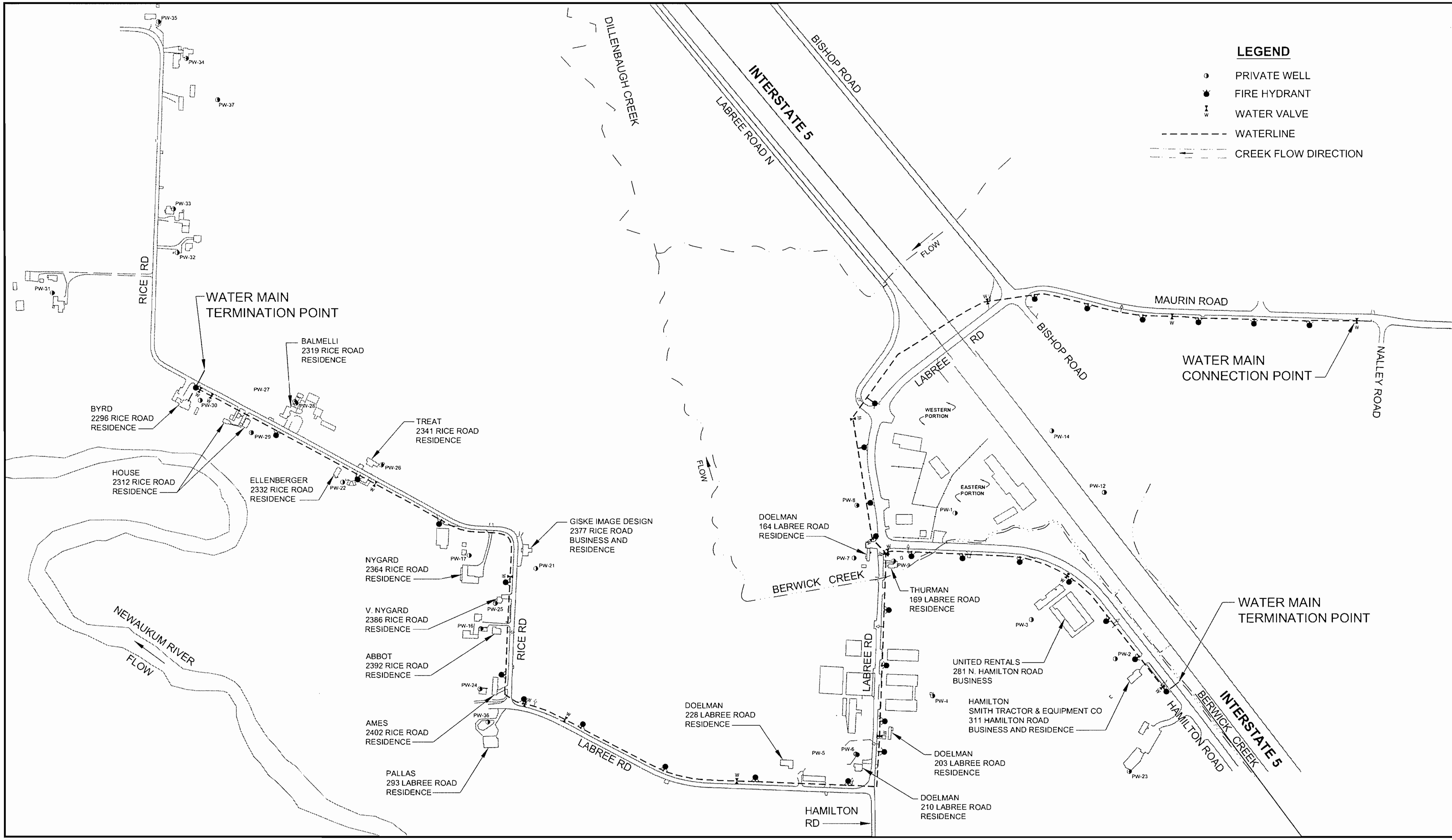


Figure 1-4
Hamilton/Labree Roads Superfund Site
Estimated Areal Extent of NAPL Zones and Treatment Zones



Parametrix DATE: May 18, 2006 FILE: BR2328007P024TRR01_F-06

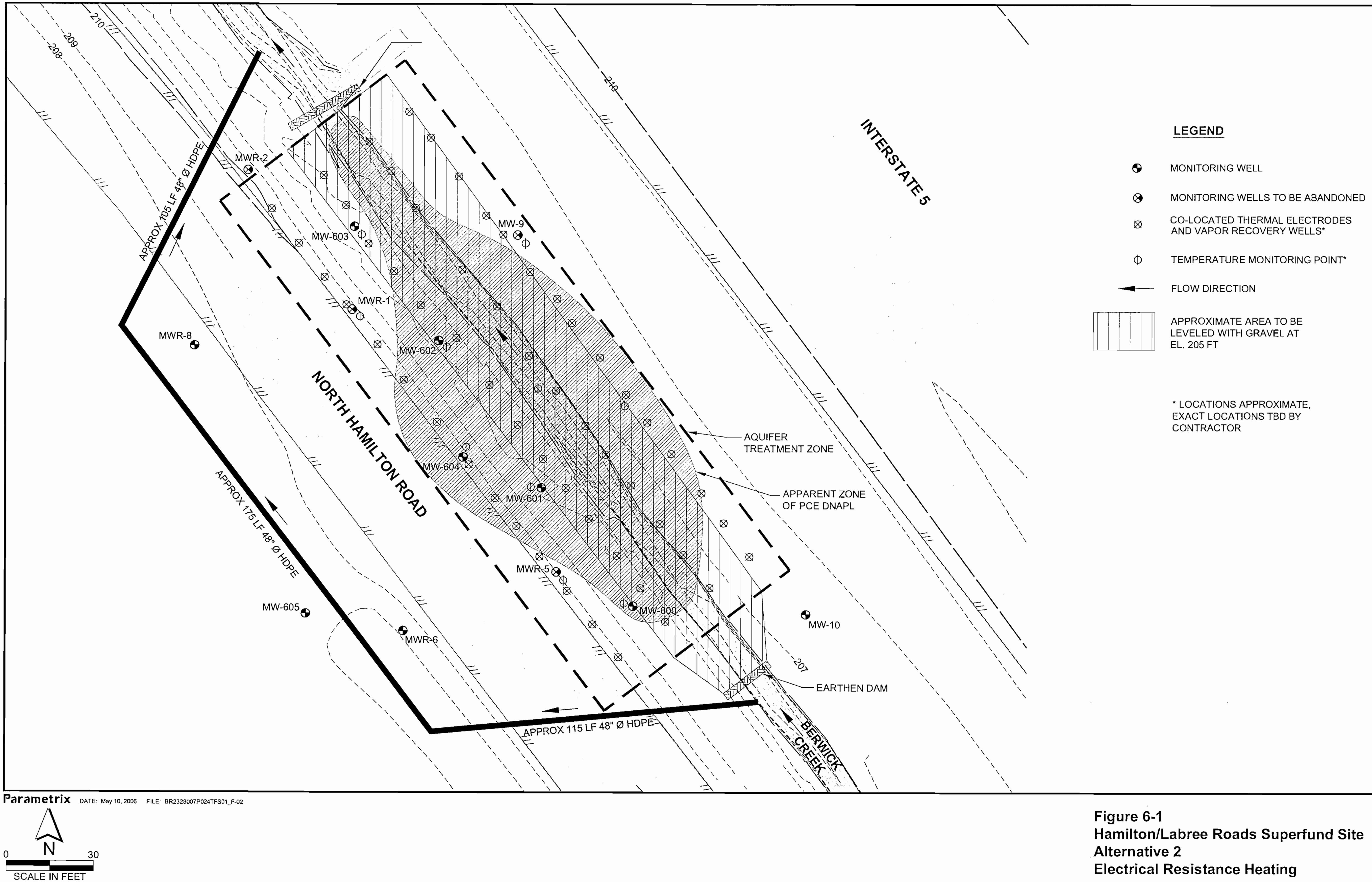
N

0 500

SCALE IN FEET

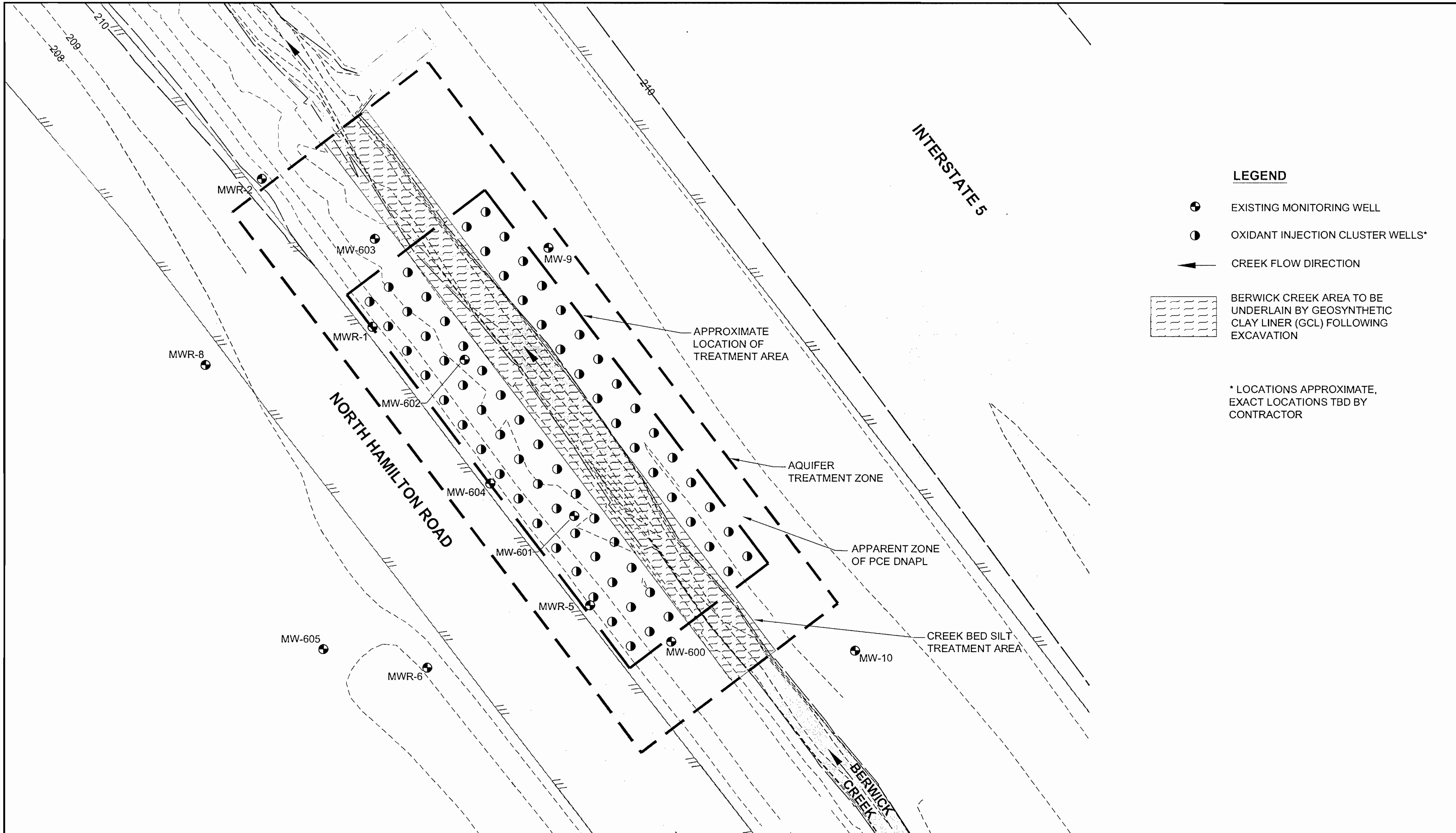
Source: Ecology and Environment, Inc. (2002)

Figure 1-5
Hamilton/Labree Roads Superfund Site
Water Supply Line



Parametrix DATE: May 10, 2006 FILE: BR2328007P024TFS01_F-02

Figure 6-1
Hamilton/Labree Roads Superfund Site
Alternative 2
Electrical Resistance Heating



Parametrix DATE: May 10, 2006 FILE: BR2328007P024TFS01_F-04

N

0 30

SCALE IN FEET

Figure 6-2
Hamilton/Labree Roads Superfund Site
Alternative 3
Chemical Oxidation

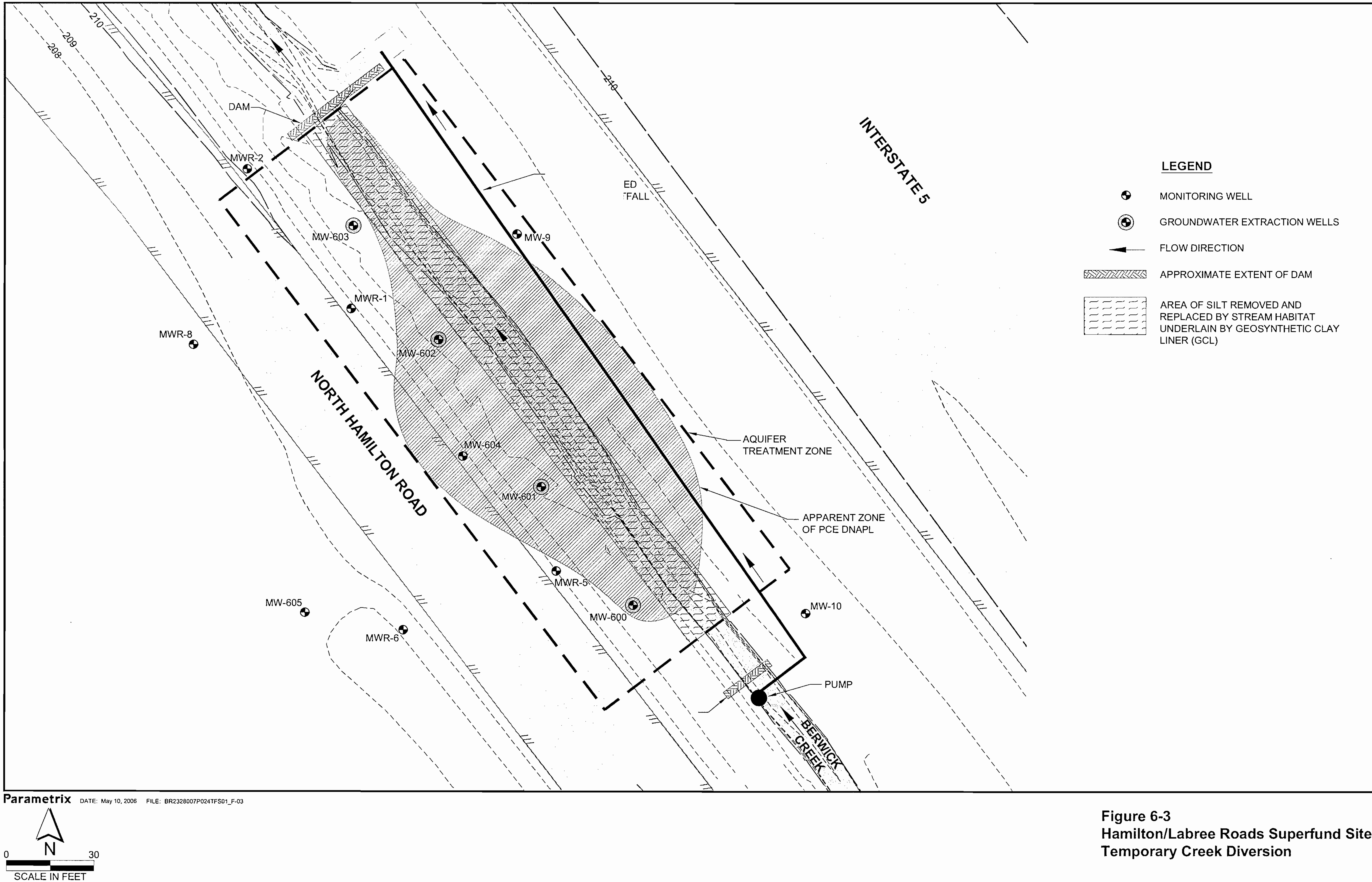
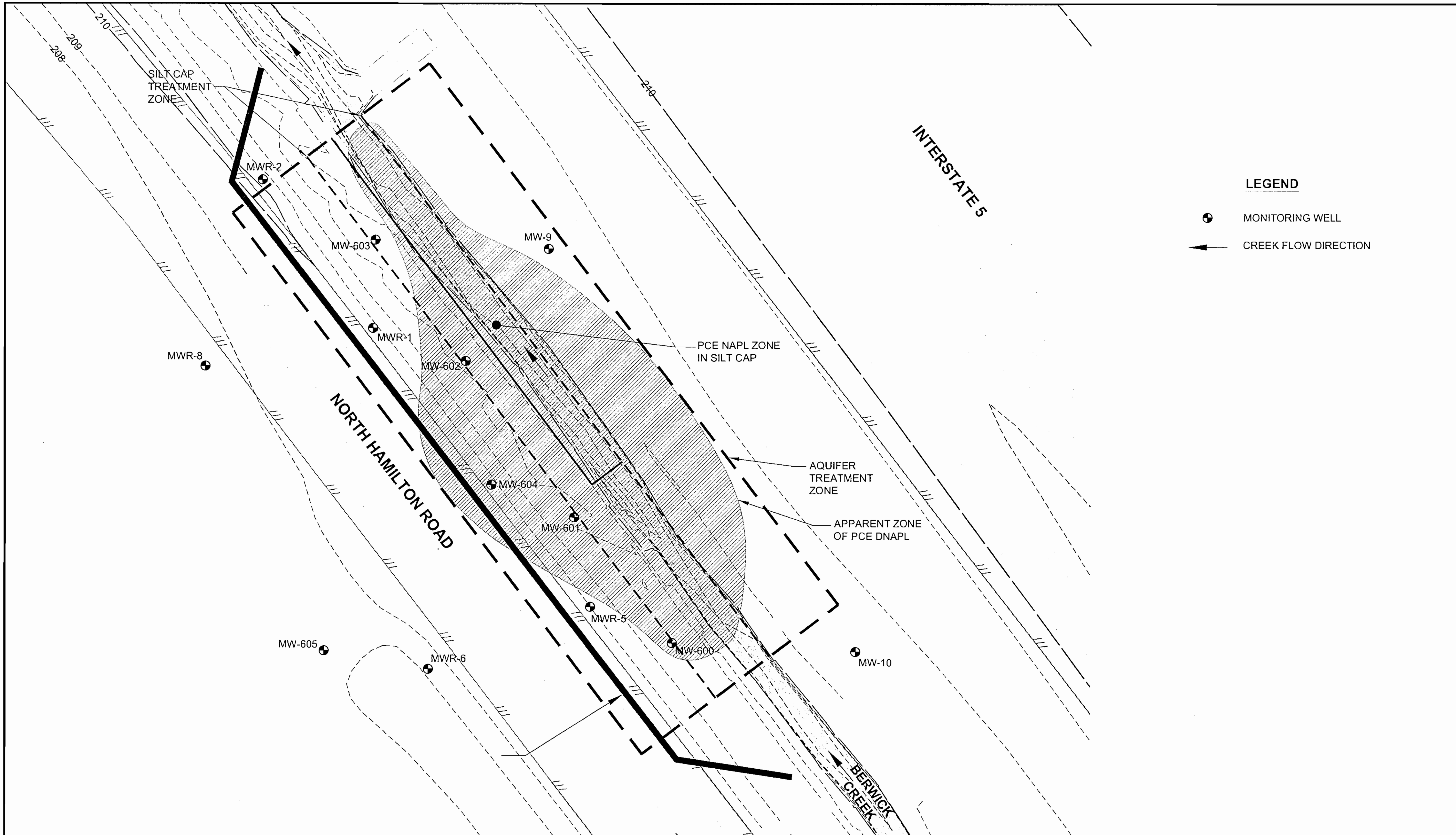


