Final
Feasibility Study Report
Kaiser Trentwood Facility
Spokane Valley, Washington

Volume I

Prepared for
Kaiser Aluminum
Washington, LLC

May 2012
2644-125

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VOLUME II

ACRONYMS AND ABBREVIATIONS

AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
BACT	best available control technology
BCY	bank cubic yards
bgs	below ground surface
BMP	best management practice
CAP	Cleanup Action Plan
CCPL	Continuous Can Process Line
COC	constituent of concern
COPC	constituent of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CQAP	Construction Quality Assurance Plan
CUL	cleanup level
CWA	Clean Water Act
CY	cubic yards
DCA	disproportionate cost analysis
DW	dangerous waste
FCT	Field-Constructed Tanks
FPP	free phase product
FS	feasibility study
FSTM	Feasibility Study Technical Memorandum
GAC	granular activated carbon
gpd	gallons per day
gpm	gallons per minute
HASP	Health and Safety Plan
HDPE	high-density polyethylene
HHERA	Final Human Health and Ecological Risk Assessments
HMA	hot-mix asphalt
IRM	interim remedial measure
LCY	loose cubic yards
LF	linear feet
LNAPL	light non-aqueous phase liquid
MCL	maximum contaminant limit
MGD	million gallons per day
mg/L	milligrams per liter
mmHg	millimeters of mercury
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
ng/L	nanograms per liter

NPV	net present value
NTU	nephelometric turbidity unit
O&M	operation and maintenance
ORB	Oil Reclamation Building
PAC	powdered activated carbon
PCB	polychlorinated biphenyl
PCUL	preliminary cleanup level
PFD	process flow diagram
POC	point of compliance
PPE	personal protective equipment
psig	pounds per square inch, gauge
RAO	remedial action objective
RBSL	risk-based screening level
RCRA	Resource Conservation and Recovery Act
RCU	Former Rail Car Unloading area
RI	remedial investigation
SAP	Sampling and Analysis Plan
SBR	sequencing batch reactor
scfm	standard cubic feet per minute
SDR	South Discharge Ravine
SDWA	Safe Drinking Water Act
SL	screening level
SPCC Plan	Spill Prevention Control and Countermeasure Plan
sq ft	square feet
SRCAA	Spokane Regional Clean Air Agency
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SWPPP	Stormwater Pollution Prevention Plan
TAP	toxic air pollutant
TCLP	toxicity characteristic leaching procedure
TMDL	total maximum daily load
TSCA	Toxic Substances Control Act
TSS	total suspended solids
UIC	Underground Injection Control (Program)
UV	ultraviolet
VOC	volatile organic compound
WDR	West Discharge Ravine
WWTP	Wastewater Treatment Plant
μm	micrometer (micron)
μg/L	micrograms per liter

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EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY
FINAL SITE-WIDE FEASIBILITY STUDY
KAISER TRENTWOOD FACILITY
SPOKANE VALLEY, WASHINGTON

ES.1 INTRODUCTION

This report presents the results of the site-wide Feasibility Study (FS) conducted on behalf of Kaiser Aluminum Washington, LLC (Kaiser) at its Trentwood Facility (Facility) located at East 15000 Euclid Avenue in Spokane Valley, Washington.

This FS was conducted pursuant to the requirements outlined in Task IX of Exhibit B to Agreed Order No. DE 2692 between Kaiser and the Washington State Department of Ecology (Ecology), dated August 16, 2005. The Agreed Order requires Kaiser to complete a FS that develops cleanup levels, develops remedial alternatives and evaluates the remedial alternatives based on the criteria in WAC 173-340-360.

This document is the site-wide FS report for soil and groundwater at the Facility. It builds upon the information and analyses summarized in the Final Feasibility Study Technical Memorandum (FSTM) (Hart Crowser 2012c). The FSTM is an integral part of the overall FS for the Facility. The FSTM began the process of developing technology-based remedial alternatives for the soil and groundwater at the Facility.

The FSTM:

- Identified constituents of potential concern (COPCs) and conservative screening levels (SLs) for those constituents and used a screening process approved by Ecology to identify constituents of concern (COCs) to be carried through the FS process.

- Divided the soil and groundwater at the Facility into five distinct segments, presented in Sections 2 through 5 of this FS and summarized below. The segments were selected since differing groups of technologies are applied to remediate the COCs contained in the environmental media present in each segment.

- Identified potential remediation technologies that may be applicable to each COC present in soil and groundwater throughout the Facility.

- Conducted an initial technical screening of the potential remediation technologies to identify those technologies and process options that were judged to be implementable and reliable for each COC present in soil and groundwater throughout the Facility.

- Defined the areas of concern (AOC) throughout the Facility, where the COCs are present in soil and groundwater.

- Developed technology-based remedial alternatives for the individual COCs and mixtures of COCs present in each segment of the Facility.

Ecology issued draft cleanup standards for the soil and groundwater at the Kaiser facility during May 2010 (Ecology 2010a and 2010b). These draft cleanup standards are summarized for soil in Table 2-1 and for groundwater in Table 4-1 of this FS.

ES.1.1 Purpose

The primary purpose of this site-wide FS is to:

- Conduct a final screening of the technologies judged to be implementable and reliable by the FSTM. This final screening includes a cost screening when appropriate.

- Evaluate the technology-based remedial alternatives based on the criteria in WAC 173-340-360 to identify the most appropriate technology-based alternatives for each individual COC or mixture of COCs in the environmental segments (media) present at the Facility. The FSTM carried forward smear zone soil as an individual environmental segment of the Facility. This FS judged that it was more appropriate to consider smear zone soil together with the groundwater that contacts this soil. Facility media were divided into four environmental segments: near-surface soil, deep vadose zone soil, the petroleum hydrocarbon plumes and associated smear zone soil, and the Remelt/Hot Line PCB plume and associated smear zone soil. The evaluations of the technology-based remedial alternatives for each segment of the Facility are presented in Sections 2 through 5 of this FS.

- Assemble the most appropriate technology-based remedial alternatives for each segment of the Facility, to identify the appropriate area-based remedial alternative(s) for each operating area of the Facility (e.g., Oil House area, Wastewater Treatment area, etc.). The recommended remedial alternatives for each area of the Facility are presented in Section 6 of this FS.

ES.2 RECOMMENDED TECHNOLOGY-BASED REMEDIATION ALTERNATIVES

Technology-based remedial alternatives identified as potential alternatives for each segment of the Facility were initially assessed to determine whether they met the threshold requirements established by MTCA (WAC 173-340-360[2][a]). Disproportionate cost analyses (WAC 173-340-360[3][e]) were conducted to determine whether the technology-based remedial alternatives that met threshold requirements used permanent solutions to the maximum extent practicable. Each technology-based remedial alternative was then evaluated to determine whether it provided for a reasonable restoration time frame (WAC 173-240-360[4]). A comparative analysis of alternatives was conducted to assess the relative capability of alternatives that met threshold requirements to use permanent solutions to the maximum extent practicable, and to provide for a reasonable restoration time frame. The comparative analysis was used to identify the most appropriate technology-based alternative for each segment of the Facility.

The most appropriate technology-based remedial alternatives identified in Sections 2 through 5 of this FS are listed in Table 6-1 and are summarized below.

ES.2.1 Near-Surface Soil

Near-surface soil consists of soil within the top 20 feet of the soil column. Alternative A2, which consists of institutional controls, monitoring, monitored natural attenuation (MNA), and containment, was selected as the most appropriate treatment alternative for each of the COCs (VOCs, SVOC, PCBs, metals [lead, arsenic]) that are in the near-surface soil at concentrations above screening levels (SLs) at the Facility. The containment surfaces provided in Alternative A2 isolate Facility workers and visitors from the COCs in near-surface soil and prevent rainwater infiltration through near-surface soil, which prevents COC migration from near-surface soil to groundwater and potentially to receptors in the Spokane River.

Alternative A2 is described in detail in Section 2.1.2 of this FS. Ecology agreed that Alternative A2 was a viable alternative for near-surface soil with COCs at concentrations above SLs. However, during review of the Draft FS, Ecology determined that their preferred remedy for some near-surface soil at the Facility was similar to Alternative A4, and would entail the excavation and off-site disposal of near-surface soil under certain conditions (Ecology 2011).

The containment surfaces used in Alternative A2 include existing floor slabs, roadways, and new cap surfaces. These containment surfaces total approximately 128,000 square feet (sq ft), of which approximately 35 percent

(45,300 sq ft) is located below existing floor slabs or pavement in the operating areas of the Facility. Of the approximately 82,700 sq ft that could comprise new cap surfaces under Alternative A2, approximately 60,400 sq ft of surface area fit the criteria (see Section 6.1.1) and can be excavated. The excavated volume is expected to total approximately 29,000 CY.