Figure 6-3
Hamilton/Labree Roads Superfund Site
Temporary Creek Diversion

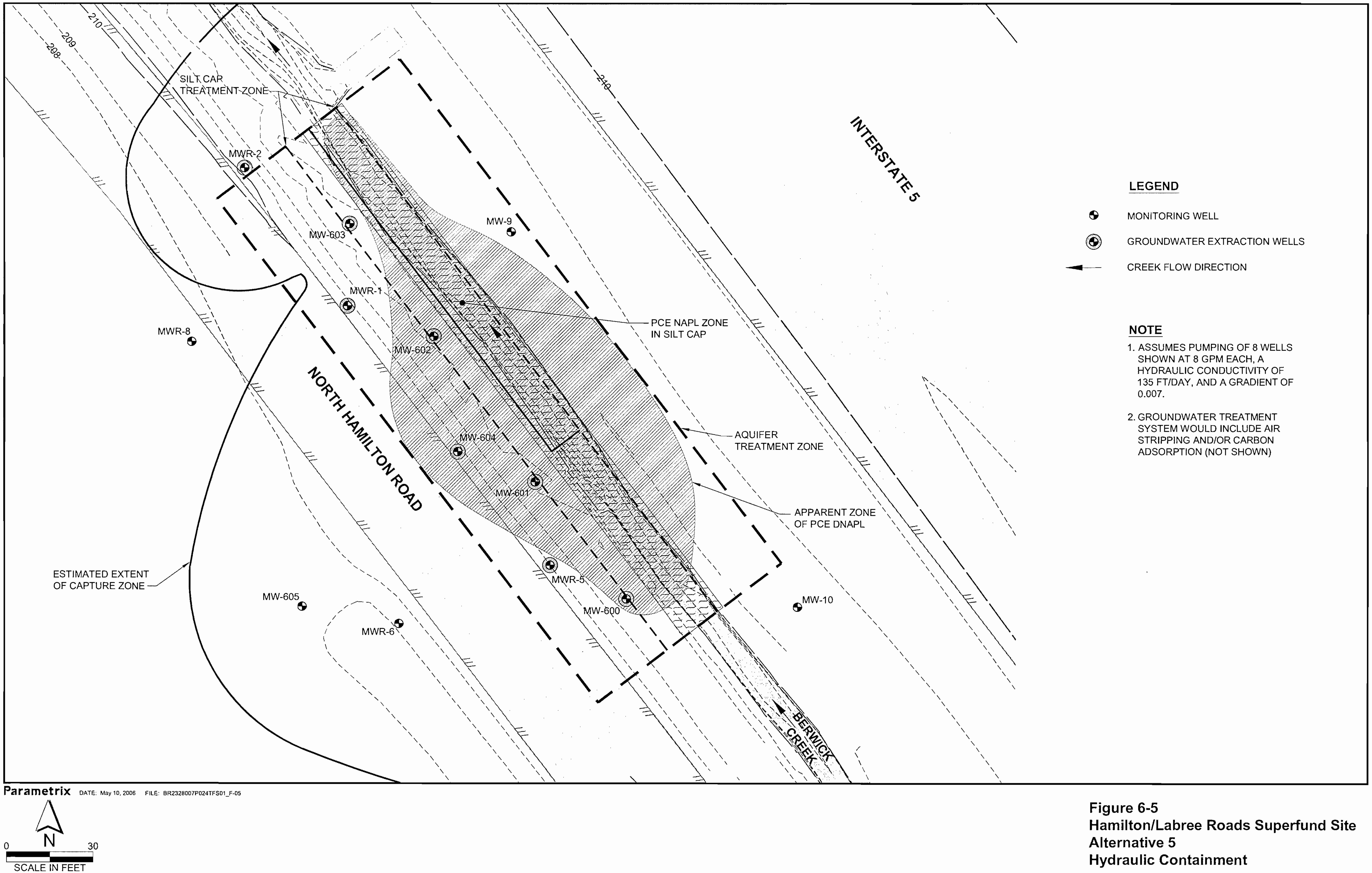


Parametrix DATE: May 10, 2006 FILE: BR2328007P024TFS01_F-06

N

0 30
SCALE IN FEET

Figure 6-4
Hamilton/Labree Roads Superfund Site
Alternative 4
Permeable Reactive Barrier Containment

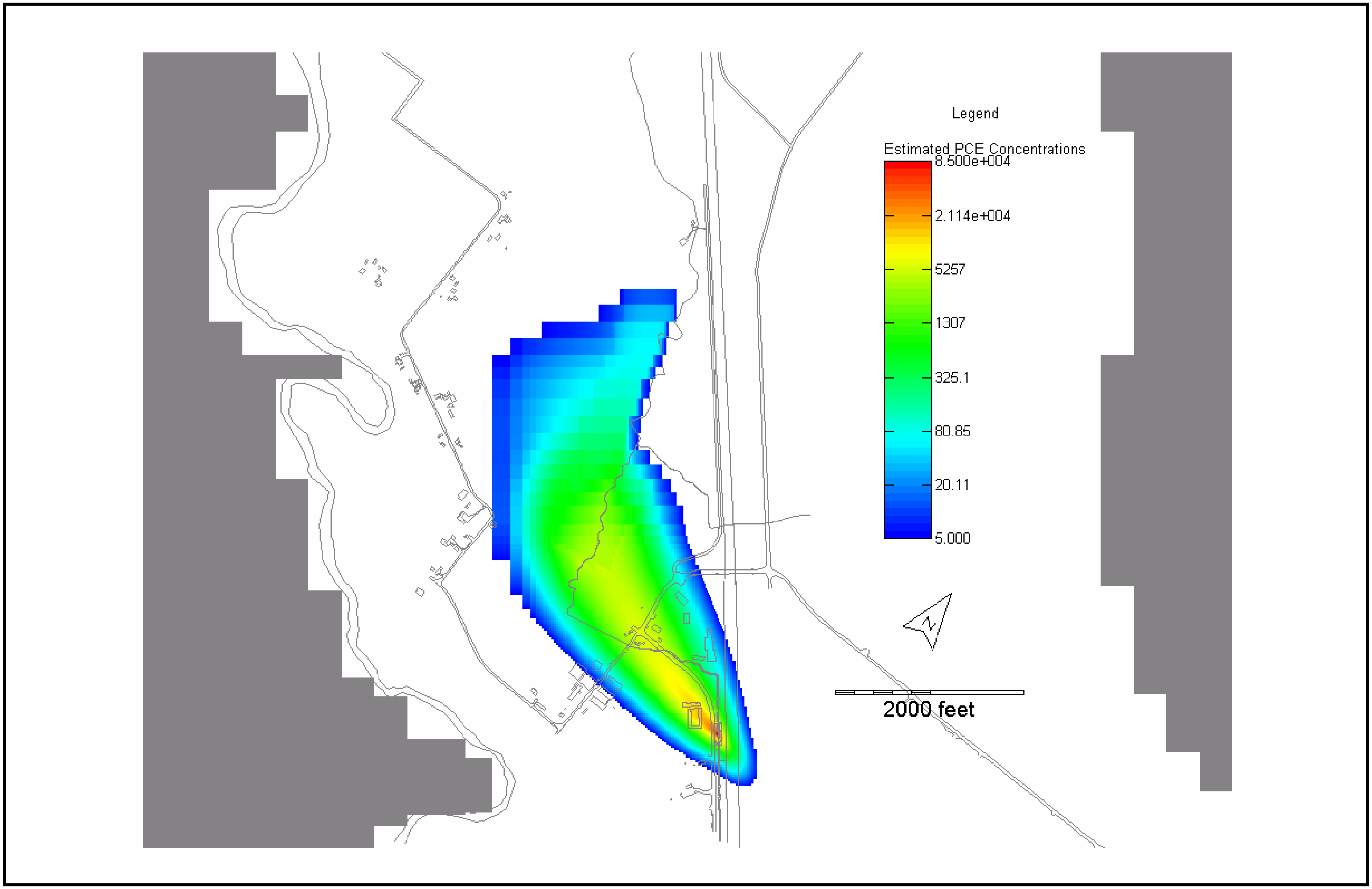


Parametrix DATE: May 10, 2006 FILE: BR2328007P024TFS01_F-05

Figure 6-5
Hamilton/Labree Roads Superfund Site
Alternative 5
Hydraulic Containment

APPENDIX A

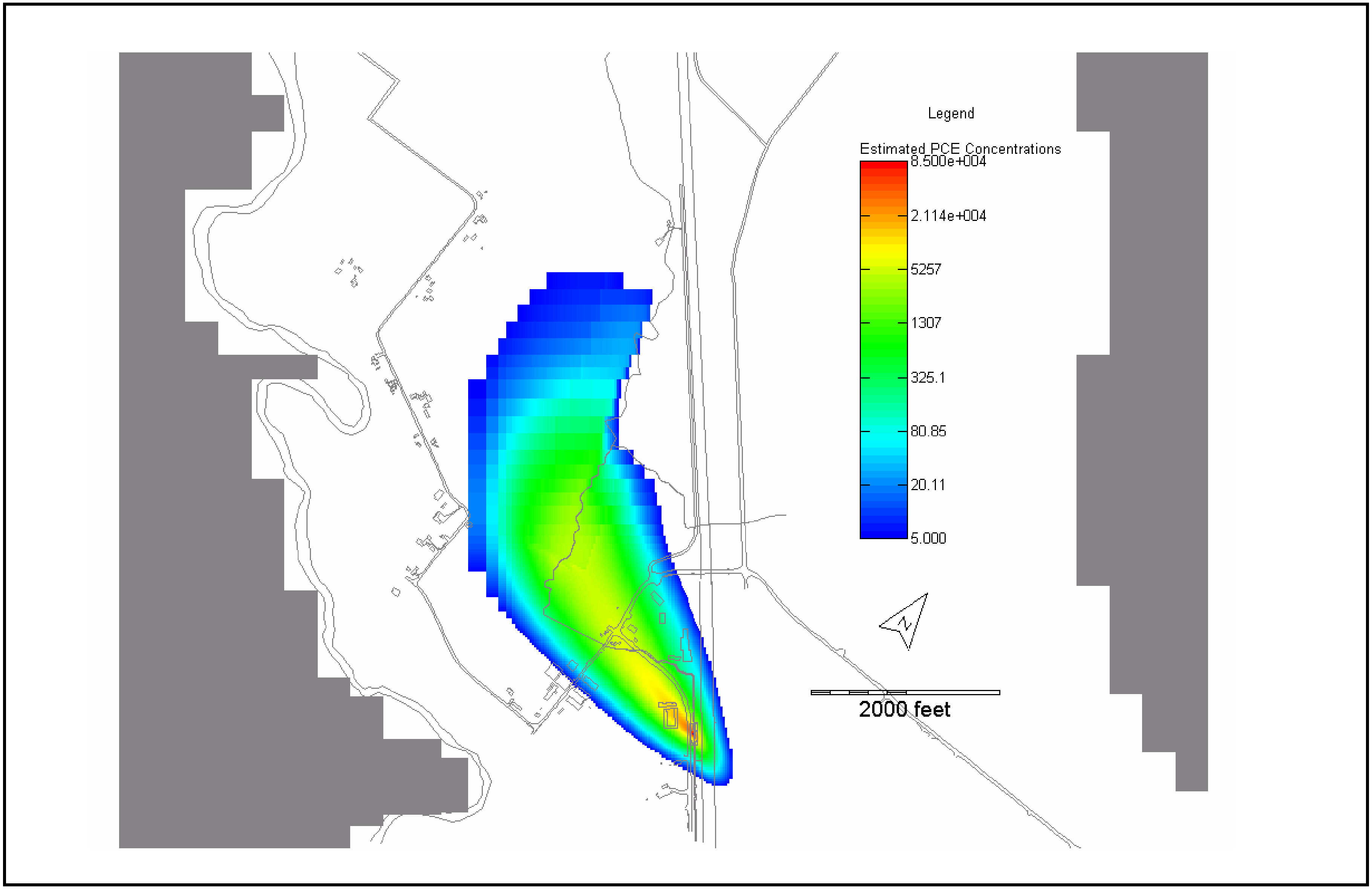
Groundwater Model



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

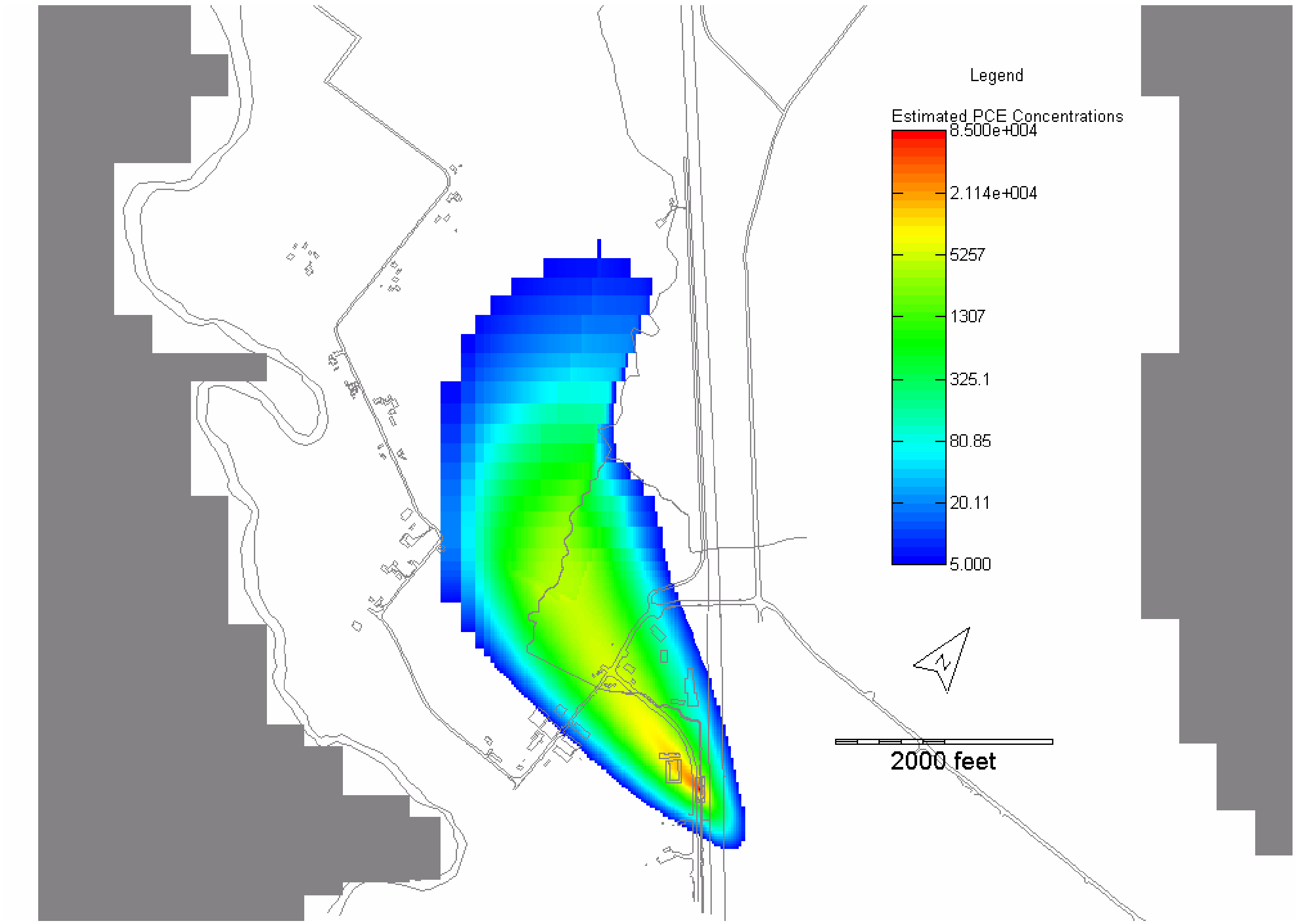
Figure 4-4
Estimated PCE Plume
No Action – 10 Years