The containment technologies judged appropriate for near-surface soil include asphalt, concrete, and multi-layer caps (refer to the FSTM Section 2, Hart Crowser 2012c). The footprint over which the cap associated with Alternative A2 could be applied is described in Section 2.1.2.1 of this FS, and the construction of the cap is outlined in Section 2.1.2.2.

The near-surface soil areas of excavation are described in Section 2.1.4.1, and a description of the excavation and off-site disposal process is provided in Section 2.1.4.2. The footprint of near-surface soil areas of excavation and new cap surfaces in each operating area of the Facility are shown in Section 6 of this FS, on Figures 6-1, 6-3, 6-5, 6-7, 6-9, and 6-11 through 6-13.

ES.2.2 Deep Vadose Zone Soil

Deep vadose zone soil consists of soil from 20 feet below the surface to the smear zone near the water table. Alternative B2, which consists of institutional controls, monitoring, MNA, and containment was selected as the most appropriate treatment alternative for VOCs, SVOCs, PCBs comingled with SVOCs, and metals (chromium, arsenic) that are in deep vadose zone soil with constituent concentrations above SLs at the Facility. Alternative B2 is described in detail in Section 3.1.2 of this FS. The containment surfaces provided in Alternative B2 prevent the infiltration of rainwater through deep vadose zone soil and thus prevent the migration of COCs from deep vadose zone soil to groundwater.

The consolidated area of deep vadose zone soil AOCs totals approximately 44,000 sq ft, of which approximately 62 percent (27,400 sq ft) is located below existing floor slabs, pavement, or caps (i.e., Hoffman Tank area multi-layer cap) within the operating areas. The total area of potential new cap installed in Alternative B2 is approximately 19,800 sq ft.

Some of the potential new cap areas overlap with the cap area identified in Alternative A2 to contain near-surface soil AOCs. The consolidated cap areas needed to isolate Facility workers and visitors from COCs in near-surface soil, prevent rainwater infiltration through near-surface and deep vadose zone soil, and prevent the migration of COCs from soil to groundwater and potentially to receptors in the Spokane River, are defined for each operating area of the Facility on Figures 6-1, 6-3, 6-5, 6-7, 6-9, and 6-11 through 6-13.

Alternative B5, consisting of institutional controls, monitoring, MNA, and containment, was selected as the most appropriate remedial alternative for PCBs not comingled with SVOCs that are in deep vadose zone soil at the Facility. Alternative B5 is described in detail in Section 3.1.5 of this FS. The deep vadose zone soil AOCs where PCBs not comingled with SVOCs are located below the concrete floor slab of the existing building in the Remelt area and below the existing pavement in the Oil House French Drain area. The surface area of these PCB AOCs totals approximately 6,900 sq ft.

The floor slab above these AOCs is assumed to be suitable as a containment cap in its current condition. Thus, Alternative B5 will not require the installation of new containment caps; however, monitoring to ensure floor slab integrity and effective containment of the deep vadose zone PCB AOCs will be required.

An index of the text and tables that summarize the comparative evaluation process for Alternatives B2 and B5 is provided in Table 6-3. The footprints of new cap surfaces for deep vadose zone soil in each operating area of the Facility are shown on Figures 6-1, 6-3, 6-5, 6-7, 6-9, and 6-11 through 6-13.

ES.2.3 Petroleum Hydrocarbon Plumes and Associated Smear Zone Soil

Petroleum hydrocarbon plumes are located in the Oil House, Cold Mill, Wastewater Treatment, and Oil Reclamation Building (ORB) areas of the Facility. The smear zone soil and petroleum hydrocarbon plume AOCs are located at depths that prevent Facility workers and visitors from direct contact with COCs in these areas.

Smear zone soil and accumulations of free phase product (FPP) are in contact with groundwater, which allows for the transport of COCs from soil and FPP in these AOCs into groundwater. Current operation of the groundwater interim remedial measure (IRM) provides hydraulic containment of the majority of the petroleum hydrocarbon plumes present at the Facility and recovers FPP from the surface of the water table (refer to Section 4.1.1.2).

The petroleum hydrocarbon plumes, FPP, and smear zone soil AOCs are shown on Figures 4-1 through 4-3. The petroleum and FPP AOCs shown on these figures are generally smaller in area than shown on corresponding Figures 5-1 through 5-3 in the FSTM. The figures in the FSTM were based on data collected through 2008. Figures 4-1 through 4-3 in this FS include more recent data collected during 2009 and 2010.

The extent of the FPP plumes has decreased by 82 and 94 percent in the Wastewater Treatment and Oil House areas, respectively, from historical highs (Hart Crowser 2012b). More than 4,000 gallons of FPP have been removed using pumps and belt skimmers from the source areas at the Facility (Hart Crowser 2012b).

The petroleum hydrocarbon plumes are shrinking based on the comparison of the maximum historical lateral extent of hydrocarbons to data from 2008 (Hart Crowser 2012b). The groundwater concentrations within these plumes have also decreased over the past decade (Hart Crowser 2012b). This shrinking footprint of the petroleum hydrocarbon plumes is attributed to the FPP removal and natural attenuation that has occurred and is continuing to occur in the plumes (refer to Appendix F). An assessment of the biodegradation processes included in Appendix F also indicates that PCBs comingled with SVOCs in the petroleum plumes and associated smear zone soil are also subject to biodegradation as the PCBs are released by the SVOCs or otherwise enter the aqueous phase where biodegradation of PCBs under anaerobic or aerobic conditions can occur.

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established. These tests will focus on both anaerobic and aerobic processes that may be present within the Oil House and Wastewater areas.

The existing groundwater IRM system in the Oil House and Wastewater Treatment areas of the Facility is used to control the migration of COCs and FPP with groundwater pumping, FPP removal from the surface of the water table, and enhancement of biodegradation of dissolved and residual petroleum hydrocarbons in groundwater in localized areas of the Facility.

Alternative C2 was selected as the most appropriate remediation alternative for the petroleum hydrocarbon plumes and associated smear zone soil at the Facility. Alternative C2 provides additional containment and FPP removal capability in addition to the institutional control, MNA, and IRM features that are currently present or planned at the Facility (refer to Section 4.1.2).

Alternative C2 contains an extraction well near the ORB petroleum hydrocarbon plume to provide the hydraulic containment of this plume. However, because of ongoing natural attenuation processes, the limited extent of the petroleum hydrocarbon plume in this area, and data that show that the petroleum plume is shrinking, it has been determined that the ORB containment system is not necessary to meet MTCA requirements and protect human health and the environment. As a result, a new extraction well located in the ORB area to contain the ORB petroleum hydrocarbon plume will not be installed.

Alternative C2 is described in detail in Section 4.1.2 of this FS. Alternative C2 uses institutional controls, containment, FPP recovery, MNA, and monitoring to break the pathways by which COCs in the petroleum hydrocarbon plumes and associated smear zone soil can reach potential receptors at the Facility or in the Spokane River. An index of the text and tables that summarize the comparative evaluation process for Alternative C2 is provided in Table 6-4 of this FS.

ES.2.4 Remelt/Hot Line PCB Plume and Associated Smear Zone Soil

The Remelt/Hot Line PCB plume extends from the Remelt area of the Facility to about 650 feet from the Spokane River (Figures 5-2, 5-3, and 5-4). Alternative D2 was selected as the most appropriate remediation alternative for the Remelt/Hot Line plume and associated smear zone soil at the Facility. Alternative D2 provides hydraulic containment in addition to the institutional controls, MNA, and monitoring features that are currently present or planned at the Facility.

The leading edge of the Remelt/Hot Line plume is considered to be stable and located more than 650 feet from the Spokane River. The future use of proposed EPA Method 1668 to measure ultra-low PCB concentrations may indicate that PCBs reach the river at a concentration below 0.0045 micrograms per liter (µg/L), and perhaps below a concentration of 0.000064 µg/L. If PCBs reach the river from the Remelt/Hot Line plume at concentrations above 0.000064 µg/L, the combined benefit of natural attenuation and containment provided by the implementation of Alternative D2 would prevent even these low concentrations of PCBs located upgradient of the groundwater containment system from reaching the receptors in the Spokane River.

Hydraulic containment of the Remelt/Hot Line PCB plume was considered necessary to assure that MTCA minimum requirements would be achieved, particularly if proposed EPA Method 1668 is approved for use by both the EPA and Ecology to measure ultra-low PCB concentrations and this method indicates that PCBs reach the river at a concentration above 0.000064 µg/L. A series of three extraction wells located to the southwest of the Remelt building, near wells HL-MW-14S and HL-MW-6A (refer to Figures 5-6 and 6-8), will be installed to contain the Remelt/Hot Line plume even though this plume does not currently appear to be reaching the Spokane River (based on modified Method 8082 with a MDL of 0.0045 µg/L). The containment system will be operated until additional downgradient monitoring information is collected to confirm that the

Remelt/Hot Line plume is not advancing and is in fact retreating toward its source area in the Remelt building.

The extracted groundwater (approximately 3 million gallons per day [MGD]) will be transported to a location upgradient of the Oil House petroleum hydrocarbon plume (refer to Figure 6-2) and reintroduced to the subsurface. Because PCBs are hydrophobic (Hart Crowser 2012a), and because of their affinity for petroleum hydrocarbons, the PCBs are expected to initially become adsorbed or sequestered by the SVOCs in the smear zone soil and FPP. The PCBs are expected to be attenuated by the natural processes that will anaerobically and aerobically degrade the PCBs as they are released by the SVOCs and enter the aqueous phase (refer to Appendix F).

The PCBs (approximately 9 pounds) that are presently comingled with SVOCs (approximately 587,000 pounds) (refer to Appendix I) and the very small quantities of additional PCBs that will be introduced to the Oil House area by implementation of Alternative D2 (approximately 5.1 pounds over 30 years) are expected to be biodegraded by anaerobic and aerobic microbes (refer to Appendix F) as the PCBs enter the aqueous phase over time.

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established. These tests will focus on both anaerobic and aerobic processes that may be present within the Oil House and Wastewater areas

Neither SVOC nor PCB concentrations above SLs have been detected in groundwater downgradient from the localized Oil House area petroleum hydrocarbon plumes (refer to Section 4.1.1.1). The containment of the petroleum hydrocarbon plumes in the Oil House area by the currently operating IRM provides an additional level of protection to human health and the environment beyond the protection provided by the ongoing natural attenuation of the plumes. In the unlikely event that any PCBs (even colloidal PCBs, such as those in the Remelt/Hot Line plume) are not biodegraded within the Oil House area, and evade hydraulic containment provided by the IRM system for this area, it is expected that natural attenuation processes would reduce the concentration of these PCBs to below the PCUL for protection of the river of 0.000064 µg/L as a result of the processes that are now attenuating the Remelt/Hot Line PCB plume (refer to Appendix E).

Alternative D2 is described in detail in Section 5.1.2 of this FS. An index of the text and tables that summarize the comparative evaluation process for Alternative D2 is summarized in Table 6-5 of this FS.

ES.3 AREA-BASED REMEDIATION ALTERNATIVES FOR THE KAISER FACILITY

The technology-based remedial alternatives selected for each segment of the Facility are summarized in Section ES.2. The first step in assembling these alternatives into remedial alternatives appropriate for each area of the Facility is to identify the affected areas of the Facility. The affected operating areas of the Facility (see Figure 2-1) were identified as the:

- Oil House area (Figures 6-1 and 6-2);
- Wastewater Treatment area (Figures 6-3 and 6-4);
- Oil Reclamation Building area (Figures 6-5 and 6-6);
- Remelt/Hot Line area (Figures 6-7 and 6-8); and
- Other AOCs (Cold Mill/Finishing area [Figures 6-9 and 6-10], Truck Shop area [Figure 6-11], Former Rail Car Unloading area [Figure 6-3], and Former South and West Discharge Ravine areas [Figures 6-12 and 6-13]).

The environmental media, COCs that are present at concentrations above SLs, and the technology-based remedial alternatives that must be assembled for each area of the Facility are summarized in Table 6-6.

The combination of technology-based remedial alternatives judged to be appropriate for each operating area of the Facility are discussed in Section ES.3.1 through Section ES.3.5. The estimated cost of implementing these remedial alternatives at the Kaiser Facility is presented in Section ES.3.6.

ES.3.1 Most Appropriate Remedial Alternatives for the Oil House Area

The Oil House operating area contains approximately 55 percent of the mass of COCs that are present at concentrations above SLs in the near-surface, deep vadose zone, and smear zone soil at the Facility (percentage derived using modified masses from FSTM Tables 2-18, 3-16, and 4-21). Approximately 98 percent or more of these COCs are SVOCs, primarily diesel, Kensol, and heavy oil. The COCs in Oil House area soil are distributed approximately as follows:

near-surface soil (about 1 percent), deep vadose zone soil (about 14 percent), and smear zone soil (about 85 percent).

Remedial Alternatives A2, B2, and B5, were selected as the most appropriate remedial alternatives for near-surface and deep vadose zone soil (refer to Table 6-6).

The locations that require surface containment in the Oil House area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-1. These areas include existing floor slabs and pavement, as well as new cap surfaces.

The two petroleum hydrocarbon plumes that are in the Oil House area, associated smear zone soil, and recent detections of FPP are shown on Figure 6-2. These petroleum hydrocarbon plumes do not currently present unacceptable risk to human health and the environment.

The groundwater extracted from the Remelt/Hot Line PCB plume to contain its flow and prevent it from flowing toward the Spokane River (refer to Section 6.1.4) will be reintroduced to the soil column at a location upgradient of the Oil House area (refer to Section 5.1.5.2). The approximate location of the infiltration trench used for this purpose is identified on Figures 5-6 and 6-2.

Alternative C2 will remove the remaining FPP that is in the Oil House area to the extent practicable using belt skimmers. Biodegradation of SVOCs present in the petroleum hydrocarbon plumes and associated smear zone soil has occurred and is expected to continue to occur. The PCBs comingled with the SVOCs are expected to be attenuated by the natural processes that will anaerobically and aerobically degrade the PCBs as they are released by the SVOCs and enter the aqueous phase (refer to Appendix F).

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established. These tests will focus on both anaerobic and aerobic processes that may be present within the Oil House and Wastewater areas

In addition, Alternative C2 will use the existing IRM system that is operating at the Facility to contain the shrinking petroleum hydrocarbon plumes in the Oil House area. Thus, three remedial measures (MNA of SVOCs and PCBs comingled with SVOCs, FPP removal, and hydraulic containment) will prevent the SVOCs and PCBs comingled with the SVOCs in the petroleum hydrocarbon plumes from reaching potential receptors in the Spokane River. These remedial measures will supplement the institutional controls and monitoring that are integral parts of Alternatives A2, B2, B5, and C2.

In the unlikely event that any PCBs (even colloidal PCBs, such as those in the Remelt/Hot Line plume) are not biodegraded within the Oil House area, and evade hydraulic containment provided by the IRM system for this area, it is expected that natural attenuation processes would reduce the concentration of these PCBs to below the PCUL of 0.000064 μg/L as a result of the processes that are now attenuating the Remelt/Hot Line plume (refer to Appendix E).

ES.3.2 Most Appropriate Remedial Alternatives for the Wastewater Treatment Area

The Wastewater Treatment area contains approximately 13 percent of the mass of COCs at concentrations above SLs in the near-surface, deep vadose zone, and smear zone soil at the Facility (percentage derived using modified masses from FSTM Tables 2-18, 3-16, and 4-21). Approximately 98 percent or more of these COCs are SVOCs, primarily diesel, Kensol, and heavy oil. The COCs in the Wastewater Treatment area soil are distributed approximately as follows: near-surface soil (about 10 percent), deep vadose zone soil (about 2 percent), and smear zone soil (about 88 percent).

Remedial Alternatives A2, A4, and B2 were selected as the most appropriate remedial alternatives for near-surface and deep vadose zone soil (refer to Table 6-6).

The locations that require surface containment in the Wastewater Treatment area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-3. These areas include existing floor slabs, pavement, and caps, in addition to new capped surfaces. The new capped surfaces include an area adjacent to and to the west of the existing Hoffman Tank multi-layer cap. The locations that will be excavated include two areas associated with the Field-Constructed Tanks.

The two petroleum hydrocarbon plumes that are in the Wastewater Treatment area, associated smear zone soil, and recent detections of FPP are shown on Figure 6-4. The petroleum hydrocarbon plumes have been shrinking because of FPP recovery and enhanced natural attenuation from ongoing IRM operation (refer to Appendix F), as have the footprints where FPP has been detected (refer to Section 4.1.1.2). These petroleum hydrocarbon plumes currently are not presenting unacceptable risk to human health and the environment.