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

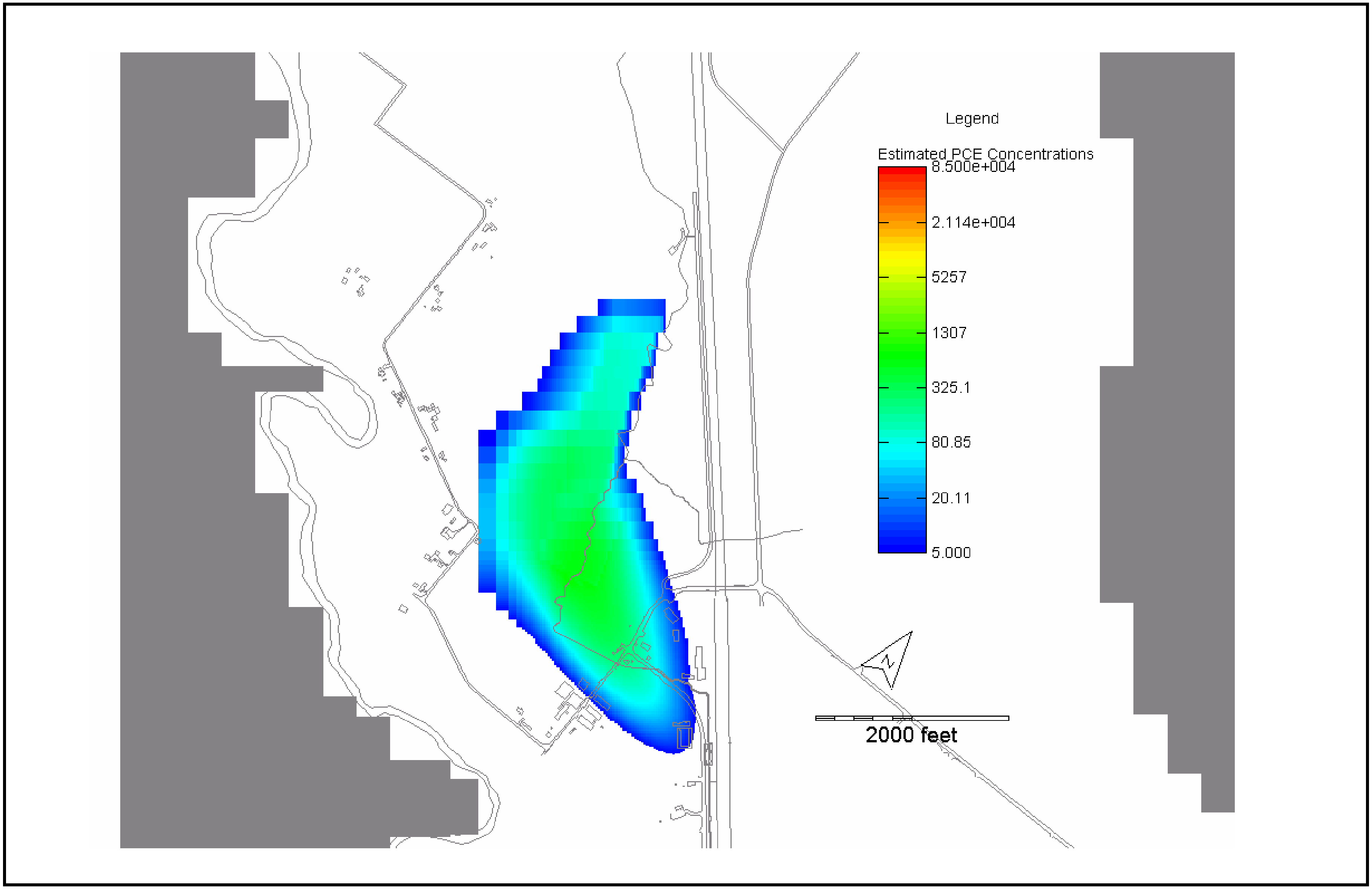
Figure 4-5
Estimated PCE Plume
No Action – 20 Years



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

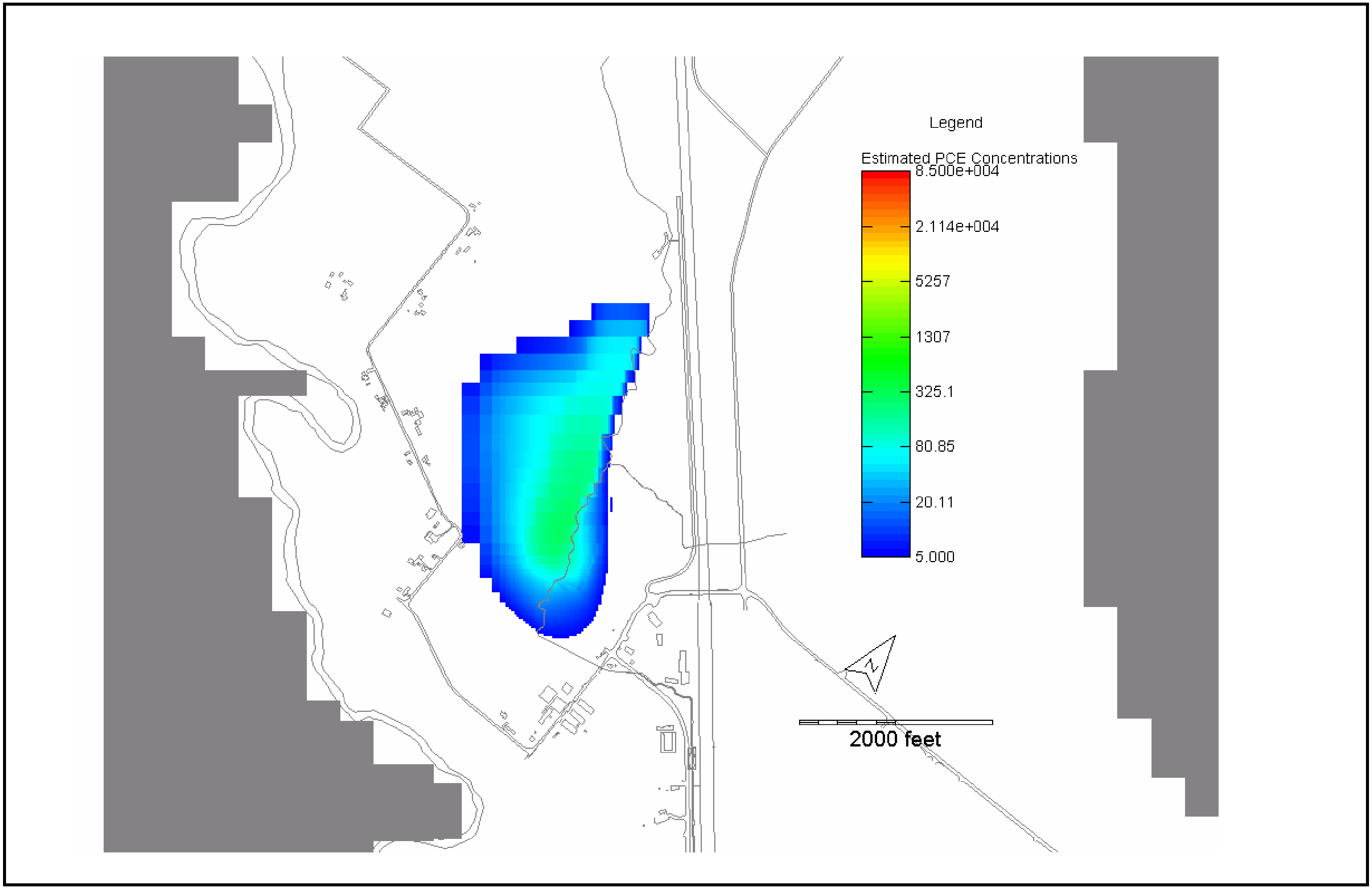
Figure 4-6
Estimated PCE Plume
No Action – 30 Years



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

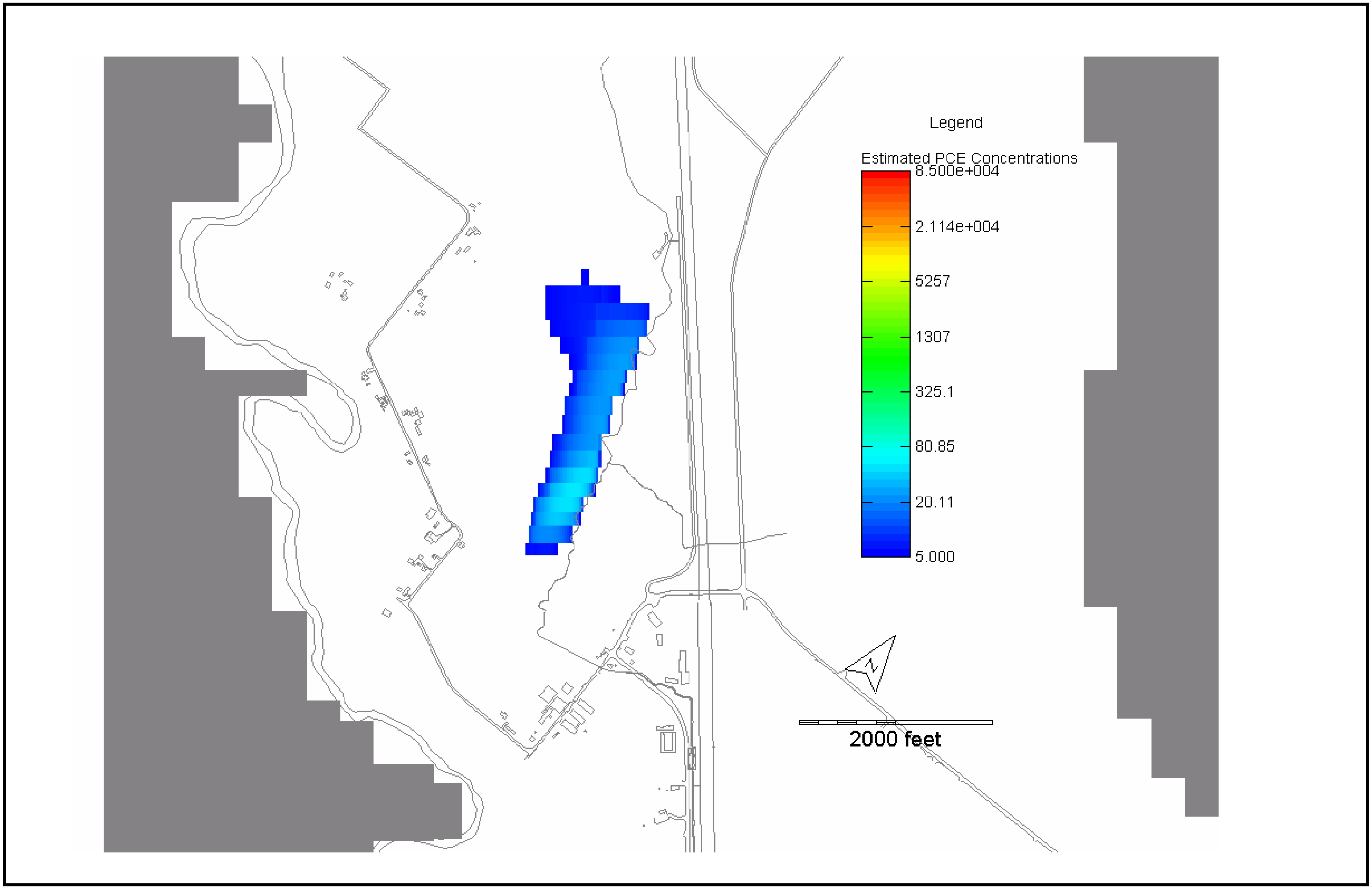
Figure 4-7
Estimated PCE Plume
Source Removal – 5 Years



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

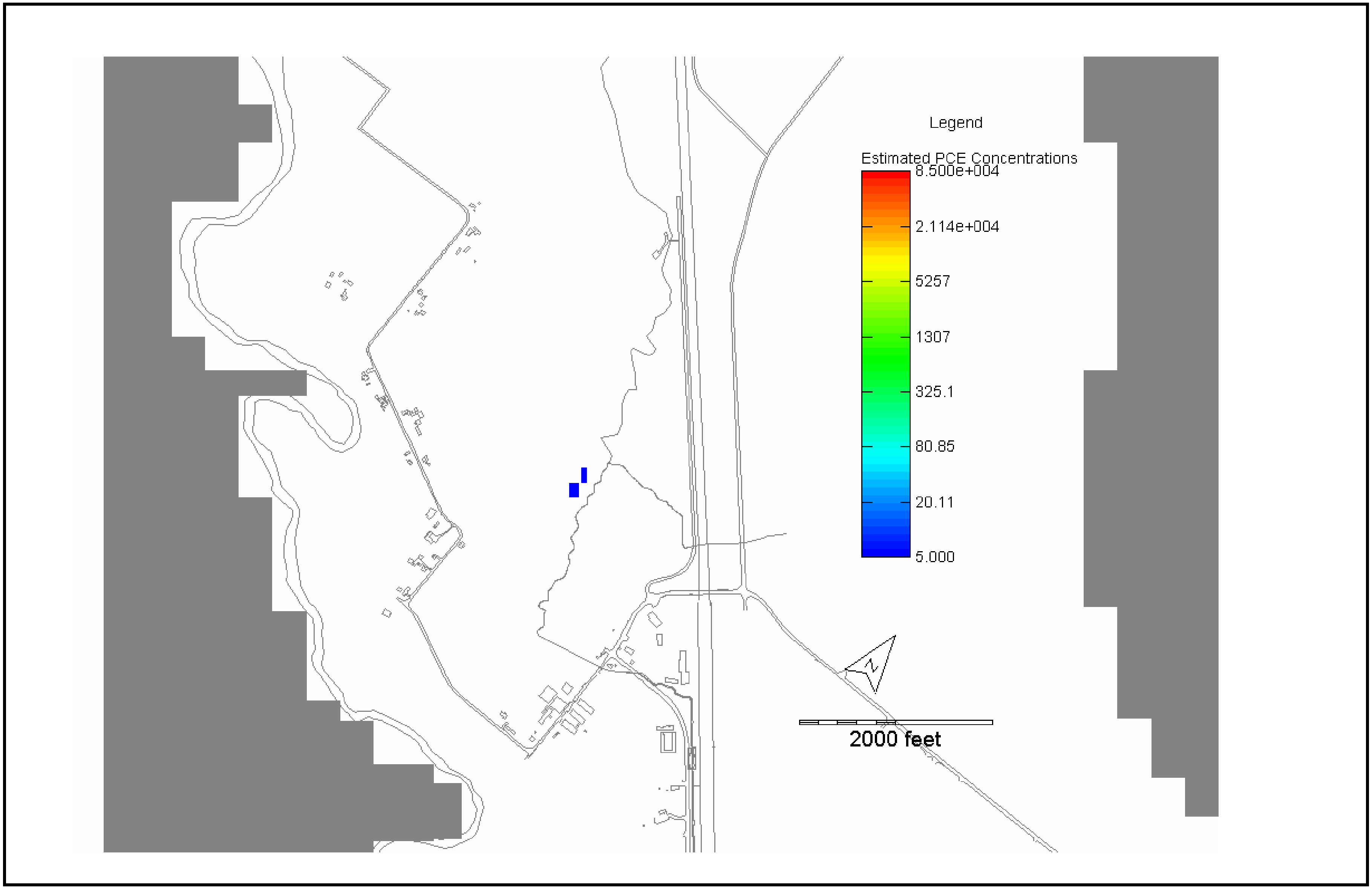
Figure 4-8
Estimated PCE Plume
Source Removal – 10 Years



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 4-9
Estimated PCE Plume
Source Removal – 20 Years



CDM

Hamilton-Labree Roads Superfund Site
Chehalis, Washington

Figure 4-10
Estimated PCE Plume
Source Removal – 30 Years

APPENDIX B

Detailed Cost Estimates and Supporting Information

Alternative 2 - Electrical Resistance Heating

Description	Quantity	Unit	Unit Costs ($)	Costs ($)	Source	Notes
DIRECT CAPITAL COSTS						
Long-Term Creek Diversion/Site Prep						
Mobilization/demobilization	1	ls	20,000	20,000	Misc. Projects	Roughly 8% total cost for activity
Fish roundup	1	day	3,500	3,500	Bob Sullivan	2 Staff ($80/hr), 10 hr days, plus equipment $400
Dewatering pump/hose	2	wk	5,700	11,400	Means 2006	6" trash and hose, operator (24 hoursx7daysx$30hr)
Berm construction	1	ls	14,000	14,000	Engineer's Estimate/PA Pond Berm Bid	For dams at both ends of creek
Import for berm	65	cy	20	1,300	PA Pond Brem	
48-inch diameter HDPE	340	lf	105	35,700	Means 2006	48" Corrugated HDPE ($75/lf), trenching and bedding ($30/lf)
Road crossings	60	sy	54	3,240	Means 2006	4" asphaltic concrete pavement replacement ($45/SY) plus removal ($9/SY)
Traffic control during installation/removal	1	ls	2,500	2,500	Engineer's estimate	
Long-term traffic control	1	ls	7,500	7,500	Engineer's estimate	
Brushing/fill creek bed/grading	1	ls	7,500	7,500	Means 2006	Dozer to fill
Gravel for creek bed	2,600	tn	22	56,394	Means 2006	Local source, crushed stone
Liner for creek bed	9,600	sf	2	19,200	PA Landfill	80 mil HDPE installed
Remove fill at project completion	1	ls	7,500	7,500	Engineer's Estimate	
Remove diversion piping	1	ls	21,000	21,000	Engineer's Estimate	Remove pipe, fill excavation, replace asphalitic concrete ($54/sy)
Habitat restoration	1	ls	65,000	65,000	Sinclair Inlet Restoration	Based on miscellaneous bid items, riparean restoration
Electrical Resistance Heating Infrastructure:						
Design, work plans, permits by vendor	1	ls	48,000	48,000	TRS Quote	
Well abandonment	4	ea	1,700	6,800	Engineers Estimate	
Probe boring installation and soil sampling	1	ls	172,000	172,000	TRS Quote/Engineer's estimate	includes sampling labor/equipment
Remediation system installation and start-up	1	ls	569,000	569,000	TRS Quote	plus construction oversight
Temp. Fencing	1	ls	22,000	22,000	Means 2006/Engineer's Estimate	around treatment area, 8' chain link
Waste disposal	1	ls	46,000	46,000	TRS Quote/WM Quote	
Electrical utility connection	1	ls	30,000	30,000	TRS Quote	
Well abandonment at project end	67	ea	250	16,750	Thea Foss/Engineer's Estimate	
Demobilization and final report	1	ls	70,000	70,000	TRS Quote	
Subtotal Direct Capital Costs				**1,256,284**		
Direct Capital Cost Contingency (20%)				**251,257**		
Tax (8.8%)				**132,664**		
Total Direct Capital Costs				**1,640,204**		
INDIRECT CAPITAL COSTS						
Engineering pre-design (3% of DCC)	3	%	1,640,204	49,000	Engineers Estimate	Pilot study, bench scale study, surveying
Engineering design (6% of DCC)	6	%	1,640,204	98,000	Engineers Estimate	
Regulatory compliance (2% DCC)	2	%	1,640,204	33,000	Engineers Estimate	Institutional controls, interaction with agencies, etc.
Construction management (5% DCC)	8	%	1,640,204	131,000	Engineers Estimate	
As-built documentation, O&M plan, monitoring plan	1	ls	35,000	35,000	Engineers Estimate	
Total Indirect Capital Costs				**346,000**		
TOTAL CAPITAL COSTS				**1,990,000**		
IMPLEMENTATION O&M COSTS (1 YEAR)						
Construction Dewatering System O&M:						
Water treatment operation	1	mo	10,000	10,000		Assumes half of cost for monthly O&M of system in Alt 4, based on experience during EE/CA investigation.
System electrical usage	1	mo	2,000	2,000		Based on estimated energy usage for equipment included in H2Oil system
Carbon change-outs	2,000	lb	2.00	4,000	Westates	$2/lb - 1 time regen of 2,000 lb system
Electrical Resistance Heating O&M:						
Remediation system operation	1	ls	362,000	362,000	TRS Quote	
Electrical energy usage	1	ls	287,000	287,000	TRS Quote	
Carbon usage, transportation and regeneration	1	ls	50,000	50,000	TRS Quote/Engineer's estimate	
Misc. operational costs (include vapor sampling)	1	ls	50,000	50,000	TRS Quote	
Groundwater sampling	1	ls	27,000	27,000	TRS Quote	Samples to Manchester

Alternative 2 - Electrical Resistance Heating

Description	Quantity	Unit	Unit Costs ($)	Costs ($)	Source	Notes
Management during operating period	10	%	776,000	77,600	Engineers Estimate	
One-time confirmation soil sampling	2	day	3,500	7,000	Misc. project costs/Cascade Quote	Assumes Geoprobe ($2,000/day) for 2 days plus Labor ($75/hr, 10 hr days)x2
Subtotal Implementation O&M Costs				**860,600**		
Implementation O&M Contingency (20%)				**172,120**		
Total Implementation O&M Costs (1 Year of O&M)				**1,032,720**		
TOTAL IMPLEMENTATION COSTS				**3,020,000**		
POSTREMOVAL ACTION PERFORMANCE MONITORING						
Groundwater sampling (semiannual for 5 years)	2	sem	27,000	54,000	Palermo LTM costs	Assumes about 12 wells sampled, analysis by Manchester lab, one report per year
Annual Cost Contingency (15%)				**8,100**		
Total Annual Cost				**62,100**		
Present-Worth Annual O&M (5 years, 5% Discount, multiplier = 4.33)				**268,893**		
TOTAL PRESENT WORTH COSTS				**3,290,000**		

THERMAL REMEDIATION services inc.

Hamilton Labree Remediation Parameters

"TRS guarantees excellence and remediation certainty. Our word is who we are."
www.thermalrs.com

Electrical Resistance Heating Treatment Area:	19,400 sq. ft.	
Average Shallow Extent of ERH:	2 ft	Filling the existing stream bed will deepen the shallow exent.
Average Deep Extent of ERH:	40 ft	
Typical Depth to Groundwater:	8 ft	
Treatment Volume:	27,300 cu yds	
Number of Electrodes:	56	
Electrode Boring Diameter:	12-inch o.d.	
Average Distance Between Electrodes:	20 ft	
Total Depth of Electrodes	42 ft	
Depth to Top of Electrodes	4 ft	
Number of Co-located Vapor Recovery Wells:	56	
Number of Temperature Monitoring Points:	11 (9 sensors each)	
Is a New Surface Cap Required?	no	
Controlling Contaminant:	PCE	
Average Clean-up Percent:	85%	
Assumed VOC Mass:	3,500 lbs	
Vapor Recovery Air Flow Rate (scfm):	470 scfm	
Minimum Vapor Recovery Blower:	30 horsepower	
Condensate Production Rate:	5.5 gpm	
Liquid Groundwater Pumping Rate:	0 gpm	
Vapor Treatment Method:	carbon	
Assumed Activated Carbon Required:	13,000 lbs	
Power Control Unit (PCU) Capacity:	2000 kW	
Average Electrical Heating Power Input:	1197 kW	
Total Heating Treatment Time:	125 - 182 days	
Design Remediation Energy (kW-hr):	4,003,000	
Assumed Number of Confirmatory Borings:	11	
Number of Soil Samples per Boring:	8	

The above remediation parameters are estimated +/- 20%. Final parameters will be determined during system design.

Budgetary (+/- 20%) Standard Fixed Price for Hamilton Labree

Thermal Remediation Services Price		Percent	
Design, Work Plans, Permits:	$48,000	3%	
Subsurface Installation:	$235,000	14%	
Surface Installation and Start-up:	$292,000	18%	
Remediation System Operation:	$362,000	22%	
Demobilization and Final Report:	$70,000	4%	
Total TRS Price	**$1,007,000**	62%	based on payment terms of net 30 days
Estimated Costs by Others			
Drilling and Soil Sampling:	$223,000	14%	assumes $52 per foot
Drill Cuttings and Waste Disposal:	$28,000	2%	assumes $300 per ton
Electrical Utility Connection to PCU:	$30,000	2%	
Electrical Energy Usage:	$287,000	18%	assumes $0.07 per kW-hr
Carbon Usage, Transportation & Regeneration:	$25,000	2%	assumes $1.90 per pound
Water/Condensate Disposal:	$1,000	0%	
Other Operational Costs:	$29,000	2%	includes vapor sampling
Total Estimated Costs by Others	**$623,000**	38%	
Total Remediation Cost:	**$1,630,000**	$60/cu yd	

"Costs by Others" are conservatively high. TRS recommends using site knowledge or getting quotes.

Prepared for Lily Isenhart, (360) 377-0014, lisenhart@parametrix.com

Some Included Items for Remediation of Hamilton Labree

Design, Work Plans, Permits:	TRS Scope	Shared Scope	Scope by Others	Estimated Cost by Others (included above)
Design or "Kick-off" Meeting	□	■	□	
Work Plan	□	■	□	
Health and Safety Plan	□	■	□	
QA/QC Plan	□	□	□	
Sample Analysis Plan	□	□	□	
Air Permit	□	■	□	
Sewer Discharge Permit	□	■	□	
Building Permit	□	■	□	
Regulatory Negotiations and Client Interface	□	□	■	difficult for TRS to estimate
Subsurface Installation:				
Re-routing of Stream and Filling of Existing Bed	□	□	■	difficult for TRS to estimate
Electrode Materials and Well Screen	■	□	□	
Drilling Subcontractor for Electrodes	□	□	■	$122,880 for 2,352 feet.
Drilling Subcontractor for VR Wells	□	□	□	Co-located with electrodes.
Drilling Subcontractor for TMPs	□	□	■	$13,450 for 462 feet.
Drilling Subcontractor for New MWs	□	□	□	
Abandonment/Replacement of Existing PVC Wells	□	□	■	difficult for TRS to estimate
Concrete Coring	□	□	□	
Utility Locator Survey	□	□	■	$1,280
Installation (pre-ERH) Soil Sample Analysis	□	□	■	$22,000 for 88 samples.
Drill Cutting Disposal	□	□	■	$27,600 for 92 tons.
Drill Cutting Disposal Labor	□	□	■	$2,440
Forklift or Skid-Steer for Drilling	□	□	■	$1,270
Photoionization Detector for Drilling	□	□	■	$2,770
Boring Logs and Report	□	□	■	$2,670
TRS On-Site Electrode Installation Supervision	■	□	□	
Traffic-rated Well Vaults and Installation	□	□	□	
Trenching and Restoration	□	□	□	
New Surface Cap	□	□	□	not required
Biological Amendment and Addition	□	□	□	
Surface Installation and Start-up:				
Surface Remediation Equipment Mobilization	■	□	□	
Crane to Offload/Position Equipment	■	□	□	
Remediation Perimeter or Equipment Fence	■	□	□	
Vapor Recovery Piping	■	□	□	
Steam Condenser	■	□	□	
30 hp VR Blower	■	□	□	
Granular Activated Carbon and Regeneration	□	□	■	$25,000 for 13,000 pounds.
600 scfm Chlorinated VOC Oxidizer	□	□	□	
Oil-Water Separator	□	□	□	not required
Equipment Sound Wall	■	□	□	
Electrical Utility Connection to PCU	□	□	■	$30,000
Telephone Connection to PCU	□	□	■	$390
Garden Hose Connection to Condenser	□	□	■	$330
Remediation System Operation:				
ERH Control and Temperature Monitoring	■	□	□	
Vapor Sampling and Analysis	□	□	■	$11,209 for 45 samples.
Condensate/Discharge Sampling and Analysis	□	□	■	$4,284 for 15 samples.
Sampling Labor and Operational Checks	□	□	■	$11,791 for 137 hours.
Groundwater Sampling and Analysis	□	□	■	difficult for TRS to estimate
Electricity Usage	□	□	■	$287,000 for 4,098,000 kW-hr.
Water/Condensate Disposal	□	□	■	$1,000 for 28,050 gallons.
Separate Phase Product Disposal	□	□	□	none expected
Demobilization and Final Report:				
Drilling Subcontractor for Confirmatory Borings	□	□	■	$12,810 for 440 feet.
Soil Sample Analysis	□	□	■	$22,000 for 88 samples.
Well Abandonment	□	□	■	$12,130 for 56 wells.
Demobilize Surface Equipment	■	□	□	
Final Report	□	■	□	

Figure 1 - ERH Energy Distribution in Subsurface
Hamilton Labree

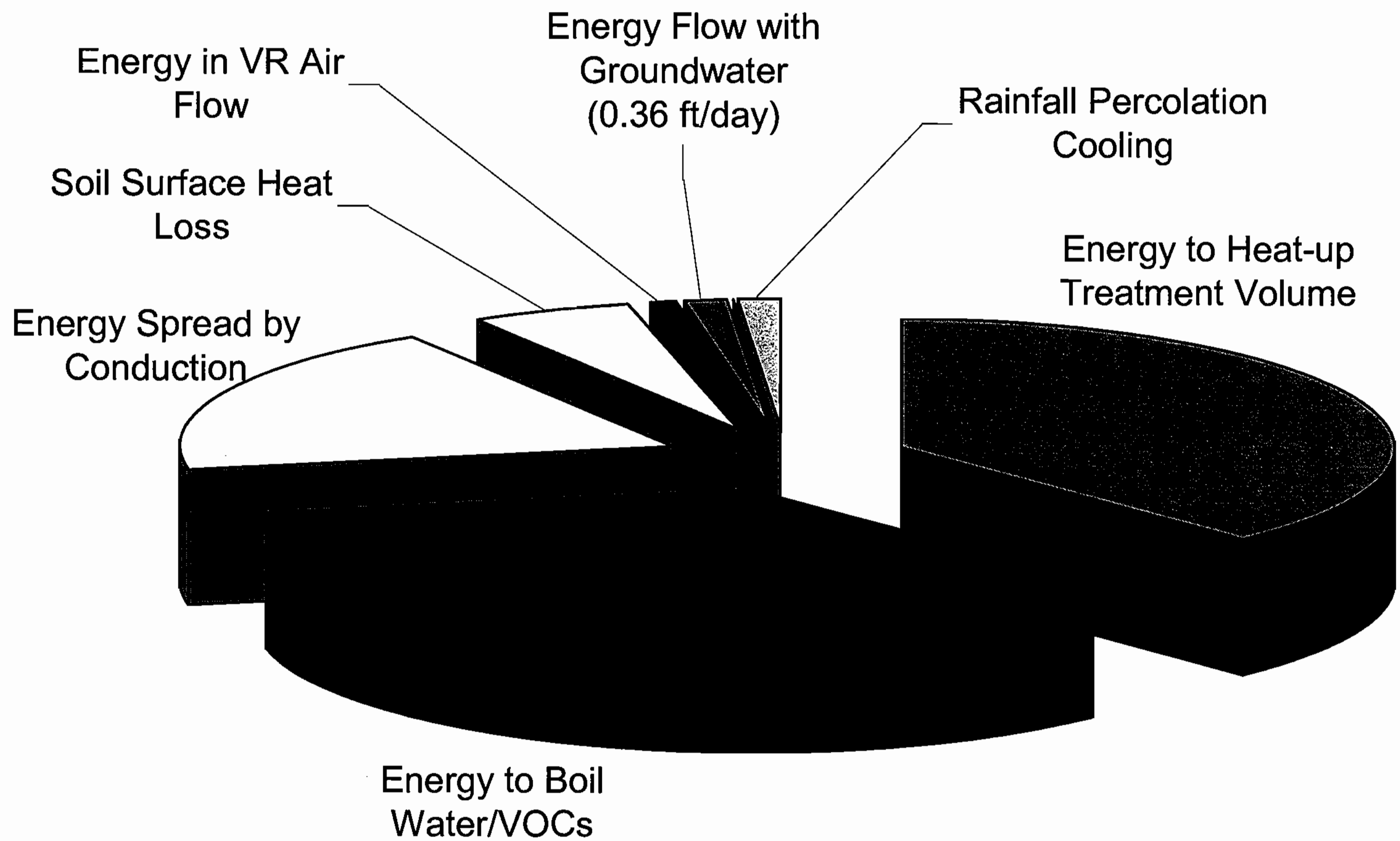
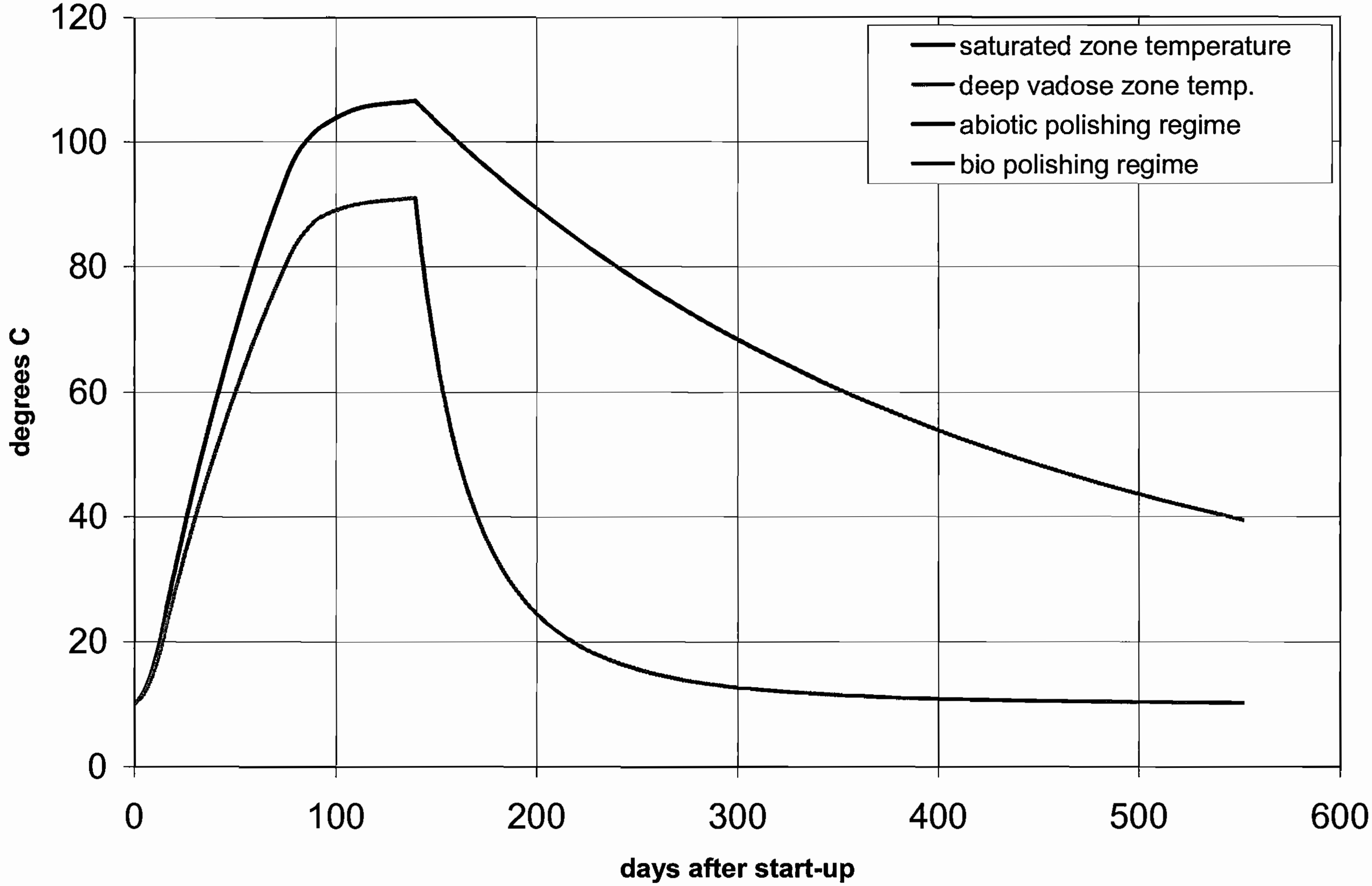


Figure 2 - Expected Subsurface Temperatures
Hamilton Labree

THERMAL REMEDIATION services inc.



P516 BS Parametrix WA 022006.ref

Temperatures shown in this graph are expected temperatures based on site conditions; this is not a guarantee.

SAFETY FIRST
CASCADE DRILLING, INC.
General Contractor No. CASCADI068KK

SEATTLE
P.O. Box 1184
Woodinville, WA 98072
(425) 485-8908 PH
(425) 485-4368 Fax
www.cascadedrilling.com

March 22, 2006

SONIC DRILLING SERVICES NOW AVAILABLE FROM CASCADE DRILLING

Lily Isenhart
Parametrix
5700 Kitsap Way
Suite 202
Bremerton, WA 98312
Bid Number: 22416

Dear Lily ,

Cascade Drilling Inc. is pleased to submit this quote for drilling on the Hamilton/Labree site located in Chehalis, Washington.

Well Decommissioning

Decommission 4-40' 4" wells, drill out
$1560.00/ea — $6,240.00

(Price Assumes wells were installed with bentonite not cement grout or additional charges apply)

Washington State Department of Ecology requires a fee for well decommissioning
(Effective 7/24/05) 4 @ $35.00/ea — 140.00

Borings

Drill, sample at 5' intervals and backfill 14-40' borings
$1580.00/ea. — $22,120.00
Incremental footage @ $8.00/ft

Concrete Coring: (12" diameter x 6" maximum thickess)
(minimum charge $300.00)

Water Containment Drums:	$65.00/ea	
Soil Drums Included		
Sample Liners:	$9.00/ea	
Standby:	$300.00/hr	
Per Diem:	10 days @ $330.00/day	3,300.00
Daily Travel Time:	$225.00/day	

PORTLAND
6400 SE 101st Ave., Ste.2-D
Portland, OR 97266
(503) 775-4118 PH
(503) 775-4099 Fax

LOS ANGELES
11250 E. Firestone Blvd.
Norwalk, CA 90650
(562) 929-8176 PH
(562) 863-9534 FAX

SACRAMENTO
3632 Omec Circle
Rancho Cordova, CA 95742
(916) 638-1169 PH
(916) 638-5611 FAX

Mob/Demob:	2,500.00
Subtotal:	34,300.00
Washington State Sales Tax: (Location #2102) 8.9%	n/a
TOTAL COST:	**$34,300.00**

Decon, soil drums, cleanup and all necessary materials, as reflected on the attached project data sheet, to complete job included.