Implementation of Alternative C2 will remove the remaining FPP in the Wastewater Treatment area using belt skimmers to the maximum extent practicable. Biodegradation of SVOCs present in the petroleum hydrocarbon plumes and associated smear zone soil has occurred and is expected to continue to occur (refer to Appendix F). The PCBs comingled with the SVOCs are expected to be attenuated by the natural processes that will anaerobically and aerobically degrade the PCBs as they are released by the SVOCs and enter the aqueous phase (refer to Appendix F).

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established. These tests will focus on both anaerobic and aerobic processes that may be present within the Oil House and Wastewater areas

In addition, Alternative C2 will use the existing IRM system that is operating at the Facility to contain the shrinking petroleum hydrocarbon plumes in the Wastewater Treatment area. Thus, three active remedial measures (enhanced MNA of SVOCs and PCBs comingled with SVOCs, FPP removal, and hydraulic containment) will prevent the SVOCs and PCBs comingled with the SVOCs in the petroleum hydrocarbon plumes from reaching potential receptors in the Spokane River. These active remedial measures will supplement the institutional controls and monitoring that are integral parts of Alternatives A2, A4, B2, and C2.

ES.3.3 Most Appropriate Remedial Alternatives for the ORB Area

The ORB area contains approximately 16 percent of the mass of COCs that are present at concentrations above SLs in the near-surface, deep vadose zone, and smear zone soil at the Facility (percentage derived using modified masses from FSTM Tables 2-18, 3-16, and 4-21). Approximately 98 percent or more of these COCs are SVOCs, primarily diesel, Kensol, and heavy oil. The COCs in ORB area soil are distributed approximately as follows: near-surface soil (about 36 percent), deep vadose zone soil (about 4 percent), and smear zone soil (about 60 percent).

Remedial Alternatives A2, A4, and B2 were selected as the most appropriate remedial alternatives for near-surface and deep vadose zone soil (refer to Table 6-6).

The locations that require surface containment in the ORB area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-5 of this FS. These areas include existing floor slabs and pavement in addition to new capped surfaces. The new capped surfaces are in areas within 20 feet of the ORB and in the West Man-

Made Depression area, and over areas that contain VOCs. The areas that will be excavated extend to the west of the ORB and include a small area farther to the west that was associated with the G3 transfer line.

The petroleum hydrocarbon plume that is in the ORB area and associated smear zone soil are shown on Figure 6-6. The petroleum hydrocarbon plume has been shrinking as a result of natural attenuation (refer to Appendix F). Significant amounts of FPP have not been recently detected in the ORB area (refer to Section 4.1.). The concentration of SVOCs in the ORB area petroleum hydrocarbon plume is currently below the SL and PCUL for SVOCs (500 μg/L). This plume is not currently presenting unacceptable risk to human health and the environment. Thus, the extraction well included in Alternative C2 for the ORB area will not be necessary.

ES.3.4 Most Appropriate Remedial Alternatives for the Remelt/Hot Line Area

The Remelt/Hot Line area contains approximately 2.5 percent of the mass of COCs that are present at concentrations above SLs in the near-surface, deep vadose zone, and smear zone soil at the Facility (percentages derived using modified masses from FSTM Tables 2-18, 3-16, and 4-21). Approximately 89 percent or more of these COCs are SVOCs, primarily diesel, Kensol, and heavy oil. The SVOCs in the Remelt/Hot Line area soil are distributed approximately as follows: near-surface soil (about 56 percent), deep vadose zone soil (about 31 percent), and smear zone soil (about 13 percent). The PCBs in the Remelt/Hot Line area soil are distributed approximately as follows: near-surface soil (about 2 percent), deep vadose zone soil (about 98 percent), and smear zone soil (approximately less than 1 percent).

Remedial Alternatives A2, B2, and B5 were selected as the most appropriate remedial alternatives for near-surface and deep vadose zone soil (refer to Table 6-6).

The locations that require surface containment in the Remelt/Hot Line area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-7 of this FS. These areas include existing floor slabs and pavement in addition to two small, new cap surfaces located in the vicinity of the formerly used West Landfill.

The PCB plume that is in the Remelt/Hot Line area and associated smear zone soil are shown on Figure 6-8. The Remelt/Hot Line PCB plume has remained relatively stable as a result of natural attenuation (refer to Sections 5.1.1 to 5.1.3 and Appendices E and F). With a minor exception near well RM-MW-14S (visible sheen), FPP has not been detected in the Remelt/Hot Line area (refer to Section 4.1.1.2). The PCB plume does not currently present unacceptable risk to human health and the environment based on modified Method 8082 with a MDL of 0.0045 µg/L. (refer to Sections 5.1.2, 5.1.3, and 5.2.2.2).

Alternative D2 will add additional extraction wells at a location near the source of PCBs detected below the Remelt building to contain the PCB plume in the Remelt/Hot Line area (refer to Figure 6-8). Thus, two remedial measures (MNA and hydraulic containment) will prevent the PCBs in the Remelt/Hot Line plume from reaching potential receptors in the Spokane River.

The groundwater extracted from the Remelt/Hot Line PCB plume to contain its flow and prevent it from flowing toward the Spokane River (refer to Section 6.1.4) will be reintroduced to the soil column at a location upgradient of the Oil House area (refer to Section 5.1.5.2). The approximate location of the infiltration trench used for this purpose is identified on Figure 6-2. Because PCBs are hydrophobic (Hart Crowser 2012a), and because of their affinity for petroleum hydrocarbons, the PCBs are expected to initially become adsorbed or sequestered by the SVOCs in the smear zone soil. The PCBs are expected to be attenuated by the natural processes that will anaerobically and aerobically degrade the PCBs as they are released by the SVOCs and enter the aqueous phase (refer to Appendix F). These remedial measures and other measures will supplement the institutional controls and monitoring that are integral parts of Alternatives A2, B2, B5, and D2 (refer to Section ES.2).

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established. These tests will focus on both anaerobic and aerobic processes that may be present within the Oil House and Wastewater areas

ES.3.5 Most Appropriate Remedial Alternatives for Other AOCs at the Kaiser Facility

The other AOCs at the Facility, which include the Cold Mill/Finishing area, Truck Shop area, Former Rail Car Unloading area, and the Former Discharge Ravine areas, contain approximately 13.5 percent of the mass of COCs that are present at concentrations above SLs in the near-surface, deep vadose zone, and smear zone soil at the Facility (percentages derived using modified masses from FSTM Tables 2-18, 3-16, and 4-21). Approximately 98 percent or more of these COCs are SVOCs, primarily diesel, Kensol, and heavy oil. The COCs in the soil in the other AOCs are distributed in soil approximately as follows: near-surface soil (about 5 percent), deep vadose zone soil (approximately less than 1 percent), and smear zone soil (about 95 percent). Approximately 95 percent of the mass of COCs present in the other AOCs is present in the Cold Mill/Finishing area.

Remedial Alternatives A2, A4, and B2 were selected as the most appropriate remedial alternatives for near-surface and deep vadose zone soil (refer to Table 6-1).

ES.3.5.1 Cold Mill/Finishing Area

The locations that require surface containment in the Cold Mill/Finishing area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-9 of this FS. These areas include existing floor slabs and pavement in addition to two small, new cap surfaces in the Chromium Transfer Line area.

The petroleum hydrocarbon plume in the Cold Mill/Finishing area and associated smear zone soil are shown on Figure 6-10. The petroleum hydrocarbon plume has been shrinking as a result of natural attenuation (refer to Appendix F). The petroleum hydrocarbon plumes are not currently presenting unacceptable risk to human health and the environment (refer to Section 4.2.2).

Alternative C2 will use the existing IRM system that is operating at the Facility to contain the shrinking petroleum hydrocarbon plume in the Cold Mill/Finishing area. Thus, two remedial measures (MNA of SVOCs and PCBs comingled with SVOCs, and hydraulic containment) will prevent the SVOCs in the petroleum hydrocarbon plume, and PCBs comingled with the SVOCs in the smear zone soil, from reaching potential receptors in the Spokane River. These remedial measures will supplement the institutional controls and monitoring that are integral parts of Alternatives A2, B2, and C2.

ES.3.5.2 Truck Shop Area

The Truck Shop area is located east of the Hot Line area and south of the Remelt area. The Truck Shop area is used for vehicle maintenance and consists of an enclosed steam-cleaning room, an equipment repair area (inside the main building), and an office structure. A 2,000-gallon UST is located east of the steam-cleaning room. The tank has been taken out of service but remains in place. Near-surface and deep vadose zone soil contains SVOCs at concentrations above SLs at this location. Near-surface soil also contains a small quantity of VOCs at concentrations above SLs.

The locations that require surface containment in the Truck Shop area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-11 of this FS. These areas include existing floor slabs and pavement plus new cap surfaces. Smear zone soil is not impacted at this location.

ES.3.5.3 Former Rail Car Unloading Area

This area of the Facility was historically used to unload fuel that arrived at the plant by rail car or truck. Currently, a pump house building, formerly used east and west fuel lines, and the rail spur remain in place. The majority of the area is bare ground. There is minimal activity on this area, which has minimal worker access, although Evergreen Way to the immediate west experiences heavy vehicle traffic.

The Former Rail Car Unloading (RCU) area contains SVOCs at concentrations above SLs in near-surface and deep vadose zone soil. The locations that require surface containment or excavation in the RCU area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-3. Several surface soil locations in the RCU area will be excavated and the soil disposed of off site. One area in the RCU area will be capped.

ES.3.5.4 Former Discharge Ravines

The approximate locations of the former discharge ravines are shown on Figures 6-12 (South) and 6-13 (West) of this FS. The former West Discharge Ravine (WDR) is located north and northwest of the wastewater lagoon and started near the sanitary wastewater treatment plant. The WDR trends south and west toward the Spokane River. This ravine was used to convey process water to the Spokane River from the northern end of the mill prior to construction of the first industrial wastewater treatment (IWT) plant in 1973.

The former South Discharge Ravine (SDR) is located directly south of the plant. The open channel section of the ravine starts at the south fence line and runs generally north to south through adjacent property toward the Spokane River. This ravine was used to convey process water from the southern end of the mill to the Spokane River prior to construction of the IWT plant in 1973.

There is no infrastructure in the ravines, although they are adjacent to unpaved perimeter roadways and fence lines. Additionally, Kaiser's current IWT outfall pipe and off-gas structure is located along the top of the slope of the southern WDR side wall. No Facility-related activities have taken place in the former discharge ravines since 1973.

The WDR contains an estimated 6 pounds of PCBs in near-surface soil. The SDR is estimated to contain approximately 640 pounds of SVOCs and 5 pounds of

PCBs in near-surface soil (masses modified from FSTM Table 2-18). The locations that require surface containment or excavation in the SDR and WDR areas are identified in Tables 6-2 and 6-3 and depicted on Figure 6-12 and 6-13, respectively. The uneven surfaces in these areas will require that a multi-layer cap be installed in locations designated for capping. The segment of the WDR west of the perimeter road has steep side walls that prohibit further excavation in this area. This area is currently undergoing additional investigation to evaluate its potential impacts on underlying groundwater. Addendums to the RI and this FS will be provided once the investigation is complete. Pending the results of this ongoing investigation, the WDR area may receive a multi-layer cap. The side walls of the SDR are less steep. This FS assumes that the soil in the SDR will be excavated and disposed of off site

ES.3.6 Estimated Cost of the Recommended Alternatives

The rough order of magnitude (ROM) estimated cost of the technology-based remediation alternatives described in Sections 2 through 5 of this FS are contained in Appendices A through D. These estimated costs were used to evaluate the financial cost of relative reductions in the human health and environmental risks posed by each of the alternatives evaluated to remediate near-surface and deep vadose zone soil, and of the remediation alternatives evaluated to address the petroleum hydrocarbon and Remelt/Hot Line PCB plumes and associated smear zone soil.

The total estimated cost of implementing the recommended alternatives at the Facility is approximately $31.6 million (-35 to +50 percent). This estimate was prepared by identifying a baseline cost (Alternative A2/A4) and adding the incremental costs associated with Alternatives B2, B5, C2, and D2 to this baseline cost. This process is summarized in Table 6-7.

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1.0 INTRODUCTION

This report presents the results of the site-wide Final Feasibility Study (FS) conducted on behalf of Kaiser Aluminum Washington, LLC (Kaiser) at its Trentwood Facility (Facility) located at East 15000 Euclid Avenue in Spokane Valley, Washington.

This FS was conducted pursuant to the requirements outlined in Task IX of Exhibit B to Agreed Order No. DE 2692 between Kaiser and the Washington State Department of Ecology (Ecology), dated August 16, 2005. The Agreed Order requires Kaiser to complete a FS that develops cleanup levels, develops remedial alternatives, and evaluates the remedial alternatives based on the criteria in WAC 173-340-360.

This document is the site-wide FS report for soil and groundwater at the Facility. It builds upon the information and analysis summarized in the Final Feasibility Study Technical Memorandum (FSTM) (Hart Crowser 2012c). The FSTM is an integral part of the overall FS for the Facility. The FSTM began the process of developing technology-based remedial alternatives for soil and groundwater at the Facility.

The FSTM:

- Identified constituents of potential concern (COPCs) and conservative screening levels (SLs) for those constituents and used this screening process to identify constituents of concern (COCs) to be carried through the FS process.

- Divided the soil and groundwater at the Facility into five distinct segments (presented in Sections 2 through 5). The segments were selected because differing groups of technologies are applied to remediate the COCs contained in the environmental media present in each segment (e.g., near-surface soil, petroleum hydrocarbon plumes).

- Identified potential remediation technologies that may be applicable to each COC present in soil and groundwater throughout the Facility.

- Conducted an initial technical screening of the potential remediation technologies to identify those technologies and process options that were judged to be implementable and reliable for each COC present in soil and groundwater throughout the Facility.

- Defined the areas of concern (AOCs) throughout the Facility, where the COCs are present in soil and groundwater.

- Developed technology-based remedial alternatives for the individual COCs and mixtures of COCs present in each segment of the Facility.

Ecology issued draft cleanup standards for the soil and groundwater at the Kaiser Facility during May 2010 (Ecology 2010a and 2010b). These draft cleanup standards are summarized for soils in Table 2-1 and for groundwater in Table 4-1 of this FS.

1.1 PURPOSE

The primary purpose of this site-wide FS is to:

- Conduct a final screening of the technologies judged to be implementable and reliable by the FSTM. This final screening includes a cost screening when appropriate.

- Evaluate the technology-based remedial alternatives based on the criteria in WAC 173-340-360 to identify the most appropriate technology-based alternatives for each individual COC or mixture of COCs in the environmental segments (media) present at the Facility. The FSTM carried forward smear zone soil as an individual environmental segment of the Facility. This FS judged that it was more appropriate to consider smear zone soil together with the groundwater that contacts this soil. Facility media were divided into four environmental segments: near-surface soil, deep vadose zone soil, the petroleum hydrocarbon plumes and associated smear zone soil, and the Remelt/Hot Line PCB plume and associated smear zone soil.

- Assemble the most appropriate technology-based remedial alternatives for each segment of the Facility, to identify the appropriate area-based remedial alternative(s) for each operating area of the Facility (e.g., Oil House area, Wastewater Treatment area).

1.2 REPORT ORGANIZATION

This Final FS report is presented in two volumes. Volume I includes the text, tables, and figures of the FS report. Volume II contains report Appendices A through I. The main text of the report is organized using one section for each primary technical aspect. Tables and figures are numbered to correspond to and are presented at the end of their respective section. References are presented after the technical discussions, in Section 7.0. Appendix-specific references are presented at the end of each appendix. Where appropriate, cross-references are made between sections rather than duplicating tables or figures. Primary report sections consist of the following:

- **1.0 INTRODUCTION.** Identifies the purpose and scope of the FS and describes the structure of the FS report.
- **2.0 EVALUATION OF REMEDIAL ALTERNATIVES FOR NEAR-SURFACE SOIL.** Evaluates technology-based remedial alternatives for near-surface soil at the Facility.
- **3.0 EVALUATION OF REMEDIAL ALTERNATIVES FOR DEEP VADOSE ZONE SOIL.** Evaluates technology-based remedial alternatives for deep vadose zone soil at the Facility.
- **4.0 EVALUATION OF REMEDIAL ALTERNATIVES FOR PETROLEUM HYDROCARBON PLUMES AND ASSOCIATED SMEAR ZONE SOIL.** Evaluates technology-based remedial alternatives for smear zone soil and petroleum hydrocarbon plumes at the Facility.
- **5.0 EVALUATION OF REMEDIAL ALTERNATIVES FOR THE REMELT/HOT LINE PCB PLUME AND ASSOCIATED SMEAR ZONE SOIL.** Evaluates technology-based remedial alternatives for the Remelt/Hot Line PCB plume at the Facility.
- **6.0 PROPOSED REMEDIAL ALTERNATIVES FOR THE KAISER FACILITY.** Assembles the appropriate technology-based remedial alternatives for each segment of the Facility (as determined in Sections 2 through 5) into the combination of alternatives that are appropriate for each AOC of the Facility.
- **7.0 REFERENCES.** Lists references cited in the report.