This quote is based on the information from our telephone conversation of March 22, 2006 and is valid for 60 days. Your firm shall be responsible for: 1. Obtaining any site specific permits. 2. Locating and clearly marking any underground installations or utilities. 3. Obtaining access to the site for a normal truck mounted drill rig with no overhead wires within 20 feet of the holes. Cascade shall not be responsible for any damages to underground improvements not clearly and accurately marked.

If bedrock, cobbles, flowing sands, or other adverse drilling conditions are encountered, drilling will be continued on a time and materials basis or terminated at the discretion of Cascade.

We look forward to working with you. Please call if any of the information is incorrect or if you have any questions.

Sincerely

John Murnane
Operations Manager

Alternative 3 - Chemical Oxidation

Description	Quantity	Unit	Unit Costs ($)	Costs ($)	Source	Notes
DIRECT CAPITAL COSTS						
Temporary Diversion of Berwick Creek:						
Mobilization/demobilization	1	ls	55,000	55,000	Misc. Projects	Roughly 8% total cost for activity
Fish roundup	1	day	3,500	3,500	Bob Sullivan verbal	2 ppl x 1d x 10 hr/d x $80/hr, plus equipment and planning ($800)
Pump - creek water	4	wk	2,000	8,000	Means 2006	Electric Submersible Pump- 4" 560 GPM rental ($600/wk.) plus 24 hr operation ($1400/wk)
4-inch PVC pipe (includes installation)	350	lf	8	2,800	Misc Bid Sheets/Means 2006	
Dam materials	65	cy	20	1,300	Engineer's Estimate/PA ponds	Soil berm
Dam construction/removal	2	ls	10,000	20,000	Engineer's Estimate	Including traffic control
Excavation Dewatering;						
Well water recovery and treatment system	1	ls	24,480	24,480	Engineer's Estimate	
Wellhead plumbing and electrical connection	1	ls	7,000	7,000	Engineer's Estimate/Means 2006	240' 4" PVC header pipe, 40' 2" PVC indiv. pipe runs, 280' 2" PVC elec. conduit, 4 well vaults, 200' temp fence.
Excavate Contaminated Silt:						
Excavation	900	cy	50	45,000	Various 2005 bids	
Contaminated soil disposal (includes transport)	1,350	tn	450	607,500	Waste Management estimate	
Creek Restoration:						
GCL in creek bed	5,100	sf	1	5,100	Sinclair Inlet Restoration/Geo-Synthetics	Vendor cost of $0.46 delivered plus labor (2 ppl x 2d x 10hr/d x $30/hr)
Habitat restoration	1	ls	65,000	65,000	Sinclair Inlet Restoration/Engineer's Estimate	
Chemical Oxidation:						
Mobilzation	1	ls	56,000	56,000	GeoCleanse quote	
Bench Scale Testing	1	ls	8,000	8,000	GeoCleanse quote	
Oxidant	1	ls	157,000	157,000	GeoCleanse quote	
Install injection points/sampling	1	ls	200,725	200,725	Cascade Drilling/GeoCleanse quote	
Subtotal Direct Capital Costs				**1,266,405**		
Direct Capital Cost Contingency (25%)				**253,281**		
Tax (8.8%)				**133,732**		
TOTAL DIRECT CAPITAL COSTS				**1,653,418**		
INDIRECT CAPITAL COSTS						
Engineering pre-design (4% of DCC)	5	%	1,653,418	83,000	Engineer's Estimate	Pilot study, bench scale study, surveying
Engineering design (5% of DCC)	4	%	1,653,418	66,000	Engineer's Estimate	
Regulatory compliance (2% DCC)	2	%	1,653,418	33,000	Engineer's Estimate	Institutional controls, interaction with agencies, etc.
Construction management (5% DCC)	5	%	1,653,418	83,000	Engineer's Estimate	
Monitoring plan	1	ls	15,000	15,000	Engineer's Estimate	
Subtotal Indirect Capital Costs				**280,000**		
TOTAL CAPITAL COSTS				**1,930,000**		
OPERATION AND MAINTENANCE COSTS						
Excavation Dewatering O&M:						
Water treatment operation	1	mo	10,000	10,000	Engineers Estimate	
System electrical usage	1	mo	2,000	2,000	Engineers Estimate	
Carbon change-outs	2,000	lb	2.00	4,000	Westates	$2/lb - 1 time recovery of 2,000 lb system
Chemical Oxidation Injections:						
Injection event	1	ls	265,000	265,000	GeoCleanse quote	Assumes one 50-day treatment
System water usage	300,000	gal	0.33	99,000	Geo Cleanse info	Assumes local source for water.
System electrical usage	3	mo	2,000	6,000	Engineer's Estimate	
Groundwater sampling between injection events	3	ea	27,000	81,000	Palermo LTM costs	Assumes analysis by Manchester lab, one report per year
Project Documentation	1	ls	10,000	10,000	GeoCleanse quote	
One-time confirmation soil sampling	1	ls	21,000	21,000	Cascade quote	Mob., 10 borings@$1580, $330 per diem, labor 2 x 10 hrs x $75, plus ODC
Subtotal Indirect Capital Costs				**498,000**		
Indirect Capital Cost Contingency (25%)				**124,500**		
Total Initial Implementation O&M Costs				**622,500**		
TOTAL IMPLEMENTATION COSTS				**2,550,000**		
ANNUAL COSTS - POSTREMOVAL ACTION PERFORMANCE MONITORING						
Groundwater sampling (semiannual for 5 years)	2	ea	27,000	54,000	Palermo LTM costs	Assumes about 12 wells sampled, analysis by Manchester lab, one report per year
Annual Cost Contingency (15%)				**8,100**		
Total Annual Cost				**62,100**		
Present-Worth Annual O&M (5 years, 5% discount, multiplier = 4.33)				**268,893**		
TOTAL PRESENT WORTH COSTS				**2,820,000**		

Geo-Cleanse®
INTERNATIONAL, INC.

March 8, 2006

Scott Elkind
Parametrix, Inc.
5700 Kitsap Way
Bremerton, WA 98312

Re: Initial Cost Estimate 306-IE-023 / Hamilton Road Site

Dear Mr. Elkind:

Geo-Cleanse International, Inc. (GCI) is pleased to present the following initial cost estimate for applying the Geo-Cleanse® remediation technology to soil and groundwater contamination at the confidential site in Chehalis, WA. GCI has extensive experience with in-situ chemical oxidation utilizing a variety of different oxidant based systems. Based upon the information provided to us, GCI proposes the use of Fenton's Reagent for this particular site. This estimate is based on preliminary site information received from Parametrix and does not constitute acceptance of a site by GCI or a final proposal. This information should not be used for permitting, contracting, or final work plan preparation. This initial estimate is only intended to provide preliminary costing information to determine if the Geo-Cleanse® Process offers a viable remedial alternative.

The geology within the contaminated zone is identified as fine to coarse sand and gravel with a natural silt cap. The contaminants of concern are PCE with an assumed average concentration of 100 ppm sorbed to soils in the vadose zone and 115,000 ppb dissolved in groundwater.

Special Conditions:

This initial estimate is based on the following assumptions:

- Based on data reviewed, a 150-foot x 40-foot area will be treated.
- Treatment area thickness: 30 feet
- 75 injectors are required; 66 injectors for the primary treatment and 9 injectors for the polishing treatment.
- Radius of influence - 12 feet
- Number of injector layers - 3
- A total of 249,000 pounds of hydrogen peroxide (50%) to be injected during a 50-day, 2-mobilization field effort.
- An estimated 5,000 pounds of hydrogen peroxide (50%) are to be injected each day. The 50% peroxide is injected simultaneously with of our catalyst blend so the actual percentage of the injected hydrogen peroxide is 3% to 12%.
- There are no carbonate solids in the treatment zone.

The initial estimated cost based upon the information provided to GCI to date is **$506,768,** which includes primary and polishing treatments. The following is the breakdown of the initial estimated cost:

Project Design:	**$6,010**, which includes preparation of the Injection Installation Plan, Injection Work Plan, Health and Safety Plan, and client assistance in permitting for the primary injection and the polishing treatment.
Injector Installation:	**$25,725**, which includes injector materials (screens, riser pipe, and fittings) and GCI oversight during injector installation. Injector installation for the primary treatment is anticipated for 12 days with GCI personnel to oversee the installation. GCI estimates that the injectors for a subsequent polishing treatment (9) will be installed over a 2-day period with one individual from GCI as oversight.
Mobilization:	**$55,383**, which includes drilling oversight and injection crew transportation, drilling oversight and injection crew per diem, drilling oversight and injection crew vehicle rentals, and treatment unit transportation for each of the injection phases.
Injection Program:	**$253,360**, which includes personnel (field crew / office support/ meetings) and injection treatment vehicle cost (1 vehicle) for 40 days of primary site treatment and injection treatment vehicle (1 vehicle) for 10 days of polishing treatment. The field crew will consist of an Injection Supervisor and one or more Injection Specialists.
Reagents:	**$156,890**, which includes 198,000 pounds of 50% hydrogen peroxide, transportation, and trailer rental for 40 days for the primary treatment and 51,000 pounds of 50% hydrogen peroxide, transportation, and trailer rental for 10 days for the polish treatment.
Project Documentation:	**$9,400**, which includes tabulating field-monitoring data, post injection status report following each of the phases, and the effectiveness evaluation report following the project completion.

This estimate includes all cost associated with the Geo-Cleanse® Injection Program except water, electricity, and drilling. Our contaminant mass calculations, which form the basis of this initial estimate, are attached. If additional site delineation data is available, this cost estimate may be revised.

GCI maintains a fully equipped and staffed laboratory that enables us to offer bench scale testing. Bench scale testing can provide information about contaminant mass reductions and chemical oxidant efficiencies that can be expected during a full-scale treatment. Bench scale testing, GCI maintains a fully equipped and staffed laboratory that enables us to offer bench scale testing. Bench scale testing can provide information about contaminant mass reductions and chemical oxidant efficiencies that can be expected during a full-scale treatment. Bench scale testing, although not required, can help to refine the full-scale chemical oxidation program. If you would like an estimate for a bench test, please let us know.

Please review this initial estimate and determine if you would like to go forward with a firm proposal. If you would like to pursue a firm proposal, please forward to GCI the complete site delineation data and desired scope of work for our review and interpretation. A sheet summarizing delineation data particularly helpful for Geo-Cleanse® project design is attached.

This document and its contents are the property of Geo-Cleanse International, Inc. It is delivered in the expressed condition that it is not to be disclosed, reproduced in whole or part, or used for any other purpose other than in connection with the Geo-Cleanse® Process as applied by Geo-Cleanse International, Inc. No right is granted to the recipient to disclose or use any information contained in this document. United States patents protect the Geo-Cleanse® Process and only Geo-Cleanse International, Inc. or those acting with a written license from Geo-Cleanse International, Inc. may apply the Geo-Cleanse® Process.

If you have any questions or comments regarding this estimate, please feel free to contact MariKay Fish or myself at (908) 206-1250 or via e-mail at mfish@geocleanse.com.

Thank you for considering the Geo-Cleanse® Process to assist you in your remedial needs.

Sincerely,

William Moody
Assistant Project Manager
Geo-Cleanse International, Inc.

Enclosures

SITE DATA DESIRED FOR GEO-CLEANSE PROJECT DESIGN

The site information desired for final Geo-Cleanse project design is typically included in a very thorough remedial investigation report. Specifically, we search for the following information:

I. General Site Information.

A. Map(s) with buildings, overhead or underground utilities, sample locations, etc.
B. Topographic map.
C. Site history, especially regarding the plume origin, previous remediation, etc.
D. Site hazards and access for drill rig, Geo-Cleanse treatment rig, peroxide tanker.

II. Soil Data.

A. Detailed lithologic descriptions and geologic cross sections.
B. Soil density.
C. All soil boring logs from the site.
D. All soil analytical data in tabular form.
E. Contaminant isopleth maps (by compound and by discrete depth intervals).

III. Groundwater Data.

A. Detailed lithologic descriptions of the aquifer (boring logs).
B. Depths of aquiclude/aquitard intervals.
C. Depth to groundwater and seasonal variations.
D. Hydraulic conductivity.
E. Porosity.
F. Water quality (pH, alkalinity and iron concentration).
G. All groundwater analytical data in tabular form.
H. Observations/thickness of free product layers.
I. Contaminant isopleth maps (by compound and by aquifer if more than one).
J. Groundwater peizometric surface map.

IV. Bedrock Data (if applicable).

A. All groundwater quality data described in Section III.
B. Depth to bedrock, and unconsolidated soil data described in Section II.
C. Depth to water and seasonal variations.
D. Distribution, strike and dip of fracture sets, and discrete zones.
E. Packer testing results (pump tests, temperature, resistivity, etc.).

Contaminant Mass Calculation
Initial Estimate 306-IE-023 (5 ft to 15 ft)
Total Chlorinated Hydrocarbons

---

1. Soil

Length (ft) = 150 ft
Width (ft) = 40 ft
Thickness (ft) = 10 ft

Soil Density (lb/cu yd) = 3,000 lb/cu yd
Soil Contamination (ppm) = 100 ppm

Soil Quantity (cubic yards) = 2,222 cu yds

Soil Contaminant Mass = 100.0 lb TCH / 1,000,000 lb soil x 3,000 lbs soil / cu yd soil x 2,222 cu yds soil = 667 lbs TCH

---

2. Dissolved Phase

Length = 150 ft
Width = 40 ft
Plume Area (sq ft) = 6,000 sq ft
Average Thickness (ft) = 10 ft
Porosity (in decimal) = 0.19
Average TCH Concentration (ppb) = 220,697 ppb

Volume of Contaminated Water (gal) = 6,000 sq ft x 10 ft thick x 0.19 (porosity) x 7.48 gal / cubic foot = 85,272 gal

Dissolved Contaminant Mass (lbs) = 85,272 gal water x 8.345 lbs / gal water x 220,697 lbs TCH / billion lbs water = 157 lbs dissolved TCH

---

3. Free Phase

Length = 80 ft
Width = 40 ft
Plume Area (sq ft) = 3,200 sq ft
Average Actual Thickness (ft) = 0.080 ft (actual product thickness = measured well thickness / 4)
Porosity (in decimal) = 0.19

Free Phase Volume = 3,200 sq ft x 0 ft thick x 0.19 (porosity) = 49 cu ft

Free Phase Mass = 49 cu ft x 7.48 gal / cu foot x 11.7 lb* / gal TCH = 4,257 lbs free phase

* 11.7 lbs/gal is assumed as the average density of TCH

Amount of 50% Hydrogen Peroxide Required

1. Soil = 667 lbs
2. Dissolved Phase = 157 lbs
3. Free Phase = 4,257 lbs

5,080 Total lbs TCH

Stoichiometric H_2O_2 Requirements: 5,080 lbs TCH x 4 lbs H_2O_2 / lb TCH = 20,322 lbs H_2O_2 required

Minimum H_2O_2 Requirements: 27 Injectors x 3,000 lbs H_2O_2 / Injector = 81,000 pounds H_2O_2

Cost estimate will include the higher of either the stoichiometric or minimum H_2O_2 requirement.

Contaminant Mass Calculation
Initial Estimate 306-IE-023 (15 ft to 25 ft)
Total Chlorinated Hydrocarbons

---

1. Soil

Length (ft) = 95 ft
Width (ft) = 50 ft
Thickness (ft) = 10 ft

Soil Density (lb/cu yd) = 3,000 lb/cu yd
Soil Contamination (ppm) = 100 ppm

Soil Quantity (cubic yards) = 1,759 cu yds

Soil Contaminant Mass = 100.0 lb TCH / 1,000,000 lb soil x 3,000 lbs soil / cu yd soil x 1,759 cu yds soil = 528 lbs TCH

---

2. Dissolved Phase

Length = 95 ft
Width = 50 ft
Plume Area (sq ft) = 4,750 sq ft
Average Thickness (ft) = 10 ft
Porosity (in decimal) = 0.19
Average TCH Concentration (ppb) = 300,310 ppb

Volume of Contaminated Water (gal) = 4,750 sq ft x 10 ft thick x 0.19 (porosity) x 7.48 gal / cubic foot = 67,507 gal

Dissolved Contaminant Mass (lbs) = 67,507 gal water x 8.345 lbs / gal water x 300,310 lbs TCH / billion lbs water = 169 lbs dissolved TCH

---

3. Free Phase

Length = 95 ft
Width = 50 ft
Plume Area (sq ft) = 4,750 sq ft
Average Actual Thickness (ft) = 0.080 ft (actual product thickness = measured well thickness / 4)
Porosity (in decimal) = 0.19

Free Phase Volume = 4,750 sq ft x 0 ft thick x 0.19 (porosity) = 72 cu ft

Free Phase Mass = 72 cu ft x 7.48 gal / cu foot x 11.7 lb* / gal TCH = 6,319 lbs free phase

* 11.7 lbs/gal is assumed as the average density of TCH

Amount of 50% Hydrogen Peroxide Required

1. Soil =	528 lbs
2. Dissolved Phase =	169 lbs
3. Free Phase =	6,319 lbs
	7,016 Total lbs TCH

Stoichiometric H_2O_2 Requirements: 7,016 lbs TCH x 4 lbs H_2O_2 / lb TCH = 28,062 lbs H_2O_2 required

Minimum H_2O_2 Requirements: 22 Injectors x 3,000 lbs H_2O_2 / Injector = 66,000 pounds H_2O_2

Cost estimate will include the higher of either the stoichiometric or minimum H_2O_2 requirement.