Supporting information and data tables are presented in appendices:

- **APPENDIX A.** Presents detailed cost estimates for implementation of Alternatives A1 through A6 in near-surface soil.

- **APPENDIX B.** Presents detailed cost estimates for implementation of Alternatives B1 through B5 in deep vadose zone soil.

- **APPENDIX C.** Presents detailed cost estimates for implementation of Alternatives C1 through C4 for the petroleum hydrocarbon plumes and associated smear zone soil.

- **APPENDIX D.** Presents detailed cost estimates for implementation of Alternatives D1 through D4 for the PCB plume and associates smear zone soil in the Remelt/Hot Line area.

- **APPENDIX E.** The updated Kaiser groundwater model is presented in this appendix along with model outputs for the various scenarios that are evaluated in this FS.

- **APPENDIX F.** Monitored natural attenuation (MNA) is an integral part of all alternatives for remediation of the petroleum hydrocarbon groundwater plumes and associated smear zone soil. Site-specific data are presented and compared to Ecology's MNA petroleum guidance (Ecology 2005b) in this appendix, demonstrating that natural attenuation is actively occurring in groundwater at the Facility. This appendix also presents a summary of published information on the chemical, physical, and biological breakdown in the environment of PCBs and PCBs comingled with petroleum products.

- **APPENDIX G.** This appendix identifies and discusses potential applicable or relevant and appropriate requirements (ARARs) to be used in assessing and implementing remedial actions at the Kaiser Facility. The potential ARARs focus on federal or state statutes, regulations, criteria, and guidelines. The specific types of potential ARARs evaluated include contaminant-, location-, and action-specific ARARs.

- **APPENDIX H.** This appendix evaluates the free phase product (FPP) recovery technologies that were carried forward as potentially implementable and reliable by the FSTM (Hart Crowser 2012c), and identifies the FPP technology judged to be appropriate for each remedial alternative.

- **APPENDIX I.** This appendix provides the restoration time frame evaluations for the remedial alternatives presented in this FS. The evaluations are presented in three separate memoranda pertaining to the petroleum hydrocarbon plumes, for PCBs comingled with petroleum hydrocarbons and for the Remelt/Hot Line PCB plume.

1.3 LIMITATIONS

Work for this project was performed, and this report prepared, in accordance with generally accepted professional practices for the nature and conditions of the work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Kaiser Aluminum Washington, LLC, for specific application to the referenced property. This report is not meant to represent a legal opinion. No other warranty, express or implied, is made.

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TABLES

FIGURES

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2.0 REMEDIATION ALTERNATIVES FOR NEAR-SURFACE SOIL

Section 2 evaluates the technology-based remedial alternatives identified in the FSTM for near-surface soil (upper 20 feet), based on the criteria in WAC 173-340-360, to identify the most appropriate technology-based alternatives for each individual constituent of concern (COC) or mixture of COCs in near-surface soil throughout the Facility. This FS focuses on remedial alternatives that will effectively treat volatile organic compounds (VOCs – e.g., gasoline and Stoddard solvent), semivolatile organic compounds (SVOCs – e.g., cPAHs, diesel, and heavy oil), polychlorinated biphenyls (PCBs), and metals (e.g., lead, chromium, and arsenic in isolated locations).

The most appropriate technology-based alternatives for near-surface soil identified in Section 2 are assembled to identify the appropriate area-based remedial alternative(s) for each operating area of the Facility (e.g., Oil House area, Wastewater Treatment area) and for the petroleum hydrocarbon and the Remelt/Hot Line groundwater plumes in Section 6 of this FS.

This section evaluates remedial technologies that were judged to be the most applicable to COCs in near-surface soil by the FSTM. Section 2 is organized as follows:

- Section 2.1 – Description of Remedial Alternatives for Near-Surface Soil;
- Section 2.2 – Evaluation of Remedial Alternatives for Near-Surface Soil; and
- Section 2.3 – Comparative Analysis of Remedial Alternatives for Near-Surface Soil.

To assist with evaluation of alternatives, estimated costs have been prepared for near-surface soil remedial Alternatives A1 through A6. These costs are summarized for each alternative in their respective descriptions in Section 2.1. Cost estimate summary tables and backup calculations for each alternative are provided in Appendix A. Table A-1 in Appendix A compares the net present value (NPV) costs for Alternatives A1 through A6 for the near-surface soil remedial alternatives. These estimated costs are used in Sections 2.2 and 2.3 as part of the process for evaluating each technology-based remedial alternative, and selecting the most appropriate alternative for each COC group (e.g., VOCs, SVOCs, PCBs, metals) present in near-surface soil.

The development and evaluation of remedial alternatives incorporate the estimated masses of COCs in the various AOCs at the Facility. Because the soil matrix at the Facility consists mostly of gravel and cobbles (Hart Crowser 2012b), the estimated COC masses were adjusted to account for the presence of these soil types. The mass estimate assumes that the COCs in collected soil samples were associated with the silt (when present), sand, and organic material (if any) that were present in the sample. The gravel and cobble portion of the sample was either not sent to or not analyzed by the laboratory, since cobbles would not fit in the sample jar and gravel would have to be pulverized in the laboratory prior to analysis. As a result, the concentration of COCs reported by the laboratory is an overestimate of the actual *in situ* concentration of COCs in soil at the Facility.

Nonetheless, the laboratory values were reported in the Final Soil Remedial Investigation (RI) (Hart Crowser 2012b) without accounting for the gravel and cobbles, since they represent a conservative estimate of the actual concentration of COCs present at the Facility, and contribute to a conservative approach to estimating risks to human health and the environment posed by COCs. Data indicate that at least 30 percent of Facility soil is greater than 2 inches in diameter (i.e., cobble size). Grain size distribution data from the Facility indicate that an average of 54 percent of the material is retained on a No. 4 sieve (0.187 inch). This fraction is considered gravel and cobbles (Hart Crowser 2012b).

The mass of COCs in each soil AOC (i.e., near-surface, deep vadose zone, and smear zone soil) presented in this FS were reduced by 54 percent from the values presented in the Final Soil RI and the FSTM to develop a more accurate estimate of COC mass.

2.0.1 Development of Cleanup Standards for the Kaiser Facility

The remediation alternatives in this FS are developed for the areas of concern (AOCs) that are defined for each COC. The AOCs for each near-surface soil COC at the Facility were defined in Section 2 of the FSTM, and are consolidated on Figure 2-3 of this FS. These AOCs were developed using the screening levels (SLs) that were originally identified in Section 1 of the FSTM. During preparation of the FS, Ecology developed preliminary cleanup levels (PCULs) for unsaturated soil, saturated soil, and groundwater at the Kaiser Facility. Soil SLs and PCULs for the Facility are compared in Table 2-1. Development of cleanup standards for groundwater is discussed in Section 4.01.

The unsaturated and saturated soil PCULs were developed using standard MTCA Method C criteria, which incorporated the preliminary groundwater cleanup levels that were developed. Groundwater PCULs were established using standard MTCA Method B criteria, which include consideration of criteria protective of both drinking water and surface water because site groundwater discharges into the Spokane River.

Groundwater and soil PCULs were developed for both a standard point of compliance (POC) and conditional POC (Ecology 2010a). If a conditional POC is granted, cleanup levels for groundwater COCs that are based on the protection of surface water should be met at the point or points where groundwater discharges into surface water. Concentrations for groundwater COCs elsewhere throughout the Facility may exceed surface water standards but would be required to meet drinking water standards, which are typically higher in concentration than surface water standards. (For example, the surface water standard for total PCBs is 6.4×10^{-5} µg/L, but the drinking water standard is 0.22 µg/L [see Table 4-1].)

Similarly, if a conditional POC is granted, soil COC concentrations would have to be protective of surface water at or near the vicinity of the point of discharge to surface water; however, elsewhere throughout soil at the Facility, COC concentrations should not exceed the concentrations that are protective of drinking water. The decision to grant a conditional POC will be made in the Cleanup Action Plan (CAP), in which final cleanup standards (i.e., cleanup levels and points at which these levels must be met) for the Facility will be determined.