Contaminant Mass Calculation
Initial Estimate 306-IE-023 (25 ft to 35 ft)
Total Chlorinated Hydrocarbons

1. Soil

Length (ft) = 95 ft
Width (ft) = 40 ft
Thickness (ft) = 10 ft

Soil Density (lb/cu yd) = 3,000 lb/cu yd
Soil Contamination (ppm) = 100 ppm

Soil Quantity (cubic yards) = 1,407 cu yds

Soil Contaminant Mass = $\frac{100.0 \text{ lb TCH}}{1,000,000 \text{ lb soil}}$ x $\frac{3,000 \text{ lbs soil}}{\text{cu yd soil}}$ x 1,407 cu yds soil = 422 lbs TCH

2. Dissolved Phase

Length = 95 ft
Width = 40 ft
Plume Area (sq ft) = 3,800 sq ft
Average Thickness (ft) = 10 ft
Porosity (in decimal) = 0.19
Average TCH Concentration (ppb) = 1,988,000 ppb

Volume of Contaminated Water (gal) = 3,800 sq ft x 10 ft thick x 0.19 (porosity) x $\frac{7.48 \text{ gal}}{\text{cubic foot}}$ = 54,006 gal

Dissolved Contaminant Mass (lbs) = 54,006 gal water x $\frac{8.345 \text{ lbs}}{\text{gal water}}$ x $\frac{1,988,000 \text{ lbs TCH}}{\text{billion lbs water}}$ = 896 lbs dissolved TCH

3. Free Phase

Length = 80 ft
Width = 40 ft
Plume Area (sq ft) = 3,200 sq ft
Average Actual Thickness (ft) = 0.080 ft (actual product thickness = measured well thickness / 4)
Porosity (in decimal) = 0.19

Free Phase Volume = 3,200 sq ft x 0 ft thick x 0.19 (porosity) = 49 cu ft

Free Phase Mass = 49 cu ft x $\frac{7.48 \text{ gal}}{\text{cu foot}}$ x $\frac{11.7 \text{ lb*}}{\text{gal TCH}}$ = 4,257 lbs free phase

* 11.7 lbs/gal is assumed as the average density of TCH

Amount of 50% Hydrogen Peroxide Required

1. Soil = 422 lbs
2. Dissolved Phase = 896 lbs
3. Free Phase = 4,257 lbs

5,575 Total lbs TCH

Stoichiometric H_2O_2 Requirements: 5,575 lbs TCH x $\frac{4 \text{ lbs } H_2O_2}{\text{lb TCH}}$ = 22,300 lbs H_2O_2 required

Minimum H_2O_2 Requirements: 17 Injectors x $\frac{3,000 \text{ lbs } H_2O_2}{\text{Injector}}$ = 51,000 pounds H_2O_2

Cost estimate will include the higher of either the stoichiometric or minimum H_2O_2 requirement.

Geo-Cleanse®
INTERNATIONAL, INC.

March 13, 2006

Mr. Scott Elkind
Parametrix, Inc.
5700 Kitsap Way
Bremerton, WA 98312

Re: Bench Scale Cost Estimate 306-BC-024 / Hamilton Road Site

Dear Mr. Elkind:

Geo-Cleanse International, Inc. (GCI) is pleased to present the following bench scale cost estimate for applying the Geo-Cleanse® remediation technology to saturated soil and groundwater contamination at the Hamilton Road site in Bremerton, WA. The following text describes the general bench testing procedures and costing.

<u>Bench Scale Treatability Testing</u>

The overall goal of bench scale treatability testing is to evaluate the effectiveness of the Fenton's reagent oxidation on the contaminants present in soil and groundwater at the Hamilton Road site. The bench is also used estimate total oxidant demand, to establish design parameters for a field treatment, and to help determine if a Geo-Cleanse® field treatment is warranted at the site.

Experiments will be conducted by GCI. The scope of work included in this cost estimate is to treat one representative soil sample and one representative groundwater sample. A total of five tests are performed, including a control. Tests are conducted on 50% soil slurries (100 g soil, 100 mL groundwater) in wide-mouth opaque high-density polyethylene bottles. The hydrogen peroxide charge added to each bottle is varied in order to calculate the most effective oxidation. The tests will be set up with 1:1, 5:1, 10:1, and 20:1 hydrogen peroxide to contaminant mass ratios (based upon a contaminant mass estimate for the samples) in order to evaluate total oxidant demand (total oxidant demand includes oxidant required to destroy the targeted organic compounds, plus oxidant demand resulting from the presence of oxidizable minerals or non-targeted organic compounds). Samples are dosed and allowed to react overnight. Treated soil and groundwater samples are then collected and submitted for analyses of target compounds. Conclusions will then be drawn regarding the overall effectiveness of the Fenton's reagent oxidation on the contaminants at the site, possible formation of hazardous intermediate products, and if a Geo-Cleanse® Initial Treatment Program (a field injection) is warranted.

Any additional experiments or analytical services not described in this scope of work will incur additional costs.

4 Mark Road • Suite C • Kenilworth • New Jersey • 07033
Telephone (908) 206-1250 • Fax (908) 206-1251 • www.geocleanse.com

The scope of work and the associated Geo-Cleanse® Treatment costs are outlined as follows:

> Phase I - Data review, work plan preparation, experiment design. The consultant is to obtain representative soil samples and ship them to GCI. Shipment must be arranged in advance and directly to the lab.
>
> Phase II - Laboratory Experimental Program, anticipated to be 3 days. This will include lab facility charges, reagents, and laboratory expendables for the bench scale test.
>
> Phase III – A Geo-Cleanse® Bench Scale Testing Report will be prepared to document the experiments conducted and results. This report will include conclusions and recommendations for implementing the Geo-Cleanse® Process at the site.

The cost for Geo-Cleanse® Bench Scale Treatability Testing is **$7,415**. This includes the sample analysis costs ($1,625). If desired by the consultant, samples will be submitted on behalf of the consultant to another laboratory under the consultant's separate contract.

If you have any questions or comments regarding this estimate, please feel free to contact MariKay Fish or myself at (908) 206-1250 or via e-mail at mfish@geocleanse.com.

Thank you for considering the Geo-Cleanse® Process to assist you in your remedial needs.

Sincerely,
Geo-Cleanse International, Inc.

William Moody
Assistant Project Manager

Enclosures

Bench Scale Test Cost Proposal

Bench Cost Estimate # 306-BC-024 / Hamilton Road Site

LINE ITEM		T & M Costs		T & M Estimate
DESIGN COSTS				
Bench Scale Experimental Design & Workplan Preparation				
Additional costs will be incurred if a project design meeting with consultant is requested.				
Project Scientist	$ 90 / hr x	4 hrs		$ 360
Overnight delivery services ($60 flat rate)				$ 60
			SUBTOTAL	**$ 420**
LABORATORY EXPERIMENTAL PROGRAM		3 Days		
Project Scientist	$ 90 / hr x	15 hrs (5 hrs/day)		$ 1,350
Laboratory Charges • Lab Facility • All Reagents • Lab Expendables (glassware, etc.)	$ 600 / day x	3 Days		$ 1,800
			SUBTOTAL	**$ 3,150**

ANALYTICAL COSTS

	Phase	*Unit Cost*	*# of Samples*	
Volatile organics (Method 8260)	Solid	$100	5	$ 500
	Liquid	$100	5	$ 500
Volatile organics (Method 8260) w/24-hr turn	Solid	$200	1	$ 200
	Liquid	$200	1	$ 200
Chloride	Solid	$0	0	$ -
	Liquid	$15	5	$ 75
Chloride w/24-hr turn	Solid	$0	0	$ -
	Liquid	$30	1	$ 30
Cooler Overnight Shipping Services ($120 flat fee)				$ 120
			SUBTOTAL	**$ 1,625**

PROJECT DOCUMENTATION

Bench Scale Experiment Evaluation Report, Monitoring Data

Additional costs will be incurred if a project documentation meeting with consultant is requested.

Project Scientist	$ 90 / hr x	24 hrs		$ 2,160
Overnight Delivery Services ($60 flat fee)				$ 60
			SUBTOTAL	**$ 2,220**
			COST PROPOSAL TOTAL	**$ 7,415**

PROPOSAL AND AGREEMENT TO PROVIDE

IN-SITU CHEMICAL OXIDATION REMEDIATION SERVICES

PROPOSED SITE:

Hamilton/Labree Roads Superfund Site
Chehalis, Washington

REQUESTED BY:

Parametrix Incorporated
5700 Kitsap Way, Suite 202
Bremerton, WA 98312

PROPOSAL # 900802

MARCH 1, 2006

ISOTEC

5600 SOUTH QUEBEC STREET, SUITE 320 D
GREENWOOD VILLAGE, COLORADO 80111

WWW.INSITUOXIDATION.COM

ISOTEC

TABLE OF CONTENTS

ISOTEC

PROJECT BACKGROUND AND SITE CONDITIONS

PROJECT BACKGROUND AND SITE CONDITIONS:

The Hamilton/Labree Roads Superfund Site is located in Chehalis, Washington (Site). The primary contaminant of concern is tetrachloroethene (PCE).

The objective of the project is to reduce the contaminant concentrations in soil by 85%. The estimated treatment interval at the Site is from approximately 10 to 35 feet below grade surface (bgs).

Based upon data provided by Parametrix, the subsurface is comprised of sand and gravel within the treatment interval overlain by clay. Dissolved chlorinated solvent concentrations in excess of 100,000 micrograms per liter (ug/L) indicate the presence of dense non-aqueous phase liquid (DNAPL) within the treatment interval. PCE concentrations in soil exceed 100,000 ug/kg.

THE ISOTEC PROCESS

ISOTEC's Fenton based oxidation process is effective on a wide range of contaminants including hard to treat recalcitrant compounds such as chlorinated solvents, MTBE, and pesticides. Hydroxyl radicals generated by the ISOTEC process will oxidize nearly all contaminants with carbon / carbon double bonds (i.e., TCE and PCE) and single bonded contaminants with extractable hydrogen (i.e., TCA).

The ISOTEC process consists of injecting stabilized hydrogen peroxide and complexed iron catalyst into contaminated aquifers or vadose zones. As compared to conventional Fenton's Reagent which requires acidic conditions ($pH \leq 3$) the ISOTEC process is effective at neutral ($pH = 7$) conditions. This is an important consideration in full-scale application since acidifying an aquifer is typically impractical. ISOTEC's oxidation method utilizes a site-specific delivery system(s) designed to treat organic contaminants within an area of concern. ISOTEC oxidants and catalysts generate hydroxyl radicals, which react with the organic contaminants within the subsurface producing innocuous by-products such as carbon dioxide and water (and chloride ions if chlorinated compounds are being treated).

The site specific stoichiometry is typically estimated through a laboratory study, with preliminary treatment quantities calculated. Application is tested in the field during a pilot program to determine process efficiency and extent of treatment, which varies depending on the site's subsurface hydrogeology and the contaminant distribution and concentration. Based on results from the laboratory study and pilot program, design and implementation of a full-scale remedial treatment program is proposed, if required.

THE ISOTEC PROCESS

(CONTINUED)

ISOTEC's process is superior to other in-situ Fenton-based oxidation technologies for the following reasons:

- Neutral pH conditions (e.g. 5-8) are used; therefore, no acidification of the aquifer is required as with other Fenton-based processes. This is a critical issue when comparing ISOTEC to other traditional Fenton's reagent providers. At Battelle's recent conference, Yong-Sook Kim, Hanyang University, Seoul Korea demonstrated through his research "Reduction of Chlorinated Compounds (CT, HCA) with Fenton's Reagent" that for traditional Fenton's chemistry, iron falls out of solution at pH greater than 4. Using traditional Fenton's reagent, acidification of the aquifer is required but usually not accomplished due to the vast amounts of acid required. As a result, it is unlikely that true Fenton's chemistry is being promoted using acid-based approaches. In addition, by not acidifying the aquifer, background conditions can be quickly re-established in the aquifer after reagent injection to promote natural attenuation.

  Additionally, in a paper by Brant Smith, Washington State University, "Destruction of DNAPLs by Modified Fenton's Reagent," his research demonstrated that in addition to hydroxyl radicals, generation of superoxide and hydroperoxide are a critical element in treating sorbed contaminants and promoting reduction reactions. Hydroxyl radicals are probably too short lived in aqueous solutions to disolve and destroy DNAPLs. Their generation is highly dependent on the aquifer pH, with pH values above 4.8 favoring creation of superoxide. Therefore, traditional Fenton's chemistry requiring a pH of 3 will not be effective in producing superoxide.

- Reagents are highly mobile in the subsurface due to the use of our patented chelated organometallic catalysts that resist precipitation and soil adsorption. This results in efficient hydroxyl radical generation throughout the plume unlike conventional Fenton's catalysts that are consumed near the point of injection.

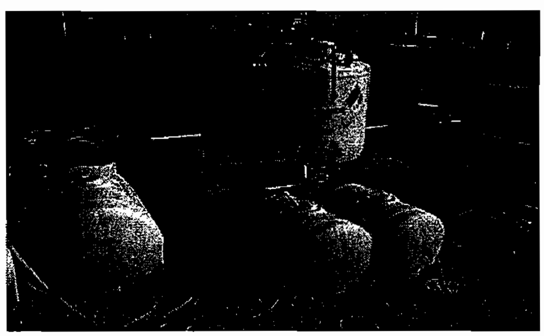
- Health and safety concerns are minimized due to the use of low concentrations of peroxide (typically < 15% H_20_2) and low pressure injection (typically < 30 psi) which results in minimal temperature increase (< 25^0 F).

ISOTEC

SAFETY

Safety is a priority with the ISOTEC process. ISOTEC has not had a significant health and safety incident in over ten years of field application. Most negative effects noted with in-situ oxidation occur with aggressive oxidation reactions utilizing high concentration reagents under pressurized conditions. These conditions can create a significant temperature rise and an enormous amount of carbon dioxide and/or oxygen off-gas, which can mobilize vapors and contaminants within the subsurface. ISOTEC does not utilize this approach. Reagents utilized by ISOTEC are stabilized and at low concentrations, with injection in a controlled manner to reduce the possibility of surface breakout or subsequent migration.

Other activities at the Site which may include drilling, direct-push, and excavating will be monitored and supervised in accordance with standard industry safety protocols, including a daily tailgate safety meeting prior to initiation of the day's activities to review safety procedures, hazards and potential hazards. All on-site personnel will be required to read and sign the site-specific health and safety plan prior to working on the Site.



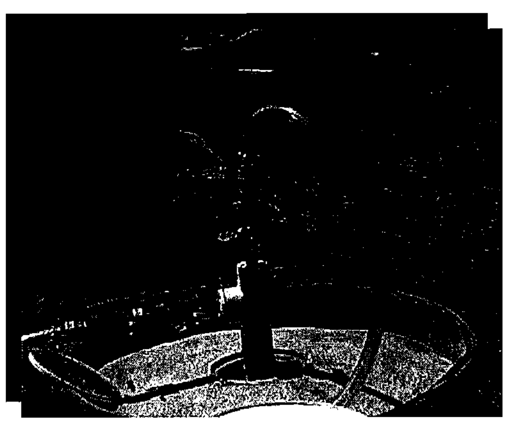
ISOTEC

WHY ISOTEC

ISOTEC's expertise over the last ten years in successfully applying in-situ chemical oxidation services to various contaminants and hydrogeology, is unsurpassed. This expertise is a combination of our professional backgrounds in groundwater and soil remediation, hydrogeology, and hands on experience gained from previous chemical oxidation remediation projects.

ISOTEC's technology is superior to other in-situ Fenton-based oxidation technologies for the following reasons:

- Neutral pH conditions (e.g. 5-8) are used; therefore, no acidification of the aquifer is required as with other Fenton-based processes.
- Reagents are highly mobile in the subsurface due to the use of our patented chelated organometallic catalysts that resist precipitation and soil adsorption.
- This results in efficient hydroxyl radical generation throughout the plume unlike conventional Fenton's catalysts that are consumed within inches from point of injection.
- Health and safety concerns are minimized due to the use of low concentration of oxidizers (typically < 15% H_2O_2) and low pressure injection which results in minimal (< 25^0 F) temperature increase.



ISOTEC

LESSONS LEARNED

Past experience at similar sites suggests several lessons learned that should be considered during this pilot test program.

- **Surfacing** – Subsurface reactions produce gases that migrate vertically. Any vertical permeability pathways or conduits can allow the gas to migrate to ground level and "surface". The gas can transport groundwater and reagent through the conduit as well, therefore liquid can bubble to surface. Conduits can be naturally occurring, i.e. fractures, or man made. Natural fractures are normally observed in clays and dry silts. Man made conduits include abandoned bore holes or probe holes, annular spaces of monitoring wells, monitoring well casings, and injection well annular spaces. All future bore and probe holes should be abandoned with hydrated bentonite to 6 inches below grade and a concrete plug to surface. Monitoring wells within 15 feet of an injection well should have a PVC threaded adapter glued on and a threaded cap with pressure gauge attached during injection. Annular spaces of monitoring wells should be observed during injection for liquid accumulation in the street box or surfacing around the street box. Injection wells are very susceptible to failure especially if they are not constructed properly. The geo-probe drilling subcontractor will plug the injection point locations with bentonite and concrete after the completion of injection activities.
- **Increasing Groundwater Concentrations** – The ISOTEC process causes contaminant desorption as well as dissolved phase oxidation. If sufficient contaminant mass is present in the adsorbed phase or as NAPL, more mass may be transferred to the dissolved phase than can be treated during one injection event. This can result in higher contaminant groundwater concentrations after injection than before injection. Total contaminant mass will still be reduced.
- **Variations in Permeability** – Permeability variations laterally can cause significantly different injection conditions. Pressures, flow rates and injection volumes can vary from location to location. Vertical permeability variations can cause poor distribution of reagent even in a relatively uniform lithology. Using multiple ISOTEC injection screens at each of the direct-push locations reduces the potential for missing entire sections of the subsurface.

ISOTEC

PROPOSED SCOPE OF WORK

SCOPE OF WORK:

The following outline summarizes ISOTEC's approach to implementing a remediation program at the Site. The approach is based upon data supplied by Parametrix and is designed to address several potentially limiting factors to implementation success. Limiting factors at the Site include the overlying clay, DNAPL presence and a thick treatment interval. These three factors, in unison, present less than desirable conditions for the implementation of modified Fenton's. The lithology tends to promote surfacing since the produced gas can build up beneath the clay rather than moving vertically into the vadose zone. The DNAPL will require large volumes of reagent in order to reach the project treatment goals, which also increases the potential for surfacing. The overall thickness of the treatment interval will require multiple injection screens to deliver reagent uniformly across the zone. The project will require large reagent volumes to be injected over time through multiple screens. In order to achieve project success, these factors must taken into account when an injection program is designed.

TECHNICAL APPROACH:

Remediation Program Design

The remediation program design is based on review of historical data provided to ISOTEC and the factors discussed above. The program will include multiple injection events and three injection screens per location. The multiple injection events are needed to deliver significant volumes of total reagent while limiting the reagent volume injected during each event. The injection locations will be spaced in order to have overlapping treatment areas. The multiple injection screens per location will deliver reagent uniformly across the vertical extend of the contaminant interval.

An initial pilot test is recommended to refine the injection approach and develop an accurate full-scale remediation cost. The pilot test will determine actual injection location spacing and reagent volumes. The pilot test should consist of three separate injection events at approximately 8 locations across a 5,000 sq-ft pilot test area. This area should be located within the area of highest PCE concentrations. Reagents will be injected through direct push injection screens. The injection screen will be 8 feet long and deployed through a 1.5-inch direct push rod. Three separate direct push rods will be installed at each location, covering a total of 24 – 30 vertical feet. This method of selective vertical injection will deliver reagent across the entire vertical extend of the treatment horizon. This method will reduce the potential of one permeable zone accepting the majority of reagent at any one location.

Although the three injection events may be sufficient to meet the project goal of 85% contaminant mass reduction. The three events will collect enough data to determine the actual number of events required to meet this goal. ISOTEC expects that four or five events may be necessary to meet the project goal in the area of the highest soil contamination. Two or three events will most likely be required to meet the goal in less contaminated areas.

Injection Method

ISOTEC reagents, 17% hydrogen peroxide and Catalyst 4460, will be injected into the subsurface at the Site through the direct push screens discussed above. The ISOTEC process is a five-step process. ISOTEC begins by injecting water into the subsurface, followed by stabilized 17% H_2O_2. Water is then injected into the rod to flush the reagent away from the borehole. Following the water flush, catalyst is injected into the subsurface. A final water injection is completed to flush the reagent from the injection equipment. This process is repeated at each screen throughout the test area. Injection pressures and flow rates will be determined in the field based upon injection responses. Typical flow rates and pressures range from 3 to 8 gallons per minute and 0 to 50 pounds per square inch.

Injection Volumes

ISOTEC reagent volumes will be determined in the field based on injection reactions observed during the initial event and modified as necessary during injections in order to maintain reagent in the subsurface.

CONFIRMATION SAMPLING PLAN:

Monitoring of the pilot test based on mass reduction across the area is critical to overall project evaluation and ultimately project success. ISOTEC recommends evaluating the test based on analytical data collected from both soil and groundwater. Three or four new monitoring wells should be installed and screened selectively across the vertical extent of the zone. These wells would be used for baseline and post-injection groundwater sampling. In addition, soil samples collected from the borings should be used to monitor mass reductions. Eighteen soil samples should be collected for baseline analysis from the four new well locations, two samples collected from each of the following depths: 12-

Proposed Scope of Work

(CONTINUED)

13'bgs, 19-20' bgs and 26-27' bgs. Progress samples would be collected from similar locations and depths after the third injection event.

Groundwater samples should be collected at baseline and following each injection event from the three monitoring wells. These sample data will help track the progress of the test, even though dissolved concentrations fluctuate greatly during the treatment process.

ISOTEC

REPORTING & MEETINGS

REPORTING:

The following reports will be prepared by ISOTEC and provided for the project:

- **Workplan**

  ISOTEC will prepare a work plan for the pilot test. The workplan will detail ISOTEC's test design including methodology, objectives, mobilization, well construction and field implementation.

- **Health and Safety Plan**

  ISOTEC will prepare a Health and Safety Plan (HASP) related to any and all health and safety issues associated with the remediation activities (such as chemical storage and handling).

- **Final Report**

  Upon completion of the treatment program and receipt of all analytical data collected, ISOTEC will submit a report outlining details of the pilot test. The report will detail the in-situ chemical oxidation process, field activities, and chemical analyses. Specifically, the ISOTEC reagent injection quantities, injection pressures, and injection rates will be discussed in the report and presented in tables. ISOTEC will discuss in detail analytical data obtained during the treatment program. Contaminant concentrations and mass calculations from baseline to post remediation program injections will be discussed in the report, tabulated, and presented in figures. Finally, ISOTEC will discuss recommendations for further injections, if any.

MEETINGS:

The following meetings will be attended by ISOTEC prior to initiating field activities:

- No pre-field activity meetings requested at the time of this proposal.

ISOTEC

PROFESSIONAL ARRANGEMENTS

This proposal presents the scope of work we believe will be necessary to meet the project goals and our best estimate of the cost of such services based on our current understanding of your requirements.

Our professional fees to complete our scope of work, projected to be three pilot test injection events during three separate mobilizations are $219,017. A break down of task fees is as follows:

Work Plan, Design and Health and Safety Plan	**$7,500**
Field Injection (per mobilization)	**$100,730**

→ *Mobilization*
Includes mobilization, demobilization, travel, shipping and storage.

→ *ISOTEC Oxidant and Preparation*
Includes one application of Modified Fenton's reagent at eight injection locations (24 separate screens) including reagents, reagent mixing, injection and equipment.

→ *Field Oversight*
Includes a site supervisor and one or two field technicians for 5-7 days, including per diem.

Technical Review, Project Management, and Final Report	**$10,000**
Two Additional Mobilizations	**$201,460**

INJECTION PROGRAM TOTAL COST: $319,690

Our fees and expenses will be lump-sum billed upon completion of the tasks outlined above. Full-scale costs, based upon our pre-pilot test assumptions, will be approximately $300,000 per event (including the pilot test area) and require two or three events to meet the project goals.

ISOTEC

PROFESSIONAL ARRANGEMENTS

(CONTINUED)

NOTES:

- ISOTEC will require a source of on-site water supply to perform treatment program activities. We will use up to 25,000 gallons of water during each pilot test event.
- Treatment program cost includes all labor, equipment, chemicals, materials, travel and other associated equipment shipping.
- Parametrix will be responsible for workplan approval, monitoring well installation and permitting, and groundwater/soil sampling.
- ISOTEC typically begins work within 30 days of authorization to proceed and all regulatory approvals are in place.
- ISOTEC has assumed that injections will not be delayed due to site access. Significant delays may influence the site injection schedule.
- Any additional meetings, site walks, or other unscheduled activities that require attendance by ISOTEC personnel, will be billed on a time and materials basis.

Parametrix

PROJECT HL FS SHEET ___ OF ___
BY BZ DATE 3/2/06 CHECKED re-vised calc DATE ___
SUBJECT Contaminated Silt JOB NO. ___ PHASE ___ TASK ___

Using EE/CA Plate 4 info

Silt depth ≈ 1.5'

Bank over-burden ≈ 6.5' (average)

Assume 230' length for silt layer → NAPL

Creek Bed Silt

W = 22'

$230' \times 22' \times 1.5' = 7{,}590\ ft^3 \approx 300\ cy$

Bank

W = 10'

$230' \times 10' \times 6.5' = 14{,}950\ ft^3 \approx 600\ cy$

Total = 300 + 600 cy = 900 cy

Assume bed silt to be disposed of as Subtitle C

→ Haz ≈ 300 cy

Bank silt → non-Haz ≈ 600 cy

→ Subtitle C

Alternative 4 - Permeable Reactive Barrier Containment

Description	Quantity	Unit	Unit Costs ($)	Costs ($)	Source	Notes
DIRECT CAPITAL COSTS						
Temporary Diversion of Berwick Creek:						
Mobilization/demobilization	1	ls	55,000	55,000	Misc. Projects	Roughly 8% total cost for activity
Fish roundup	1	day	3,500	3,500	Bob Sullivan verbal	2 ppl x 1d x 10 hr/d x $80/hr, plus equipment and planning ($800)
Pump - creek water	4	wk	2,000	8,000	Means 2006	Electric Submersible Pump- 4" 560 GPM rental ($600/wk.) plus 24 hr operation ($1400/wk)
4-inch PVC pipe (includes installation)	350	lf	8	2,800	Misc Bid Sheets/Means 2006	
Dam materials	65	cy	20	1,300	Engineer's Estimate/PA ponds	Soil berm
Dam construction/removal	2	ls	10,000	20,000	Engineer's Estimate	Including traffic control
Excavation Dewatering:						
Well Water recovery and treatment system	1	ls	24,480	24,480	Engineer's Estimate	
Wellhead plumbing and electrical connection	1	ls	7,000	7,000	Engineer's Estimate/Means 2006	240' 4" PVC header pipe, 40' 2" PVC indiv. pipe runs, 280' 2" PVC elec. conduit, 4 well vaults, 200' temp fence.
Excavate Contaminated Silt:						
Excavation	900	cy	50	45,000	Various 2005 bids	Excavator, hydraulic crawler mounted 1 CY capacity ($2000/wk) plus operator ($80/hr)
Contaminated soil disposal (includes transport)	1,350	tn	450	607,500	Waste Management estimate	
Creek Restoration:						
GCL in creek bed	5,100	sf	1	5,100	Sinclair Inlet Restoration	Vendor cost of $0.46 delivered plus labor (2 ppl x 2d x 10hr/d x $30/hr)
Habitat restoration	1	ls	65,000	65,000	Sinclair Inlet Restoration	Based on miscellaneous bid items, riparean restoration
PRB Direct Capital Costs:						
PRB vendor design fee	1	ls	10,000	10,000	Envirometal Technologies estimate	
Bench-scale testing	1	ls	15,000	15,000	Envirometal Technologies estimate	
PRB iron	1	ls	520,000	520,000	Envirometal Technologies estimate	
PRB construction	1	ls	450,000	450,000	Envirometal Technologies estimate	
Contaminated soil disposal (includes transport)	1,450	cy	450	652,500	Waste Management estimate	
PRB license fee	12	%	970,000	116,400	Envirometal Technologies estimate	
Subtotal Direct Capital Costs				**2,608,580**		
Direct Capital Cost Contingency (20%)				**521,716**		
Tax (8.8%)				**275,466**		
Total Direct Capital Costs				**3,405,762**		
INDIRECT CAPITAL COSTS						
Engineering pre-design (3% of DCC)	3	%	1,965,450	59,000	Engineer's estimate	includes surveying
Engineering design (4% of DCC)	4	%	1,965,450	79,000	Engineer's estimate	Assumes substantial design effort by vendor
Regulatory compliance (2% DCC)	2	%	1,965,450	39,000	Engineer's estimate	Institutional controls, interaction with agencies, etc.
Construction management (3% DCC)	3	%	1,965,450	59,000	Engineer's estimate	
As-built documentation and monitoring plan	1	ls	20,000	20,000	Engineer's estimate	
Total Indirect Capital Costs				**256,000**		
TOTAL CAPITAL COSTS				**3,660,000**		
OPERATION AND MAINTENANCE COSTS						
Excavation Dewatering O&M:						
Water treatment operation	1	mo	10,000	10,000	Engineers Estimate	
System electrical usage	1	mo	2,000	2,000	Engineers Estimate	
Carbon change-outs	2,000	lb	2.00	4,000	Westates	$2/lb - 1 time recovery of 2,000 lb system
Subtotal Indirect Capital Costs				**16,000**		
Indirect Capital Cost Contingency (25%)				**4,000**		
Total Initial Implementation O&M Costs				**20,000**		
TOTAL IMPLEMENTATION COSTS				**3,680,000**		
ANNUAL COSTS - POST REMOVAL ACTION (30 YEARS)						
Groundwater sampling (semiannual)	2	ea	9,000	18,000	Palermo LTM	Assumes about 4 wells sampled, analysis by Manchester lab, one report per year
Subtotal Annual Costs				**18,000**		
Annual Cost Contingency (15%)				**2,700**		
Total Annual Costs				**20,700**		
Present-Worth Annual O&M (30 years, 5% discount, multiplier = 15.53)				**321,471**		
TOTAL IMPLEMENTATION COSTS (CC + 1 YEAR MONITORING)				**3,700,000**		
TOTAL PRESENT WORTH COSTS				**4,000,000**		

technologies
inc.

22 February 2006

Scott Elkind
Parametrix, Inc.
5700 Kitsap Way, Suite 202
Bremerton, WA 98312

via email: SElkind@parametrix.com

Reference: Potential Application of a Granular Iron PRB at a Site in Chehalis, WA–31846B.88

Dear Mr. Elkind:

Thank you for your interest in using a granular iron permeable reactive barrier (PRB) for remediation of contaminated groundwater at a site in Chehalis, WA. We believe the granular iron technology has the potential to provide a cost-effective remedy for treatment of the volatile organic compounds identified in groundwater at the site. Enclosed is a revised cost estimate regarding a PRB application.

ETI would be happy to attend a meeting or set up a webinar with you and your client to provide you with an update of our technology, as well as discuss the site in more detail. In the meantime, if you have any questions concerning the following cost estimate, please feel free to contact us.

Sincerely,

EnviroMetal Technologies Inc.

via email

Jennifer Son, B.A. Sc.
Remediation Engineering

via email

Stephanie O'Hannesin, M.Sc.
Principal Hydrogeologist

Attachment

technologies inc.

Cost Estimate

31846B.88 REVISED

Potential PRB Application at a Site in Chehalis, WA

21 February 2006

EnviroMetal Technologies Inc. (ETI) has prepared a revised cost estimate for using a granular iron permeable reactive barrier (PRB) for groundwater remediation at a site in Chehalis, WA. It is ETI's understanding that the site conditions are the same as in 2004 and therefore, the data on water quality data, hydrogeologic information and design parameters (Table 1) received from URS on 10 March 2004 will be used.

From our initial review of the data, ETI is confident that a granular iron PRB will degrade the tetrachloroethene (PCE) and trichloroethene (TCE), as well as their breakdown products, like cis 1,2-dichloroethene (cDCE) and vinyl chloride (VC), present in the site groundwater to non-toxic compounds. A brief description of the chemistry involved in this process can be found in Attachment A. To date, granular iron PRBs have been installed at over 130 sites in the United States, Canada, Europe, Japan, and Australia. These PRBs have been installed at Superfund sites; as part of brownfield site redevelopment; at various active manufacturing, DoD and DOE facilities; at several former dry cleaning facilities; and landfills. The earliest commercial applications in California and Belfast, Ireland have been in operation for the past 11 years. These installations have performed consistently with the expectation that they will continue to perform for another 5 to 10 years without any maintenance.

Using data from these sites, we have prepared a preliminary cost estimate for an *in-situ* PRB system at the site. Further detailed design information would be required in order to refine this cost estimate.

PRB Technology Implementation

ETI's typical approach to applying our PRB technology involves an initial review of hydrogeologic data and site visit/meeting. Treatability testing with site groundwater may be undertaken to obtain design parameters for use in the field application, however for more common volatile organic compounds (VOCs), ETI's database of degradation rates can be used. ETI then acts as part of the design and implementation team to assist with the PRB installation. ETI assistance is provided on a professional time and expense basis for this work. For a description of ETI's involvement and cost, please refer to Attachment A and Table 2.

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Web page: www.eti.ca

Cost Estimate for PRB Application

Based on previous discussions with URS, ETI has considered two separate PRBs at the site:

- Source PRB: a 340 ft long PRB located directly west and parallel to the contaminated creek bed to remove most of the PCE mass emanating from the source area; and
- Secondary PRB: a secondary 800 ft long PRB intercepting the VOC plume about 500 ft west of the source PRB to treat the lower concentrations of VOCs present.

Based on ETI's database of half-lives, a residence time of 1.7 days would be required to reduce the anticipated VOC concentrations entering the source PRB by 85% total mass, which is the provisional cleanup goal at this location. Note that the residence time in the source PRB would increase to 1.9 days for 90% mass removal and to 2.5 days for 95% mass removal. The required residence time in the secondary PRB to achieve the U.S. Federal MCLs is 2.2 days. The influent concentrations and regulatory limits used for residence time calculations are listed in Table 1. ETI would recommend a review of both the organic and inorganic site data, before determining if bench-scale testing would be necessary to refine this estimate of residence time.

Based on a groundwater velocity of 0.36 ft/day, a theoretical iron thickness of 0.6 and 0.8 ft would provide the required residence times for achieving the cleanup goals in the source and secondary PRB, respectively. Based on the construction method used for the installation of a PRB, the granular iron is mixed with similar grain size native sand, as a bulking agent, where the construction thickness of a trench may be wider than the required iron amount. Note that the required iron thickness is directly proportional to the groundwater flow velocity.

For the iron PRBs with a saturated depth of 40 ft, the total amount of iron can be calculated as follows:

Volume of Iron	=	length of treatment zone × saturated depth × flow-through thickness
Source PRB	=	340 ft × 40 ft × 0.6 ft = 8,160 ft^3
Secondary PRB	=	800 ft × 40 ft × 0.8 ft = 25,600 ft^3

Assuming a bulk density for the iron material of 0.075 ton/ft^3 and a delivered cost of approximately US$850/ton, the iron requirement for the source PRB would be 612 tons at a cost of $0.52M (Table 1). For the secondary PRB, 1,920 ton would be required at a cost of $1.6M (Table 1). We understand that further site investigation is planned in the area of the secondary PRB. If the concentration of PCE along the 800 ft length varies, then the iron thickness could be tailored to the PCE lateral distribution, thus refining the amount of required iron.

<u>Biopolymer Trenching</u> - Installation of a treatment zone of iron using biopolymer (biodegradable) slurry is similar to constructing a conventional impermeable slurry wall. The biopolymer slurry used is typically guar based. As the trench is excavated, the biopolymer slurry provides stability to the trench walls. Granular iron can then be placed into the trench through the slurry. After some time, the biopolymer slurry breaks down (i.e. become less viscous) allowing groundwater to flow through the iron treatment zone. An estimated cost of

installing a continuous iron wall by this method may be $0.45M and $1.0M for the source and secondary PRBs, respectively (assumes unit cost of $25/ft^2 plus mobilization/demobilization).

Table 2 summarizes the installation costs discussed above. Refinement of these costs will depend on more detailed site information. The site license fee for use of the patented technology at U.S. government site is 12% of capital cost (construction labour and delivered iron costs). Costs for activities such as site preparation, permitting, site construction management, soil disposal, etc., which are not included in the above estimate, should also be taken into account.

Table 1: Summary of PRB Design Parameters

Parameters [a]	Conceptual Design Value	
	Anticipated Influent Concentration (µg/L)	
	Source PRB	Secondary PRB
PCE	135,000	5,000
TCE	1,000	1,000
Cleanup goals	**85% mass removal**	**Federal MCLs**
Residence Time Required for Treatment (days)	**1.7**	**2.2**
Groundwater Velocity (ft/day)	**0.36**	
Dimensions		
PRB width (ft)	340	800
Depth to Plume Bottom (ft)	48	
Saturated Plume Thickness (ft)	40	
Required Granular Iron Amount and Cost (US$)		
Iron Thickness (ft)	0.6	0.8
Granular Iron Volume [b] (ft^3)	8,160	25,600
Granular Iron Amount [c] (ton)	612	1,920
Delivered Granular Iron Cost [d] (US$850/ton)	$0.52M	$1.6M

[a] Provided by URS
[b] Iron thickness is directly proportional to groundwater flow velocity
[c] Assuming a bulk density for the iron material of 0.075 ton/ft^3
[d] Based on current iron costs

Table 2: PRB Cost Estimate for a site in Chehalis, WA.