Although the soil and groundwater PCULs were provided during the writing of this FS report, Ecology has allowed the continued use of the SLs in developing and evaluating the remediation alternatives for near-surface and deep vadose zone soils presented herein (Ecology 2010b). Continuing to use the SLs in this regard ultimately does not significantly affect the evaluation of individual soil remediation alternatives, the evaluation of differences among alternatives, or the identification of a preferred alternative.

The SLs and PCULs for the COCs included in the FS are in general agreement, except for total polychlorinated biphenyls (PCBs) and carcinogenic polycyclic aromatic hydrocarbons (cPAHs) (refer to Table 2-1). The difference between SLs and PCULs affects the delineation of AOC boundaries, which in turn influences other estimated parameters, such as impacted soil volumes and total mass of COCs. For instance, the total AOC area for PCBs in near-surface soil would likely increase in size if the PCUL for the standard POC was used to delineate the boundaries rather than the SL. Conversely, if a conditional POC is granted, the total AOC area would likely decrease in size.

The SLs for gasoline, diesel, heavy oil, and Kensol are the same as the PCULs for both standard and conditional POCs, so there would be no change in total AOC size for these COCs. Both the SL and the PCUL for arsenic are based on its natural background concentration in the Spokane area and are not dependent on the POC. The PCUL for arsenic is slightly lower than the SL, and a slightly larger AOC may result in the use of this PCUL.

During the development of the PCULs for soil, chromium and lead were eliminated from consideration because of the low detection frequencies of these substances (Ecology 2010b). Therefore, PCULs have not been developed for these COCs.

The development and evaluation of remediation alternatives for soil in this FS will continue to use SLs; although, the PCULs developed by Ecology for the Kaiser Facility are used, as appropriate, in estimating the restoration time frames for each alternative. Final determination of cleanup levels and POCs will be identified in the CAP, which will be prepared by Ecology following selection of the preferred remediation alternative.

2.1 DESCRIPTION OF REMEDIAL ALTERNATIVES FOR NEAR-SURFACE SOIL

The technology-based remedial alternatives developed by the FSTM are discussed in this section as follows:

- Section 2.1.1 – Alternative A1: Institutional Controls, Monitoring, and Monitored Natural Attenuation;
- Section 2.1.2 – Alternative A2: Institutional Controls, Monitoring, Monitored Natural Attenuation, and Containment;
- Section 2.1.3 – Alternative A3: Alternative A2 with Soil Vapor Extraction (SVE) with Off-Gas Treatment;
- Section 2.1.4 – Alternatives A4a and A4b: Alternative A1 or A2 with Excavation and Off-Site Disposal;
- Section 2.1.5 – Alternatives A5a and A5b: Alternative A1 or A2 with Excavation and On-Site Biotreatment (A5a), and Alternative A1 or A2 with Excavation and On-Site Thermal Desorption (A5b); and
- Section 2.1.6 – Alternative A6: Alternative A1 or A2 with Excavation and Off-Site Incineration.

2.1.1 Alternative A1: Institutional Controls, Monitoring, and Monitored Natural Attenuation

Alternative A1, which consists of institutional controls, monitoring, and monitored natural attenuation (MNA), is common to each of the alternatives that were evaluated for the remediation of near-surface soil at the Kaiser Facility. Areas of interest for near-surface soil at the Facility are shown on Figure 2-1. These common elements are described below and are evaluated in Sections 2.2 and 2.3. Institutional controls and monitoring requirements that are unique to Alternatives A2 through A6 are described in their respective sections.

Institutional controls are measures undertaken to limit or prohibit activities that may interfere with the integrity of an interim action or cleanup action, or result in exposure to hazardous substances at a site (WAC 173-340-440). These controls include: (1) physical measures (e.g., fences and access controls) to limit activities that may interfere with a cleanup action or result in exposure to hazardous substances at a site; (2) use restrictions such as limitations on the use of property or resources, or requirements that cleanup action occur if existing structures or pavement are disturbed or removed; (3) maintenance requirements for engineered controls such as the inspection and repair of monitoring wells, treatment systems, caps, or groundwater barrier systems; (4) educational systems such as signs, postings public notices, health advisories, mailings, and similar measures that educate the public and/or employees about site contamination and ways to limit exposure; and (5) financial measures such as assurances that sufficient financial resources are available and in place to provide for the long-term effectiveness of the institutional and engineered controls that are provided.

Best management practices (BMPs) are pollution prevention practices that are aimed at avoiding contact between a pollutant and environmental media (e.g., soil or groundwater), because of leaks, spills, or improper waste disposal. BMPs can include production modifications, operational changes, materials substitution, water conservation, the installation of engineered controls (e.g., slip lining trenches, double-walled pipes) and other similar measures. BMPs have been classified as institutional controls for the purposes of this FS.

The existing institutional controls at the Kaiser Facility, as well as the additional institutional controls proposed for near-surface soil at the Facility, are described in Section 2.1.1.1.

The MTCA (WAC 173-340-410) defines three types of compliance monitoring: protection monitoring, performance monitoring, and confirmational monitoring. Per MTCA definition, protection monitoring confirms that human health and the environment are adequately protected during construction and the operation and maintenance period of an interim action or cleanup action as described in the Interim Action/Cleanup Action Plan and Health and Safety Plan (HASP). Performance monitoring confirms that the interim action or cleanup action has attained cleanup standards and, if appropriate, remediation levels or other performance standards such as construction quality control measurements or monitoring necessary to demonstrate compliance with a permit or, where a permit exemption applies, the substantive requirements of other laws. Confirmational monitoring confirms the long-term effectiveness of the interim action or cleanup action once cleanup standards and, if appropriate, remediation levels or other performance standards have been attained. The protection and performance monitoring that are currently being conducted at the Kaiser Facility are described in Section 2.1.1.2.

Natural attenuation involves a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass toxicity, mobility, volume, or concentration of hazardous substances in the environment (WAC 173-340-200). The monitoring plan that will be used to assess the natural attenuation processes active in near-surface soil at the Facility is described in Section 2.1.1.3.

2.1.1.1 Institutional Controls

Kaiser has implemented institutional controls, which are summarized in this section, as part of its industrial activities at the Trentwood Facility. Additional institutional controls that are associated with each remedial alternative proposed for near-surface soil will be included in the description of that alternative provided in this section of the FS (i.e., Sections 2.1.2 through 2.1.6).

Existing Institutional Controls

Institutional controls currently in use at the Facility include physical measures, BMPs, and administrative measures. Although interim remedial measures (IRMs) have been conducted on near-surface soil at the Facility, no institutional controls have been formally established for these IRMs, except for the West Discharge Ravine area. Following contaminated soil removal from the West Discharge Ravine, a restoration monitoring plan (Hart Crowser 2007b) was implemented for the upland and riparian zones in this area. Informal controls exist as part of operating procedure at the Facility. Work authorizations are provided through company personnel who have sufficient institutional knowledge to ensure that work taking place in IRM areas will not compromise the IRM (for example, knowledge of the multi-layer cap installed in the Hoffman Tank area would alert authorizing personnel to take measures to protect the cap before excavating or drilling in this area).

Physical Measures. Physical measures that are currently being applied at the Facility include fences, signs, access controls, and environmental upgrades in the Remelt/Hot Line area. The Facility is completely fenced, and security guards stationed at the main gate control access on a 24-hour basis. The Facility contains internal restricted areas, such as electrical transformer locations, which are completely fenced with a locked gate and are placarded to warn of potential hazards within the restricted area.

Best Management Practices. Additionally, various environmental improvements have been completed, or are planned for implementation, for the casting complexes (DC-1 through DC-8 – see Figure 2-1a) in the Remelt/Hot Line area, as summarized in Table 2-2. Completed improvements in this area include the following:

- Replacing melter furnace door jambs with waterless door jambs (DC-2E, DC-4, DC-5, DC-6, and DC-7);
- Rerouting door jamb water drains to casting pits (DC-1, DC-2W, and DC-3);
- Verifying casting pit integrity (DC-1 through DC-8);
- Eliminating embedded water supply piping (DC-1 through DC-8);
- Installing containment for hydraulics/lubrication (DC-1, and DC-3 through DC-8);
- Routing overflow lines to sewer (DC-1); and
- Slip lining of sewer piping (manhole [MH] 3B to MH 3 and MH7B to MH 9).

Improvements for the remaining casting complexes are in planning stages or are yet to be scheduled, as summarized in Table 2-2.