PRB Implementation	**Estimated Cost (US$)**	
ETI Assistance with Data Assessment, Field Design and Implementation [a]	$5,000 - $10,000	
Bench Scale Testing [b]	$15,000	
Estimated Contractors Installation Cost:	**Source PRB**	**Secondary PRB**
Delivered Iron Material	$0.52M	$1.60M
Construction [c]	$0.45M	$1.00M
Subtotal	$0.97M	$2.60M
ETI's License Fee (12%)	$0.12M	$0.31M
TOTAL	$1.09M	$2.91M

Detailed cost estimates can be provided upon request.

[a] Based on professional time and expenses.

[b] Costs of sample collection and shipment are not included.

[c] Based on cost data from other sites. Would need to be refined based on a more complete review of site data and quotation from construction contractors. Does not include costs for activities such as site preparation/restoration, permitting, soil/water disposal, site construction management, etc.

ATTACHMENT A

IMPLEMENTATION OF A GRANULAR IRON PERMEABLE REACTIVE BARRIER FOR REMEDIATION OF ORGANIC COMPOUNDS IN GROUNDWATER

The Process

ETI's patented process destroys dissolved volatile organic compounds (VOCs) in groundwater, including common chlorinated solvents such as tetrachloroethene (PCE), trichloroethene (TCE), dichloroethenes (DCEs), vinyl chloride (VC) and trichloroethane (TCA). The degradation process involves abiotic reductive dehalogenation on the granular iron surface, with the iron acting as an electron source. During the dehalogenation process, the halide ions on the compound (chloride, fluoride and bromide) are replaced by hydrogen resulting in the transformation of halogenated VOCs to ethene, ethane, methane and the release of halide ions (Cl^-, Fl^- and Br^-) into solution. ETI's technology, also know as granular iron permeable reactive barrier (PRB) technology, is applicable under most geochemical conditions and does not require frequent reapplications, resulting in a predictable, reliable, long-term treatment solution.

ETI's Assistance with Implementation of PRB Technology

ETI's staff of professional hydrogeologists and engineers are retained by site owners, consultants and government agencies to assist with the site assessment, design, installation and evaluation of PRBs. Senior staff at ETI have been involved with the technology from its initial development and are amongst the most experienced professionals worldwide in the application of this technology. Particular tasks that may involve ETI's expertise include:

- a review of available site hydrogeology and groundwater chemistry;
- bench-scale testing, if required;
- determination of residence time requirements for VOC treatment;
- consultation on system configuration and design;
- determination of granular iron treatment zone dimensions;
- consultation on groundwater flow modeling;
- assistance in selecting an appropriate construction method and contractor;
- provision of construction specifications;
- specification/procurement/quality assurance testing of reactive material;
- assistance during field installation;
- development of a performance monitoring program; and
- data interpretation and evaluation of system performance.

Residence Time Requirement

ETI strongly recommends bench-scale testing using site water, if the groundwater contains specific organic compounds or inorganic constituents that could affect VOC degradation, or if the project requires that the site-specific degradation rates be determined. Otherwise, ETI's extensive database can be used in the design. The necessity of bench-scale testing is evaluated during the initial data review.

i) Bench-Scale Treatability Testing

Bench-scale treatability tests using groundwater from the site and a commercial granular iron material may be undertaken for certain projects. The bench-scale testing is conducted at the University of Waterloo, Waterloo, Ontario under contract to ETI. The treatability column tests establish site-specific VOC degradation rates under flowing conditions (Figure 1).

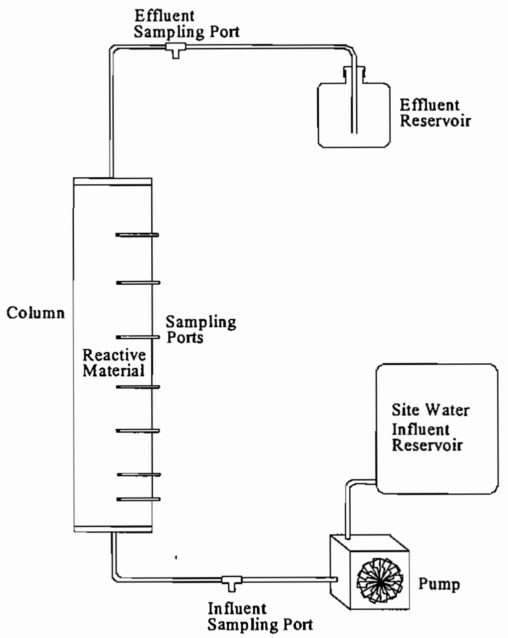

Figure 1: Schematic of the apparatus used in the treatability test.

The laboratory column tests also include inorganic sampling of column influent and effluent. Based on expected VOC design influent concentrations and the desired effluent, the VOC degradation rates determined from bench-scale testing are used to determine the required residence time in the reactive material. Using the residence time and the expected groundwater flow velocity, the size of the treatment zone is determined. These tests enable site-specific prediction of system performance and provide data for field design.

Depending on the flow velocity selected, the test may run for approximately 1 to 2 months. A report providing the results and interpretations of the treatability studies will be issued at the conclusion of the column testing. The report will contain:

- all chemical analyses completed on column samples;
- calculated degradation rates of organic compounds;
- summary tables of major results; and
- graphs showing degradation behavior.

These results will be interpreted in the context of the site hydrogeologic data to provide a basic conceptual residence time simulations for field-scale designs. Detailed bench-scale treatability procedures and water shipment instructions can be provided upon request.

ii) ETI Database

As an alternative to completing bench-sale testing, degradation rates from ETI's database can be used in design. ETI has completed over 300 treatability tests using a variety of commercial iron sources and a wide range of groundwater characteristics. The database is searched to select VOC degradation rates for sites with similar groundwater characteristics to the subject site. Based on the expected VOC design influent concentrations and the desired effluent criteria, residence time requirements are estimated for the field application using these degradation rates.

Maintenance

Other than groundwater monitoring, the only maintenance issue may be the need for periodic rejuvenation of granular iron sections affected by precipitates. The granular iron material itself should last for decades. The precipitates (if significant) will likely form in a zone on the upgradient face of the PRB. We note that no significant precipitates were observed in cores from an *in-situ* reactive wall at an Ontario test site 4 and 10 years after it was installed as well, the iron reactivity was maintained at this site for over 10 years. There is also no evidence of plugging or sliming in commercial *in-situ* systems operating successfully for over 11 years. Based on these field data, most sites will not require rejuvenation until after 15 years of operation.

The objective of rejuvenation of the granular iron would be to restore the reactivity and permeability of the iron material. Since it is presumed that the majority of the precipitate formation will occur on the upgradient face of the PRB, rejuvenation methods would likely target the upgradient face. Possible rejuvenation methods include:

1) Using ultrasound to break-up the precipitate on the upgradient face;
2) Using a pressure wave hydraulic pulse method to break-up the precipitate;
3) Using solid-stem augers to agitate the upgradient face of the PRB.

To date these possible rejuvenation methods have not been needed and only ultrasound has been tested in the field to determine its effectiveness. At this point we can only state that these methods may prove to be successful in rejuvenating a PRB, and as stated above, will only be necessary at 15 year intervals at most sites.

Costs Involved in Technology Implementation

i) ETI Technical Assistance

ETI normally bills on a time and materials basis for our assistance in performing the design activities listed herein, with the exception of bench-scale studies, which are completed on a lump sum basis. Detailed cost estimates can be provided upon request. ETI retains the right to have on-site representation during the installation phase of the project.

ii) Site License

ETI has been granted exclusive worldwide rights for commercialization of this patented technology by the patent holder, the University of Waterloo. A site license fee of 15% of capital construction costs is normally charged should full-scale implementation of the technology at the site proceed. The fee is based on the cost of delivered iron to the site and the treatment system construction (including mobilization and demobilization). Discounts are available to end users with multiple site applications.

Alternative 5 - Hydraulic Containment

Description	Quantity	Unit	Unit Costs ($)	Costs ($)	Source	Notes
DIRECT CAPITAL COSTS						
Temporary Diversion of Berwick Creek:						
Mobilization/demobilization	1	ls	50,000	50,000	Misc. Projects	Roughly 8% total cost for activity
Fish roundup	1	day	3,500	3,500	Bob Sullivan verbal	2 ppl x 1d x 10 hr/d x $80/hr, plus equipment and planning ($800)
Pump - creek water	4	wk	2,000	8,000	Means 2006	Electric Submersible Pump- 4" 560 GPM rental ($600/wk.) plus 24 hr operation ($1400/wk)
4-inch PVC pipe (includes installation)	350	lf	8	2,800	Misc Bid Sheets/Means 2006	
Dam materials	65	cy	20	1,300	Engineer's Estimate/PA ponds	Soil berm
Dam construction/removal	2	ls	10,000	20,000	Engineer's Estimate	
Excavate Contaminated Silt:						
Excavation	900	cy	50	45,000	Various 2005 bids	
Contaminated soil disposal (includes transport)	1,350	tn	450	607,500	Waste Management estimate	
Creek Restoration:						
GCL in creek bed	5,100	sf	1	5,100	Sinclair Inlet Restoration	Vendor cost of $0.46 delivered plus labor (2 ppl x 2d x 10hr/d x $30/hr)
Habitat restoration	1	ls	65,000	65,000	Sinclair Inlet Restoration	
Combined Dewatering/Hydraulic Control System:						
Water treatment system purchase	1	ls	148,000	148,000	H2Oil estimate	includes shipping ($2k), electrical ($5k), installation ($20k)
Electrical power drop	1	ls	10,000	10,000	Engineer's Estimate	
Wellhead plumbing and electrical connection	1	ls	15,000	15,000	Means 2006	710', 4" header pipe, 80', 2" PVC indiv. Pipe runs, 790', 2" elec.conduit. New vaults at 8 wells.
Discharge plumbing	50	lf	50	2,500	Means 2006	50 feet of discharge piping from system to Berwick Creek, with riprap stabilized outfall.
Concrete pad w/ fencing	1	ls	10,500	10,500	Means 2006	Assume 8' tall industrial security fence + gate, 10x10concrete pad with curb ($1500), sump pump ($500)
Subtotal Direct Capital Costs				**994,200**		
Direct Capital Cost Contingency (20%)				**198,840**		
Tax (8.8%)				**104,988**		
Total Direct Capital Cost				**1,298,028**		
INDIRECT CAPITAL COSTS						
Engineering pre-design (4% of DCC)	4	%	1,298,028	52,000	Engineer's Estimate	Include survey
Engineering design (4% of DCC)	4	%	1,298,028	52,000	Engineer's Estimate	
Regulatory compliance (2% DCC)	3	%	1,298,028	39,000	Engineer's Estimate	Institutional controls, interaction with agencies, etc.
Construction management (4% DCC)	8	%	1,298,028	104,000	Engineer's Estimate	
As-built documentation, O&M plan, monitoring plan	1	ls	30,000	30,000	Engineer's Estimate	
Total Indirect Capital Costs				**277,000**		
TOTAL CAPITAL COSTS				**1,580,000**		
OPERATION AND MAINTENANCE COSTS (30 YEARS)						
Maintenance and oversight	12	mo	10,000	120,000	Engineer's Estimate	Assumes costs slightly less than Well 12A, which was $140,000 per year, labor and misc. ODCs
Groundwater sampling (semiannual)	2	sem	27,000	54,000	Palermo LTM costs	Assumes about 12 wells sampled, analysis by Manchester lab, one report per year
System electrical usage	1	yr	10,500	10,500	H2Oil estimate	Based on electrical draw of system components - $0.03/kW-hr
Major repair (1 per year, as a percent of system cost)	5	%	148,000	7,000	Percent of system capital costs	Assume 5% of original system cost in major repair per year
Carbon change-outs	4,000	lb	1.75	7,000	Westates	$1.75/lb
Subtotal O&M				**198,500**		
O&M Contingency (15%)				**29,775**		
Total Annual O&M				**228,275**		
Present-Worth Annual O&M (30 years, 5% discount, multiplier = 15.53)				**3,545,111**		
TOTAL IMPLEMENTATION COSTS (CC + 1 YEAR O&M)				**1,810,000**		
TOTAL PRESENT WORTH COSTS				**5,130,000**		

H2 Oil Recovery Equipment, Inc.

P.O. Box 9028, Bend, OR 97708 (541) 382-7070 Fax (541) 382-2242

Friday, March 31, 2006

Lily Isenhart
Parametrix
5700 Kitsap Way #202
Bremerton, WA 98312

H2 Reference #240026KW rev 06A
Hamilton/Labree EPA superfund site
Chehalis WA

Dear Lily:

H2 Oil Recovery Equipment, Inc. is pleased to offer **budgetary** pricing on the following remediation equipment based on information received.

A. (1) H2TFPS-Redi-Flow3 Total Fluids Submersible Pumping System -

To include: (75 gpm total flow)

- (8) Grundfos 3" submersible environmental pumps model 10Redi-Flow 3-220 with a 3/4 HP, 230 VAC 1 phase motors
- (8) 50' of two-wire environmental power leads
- (8) 50' of support cables
- (8) Total fluids intrinsic down well sensor with 50' leads
- (8) 50' of 1 1/4" rubber wall discharge hoses, coupled to pump with cam lock fitting
- (8) Flow meters
- UL listed electrical assembly including (8) motor starters with thermal overload protection, on/off switch for pump, status indicating lamps for power on, pump on and standby, on delay timer, intrinsic sensor relay, mounted in a NEMA 4 enclosure (shipped loose)
- Factory tested

B. (1) H2 TS600 2x6 4 Tray Aeration Water Treatment System -

To include: (80 gpm flow)

- Stainless steel, low profile tray stripper
- (4) 2 ft. x 6 ft. stainless steel removable trays
- (4) Tray inspection ports
- Siphon break for gravity drain
- Pumped effluent discharge port

- Stainless steel demister
- Dwyer Magnehelic differential pressure gauge
- Sump level site tube
- Rotron DR979 600 SCFM fan with 20 HP 240 VAC, TEFC 3 phase motor with a weather protective hood and inlet silencer
- Sump high level switch
- (1) Flow meter with transmitter
- Skid mounted
- Factory paint and tested
- UL listed electrical assembly with (3) motor starters for the blower and influent and effluent batch pump, with thermal overloads, pressure switch, hand/off/auto switches, intrinsic relays for batch pump sensors and tray stripper sump high level switch, on/off delay timers, status indicating lights, chart recorder for recording total flow, Pico mini PLC, panel heater, mounted in a NEMA 4 enclosure

C. (1) H2 BPS-2ST Batch Pump System -

To include:

- (2) Close coupled centrifugal stainless steel pumps with a 2 HP, 240 VAC, 60 Hz, 3 phase TEFC motor
- 80 GPM at 50 ft total dynamic head
- Conductance pump control sensors with 20 ft. lead
- Factory paint and tested
- (1) 600 gal poly batch tank with high level shutdown and intrinsic module
- (1) Dual bag filter system with pressure switch
- Mounted on the stripper skid

D. (2) H2-2000 liquid phase carbon vessels with 2000 lbs of reactivated carbon

E. (2) H2TSU-1000 vapor phase carbon vessels with 1000 lbs of reactivated carbon

Budgetary Price **$111,000.00**

Notes:

1) This quote is subject to H2 Oil's standard warranty-disclaimer.

2) Shipment of equipment 8 to 10 weeks after receipt of order. This is based on current back log and could change prior to receipt of an approved order.

3) Equipment skids that incorporate integrated controls and wiring meet our facilities local and national electrical codes. It is the buyers responsibility to determine if additional electrical codes apply for the location of this system.

4) Carbon prices do not include regeneration of spent carbon

5)The performance of our tray stripper has been estimated on the basis of computer modeling for the removal of dissolved VOC contaminants only. Performance of this water treatment unit can be greatly effected by unknown site specific conditions such as oils, greases, free product and various dissolved or particulate matter. No compensation or corrections have been made for these unknown conditions.

Prices do not include any applicable sales tax, electrical service equipment (breaker panel, main disconnect, or meter base), or installation, unless specifically noted. Price duration is 60 days.

Terms: Shipping is FOB at Buyer's expense, H2 Oil Recovery Equipment, Inc., Bend, Oregon. Buyer bears risk of loss during shipping. Seller shall notify Buyer of shipment. Payment terms are Net 30 days from date of shipment. Payment by check in US funds payable to H2 Oil Recovery Equipment, Inc., unless otherwise agreed. Service charges will be computed at 1.5% per month (18% per year) on amounts past due. Products are deemed accepted on the third business day following date of delivery. Acceptance cannot be revoked.

Seller reserves all remedies available under the Uniform Commercial Code as codified under the revised statutes for the State of Oregon in effect at the time of this agreement or as subsequently amended. Buyer waives any right to the remedy of "cover" and all claims for injury to person or property arising out of the manufacture, production, sale or use of the product(s). Buyer authorizes, at Seller's option, as liquidated damages and not a penalty, a sum equal to a minimum of 50% of purchase contract price in the event of Buyer's breach or repudiation of the contract. Buyer's remedy for Seller's breach is limited to return of the product(s) for the price paid, at Seller's option, repair or replacement of any non conforming product(s).

Any action for breach of contract must be brought within one year after the claim accrues.

Venue for any dispute regarding this agreement in any way is exclusively in the courts for Deschutes County, Oregon and governed by Oregon law. The prevailing party in any such dispute shall recover from the other its reasonable attorney fees, whether incurred at arbitration, trial or on appeal.

Buyer confirms this is a firm offer to purchase the attached product(s) under the terms stated above.

Buyer's confirmation of purchase order, acceptance of terms and H2 Oil's standard warranty-disclaimer, and H2 Oil's standard rental agreement is represented by signature below.

Total Purchase Price: ____________________

Purchase Order Number: __________________

Shipping Date: _________________________

By: __________________________________

Printed Name: ______________________

Title: ______________________

Date: ______________________

Company: ______________________

Best Regards,

Kevin Wooster, P.E.
H2 Oil Recovery Equipment, Inc.
h2oilrecovery.com
email: sales@h2oilrecovery.com