Administrative Measures. BMPs and administrative measures currently being implemented at the Facility to minimize exposure of Facility workers, the public, and the environment to hazardous materials include the following:

- Compliance with requirements outlined in the National Pollutant Discharge Elimination System (NPDES) Waste Discharge Permit No. WA-000089-2 (Ecology 1997) issued to the Kaiser Facility;

- Compliance with Washington State Department of Ecology Agreed Order No. 02WQER-3487 (Ecology 2002) and with Amended Order No. 2868 (Ecology 2005a) issued to Kaiser;

- Employee safety and spill response training programs;

- Emergency response program that includes spill management;

- Special training requirements to access restricted areas within the Facility; and

- Waste handling procedures.

NPDES permitting in the State of Washington is administered by Ecology to regulate the discharge of wastewater to state surface water and groundwater. NPDES permit regulations include establishment of a basis for effluent limitations and other requirements to protect state waters. Permit conditions specific to the Kaiser Facility include outfall effluent limitations; outfall monitoring and reporting requirements; solid waste handling and disposal requirements; and maintenance of a Treatment System Operation and Maintenance (O&M) Plan, a Spill Prevention Control and Countermeasure (SPCC) Plan, and a Stormwater Pollution Prevention Plan (SWPPP). For specific details of these permit conditions, refer to the NPDES permit issued to Kaiser (Permit No. WA-000089-2), which is available to the public through Ecology. Items specific to the SPCC Plan and SWPPP are summarized below. Table 2-3 summarizes monitoring items associated with the NPDES permit, SPCC Plan, and other institutional controls.

Agreed Order No. 02WQER-3487 and Amended Order No. 2868 are enforceable by Ecology and are currently being implemented by Kaiser. These orders require monitoring of PCBs in the final discharge (Outfall 001) from the Facility in addition to PCB concentrations in the influent of the black walnut shell filter system. Monitoring locations are summarized in Table 2-3. Refer to the Agreed Order and Amended Order, which are available to the public through Ecology, for the specific Order details.

The SPCC Plan (GeoEngineers 2008) describes the areas at the Facility where spills or leaks may potentially occur (e.g., storage tanks, transfer lines, or tank truck unloading areas) and the physical, operational, and administrative measures that are in place to reduce the likelihood of spills or leaks. Physical measures include items such as secondary containment and level sensors for storage tanks. Double-walled piping is used for transfer lines (e.g., G4 transfer line and Cold Mill transfer lines), which provides secondary containment in the event of a line breach. Operational measures include procedures for transferring hazardous substances (for example during truck unloading). Administrative measures include inspection of oil-containing equipment and tanks, reporting procedures, and training programs.

The SWPPP, in general, was developed using Ecology's Guidance Manual for Preparing/Updating a Stormwater Pollution Prevention Plan for Industrial Facilities (Ecology 2004). The SWPPP establishes practices and procedures that are necessary to prevent stormwater pollution that may impact the Kaiser Facility. These practices and procedures are defined through the following elements contained in the SWPPP:

- Assessment and description of existing and potential pollutant sources;
- Description of operational BMPs;
- Description of selected source control BMPs;
- Description of erosion and sediment control BMPs; and
- An implementation schedule.

The SWPPP is modified whenever there is a change in design, construction, or O&M that causes the SWPPP to be less effective in controlling pollutants, and whenever the description of pollutant sources or pollution prevention measures identified in the SWPPP are inadequate.

Waste handling procedures for managing waste oil, lamps, batteries, electronic equipment, and devices containing mercury are in place at the Kaiser Facility. These guidelines outline relevant information to appropriately handle and accumulate these specific waste types, which includes regulatory background, applicable waste constituent concentrations, handling instructions, options for handling larger quantities of waste, locations of waste accumulation/collection areas, waste collection schedules, and contact information for further information. In addition, specific guidelines are in place for defining hazardous waste accumulation areas and associated requirements for managing these areas.

Additional Institutional Controls Needed

As part of Alternative A1, additional institutional controls will need to be implemented at the Kaiser Facility. These institutional controls include physical measures, BMPs, and administrative measures. These additional controls are also included in Alternatives A2 through A6. Additional institutional controls that are associated with Alternatives A2 through A6 are discussed in the description of that alternative provided in this section of the FS (i.e., Sections 2.1.2 through 2.1.6).

Necessary physical measures include the upgrades at the casting complexes mentioned above and summarized in Table 2-2. Existing physical measures will need to continue to be monitored and maintained, and will need modifications or periodic updates as future operations dictate.

Necessary BMPs include O&M and monitoring plans for various site features and engineered controls that currently do not have BMPs in place. In addition, existing BMPs will require regular updates (e.g., the SPCC Plan). Specific O&M and monitoring plans will be needed for the following:

- Facility pavement (floor slabs and road surface) located above soil that contains COCs at concentrations above SLs;

- Completed IRMs that include engineered controls (e.g., the Hoffman Tank capped area); and

- Stormwater collection system (e.g., stormwater drainage in secondary containment areas).

Additional administrative measures will be needed at the Kaiser Facility. These measures include applying a restrictive covenant to those areas of the Kaiser property where COCs remain in place at concentrations that exceed cleanup standards established by Ecology. The requirements of the restrictive covenant are presented in WAC 173-340-440(9). In addition, after implementation of remedial actions, periodic reviews of the remedial actions will be required. Where institutional controls or financial assurances are required, or if certain other conditions exist, Ecology will conduct a review of the site every five years to ensure the continued protection of human health and the environment. Ecology will also publish a notice of any periodic review in the Site Register and provide an opportunity for public review and comment.

Safety training and spill response training are currently established for Kaiser employees and contractors. These training programs may need to be expanded to include other educational programs to keep employees and the public informed about existing COCs and AOCs at the Facility, what type of remedial work is being planned or has been completed in these areas, what associated risks or hazards may be associated with these areas, and what safety guidelines would need to be followed when accessing these areas to minimize any potential exposure. These programs would be modified as Facility conditions change and as new information is received.

Institutional Controls Estimated Costs

The estimated cost for implementing the new institutional controls proposed above is summarized in Table A-2 in Appendix A and totals approximately $1.4 million. The cost of designing and implementing the existing institutional controls is considered to be a sunk cost and is not included in the cost estimate for Alternative A1. The yearly cost of operating, maintaining, and monitoring existing and new institutional controls for Alternative A1 totals approximately $520,000 per year, which is based on the annual estimated cost of the institutional controls plus contingency cost (10 percent) and professional services costs (project management and technical support, each 10 percent – see Table A-2 in Appendix A).

2.1.1.2 Monitoring

Performance and protection monitoring is currently underway at the Kaiser Facility, which includes the extensive ongoing groundwater monitoring program that confirms that the numerous interim remedial measures that have been completed at the Facility and are currently underway (e.g., extraction and recirculation of groundwater) are adequately protecting human health and the environment. This ongoing monitoring program is described in the approved Sampling and Analysis Plan (SAP) for the Facility (Hart Crowser 2007a) as amended (Kaiser 2010a). The current sampling locations are shown on Figure 2-2. This monitoring program will be a part of each of the remedial alternatives discussed in this FS. The current monitoring plan for Alternative A1 is summarized in Table 2-3, which includes monitoring provisions for the MNA element of this alternative discussed below. For monitoring plan details, one should refer to the current SAP (Hart Crowser 2007a).

It should be noted that the SAP is modified over time as warranted by changing conditions, operations, and data needs at the Facility. For the purpose of describing Alternative A1 and preparing estimated costs, we have used the most recent amended version of the SAP (Hart Crowser 2007a, Kaiser 2010a) as referenced herein.

Current Monitoring Plan Description and Objectives

Facility-wide groundwater sampling events in most wells were reduced from quarterly to semi-annually in approximately 2003. Kaiser did this after careful evaluation of the existing data from each well and its location relative to source areas and the river. This sampling schedule provides data on the seasonally high (spring) and low (fall) groundwater elevation periods sufficient to identify trends and monitor for compliance. However, Kaiser has agreed to monitor certain downgradient protection wells on a quarterly basis, which provide data to ensure that contaminants are not leaving the Facility via groundwater. Periodic water and product levels continue to be collected during the summer and fall to provide information on free phase product accumulation and groundwater flow. This information will alert Kaiser when sufficient free phase product is present so that skimming wells may be activated.

New wells are being sampled for a minimum of four quarters to assess seasonal fluctuations in groundwater quality. After that time, the sampling schedule may be modified depending on the chemical results from each well and data needs for the ongoing RI/FS.

Groundwater samples are collected and analyzed primarily for ultra-low-level polychlorinated biphenyls (PCBs), total petroleum hydrocarbons (TPH), total suspended solids (TSS), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and metals.

Monitoring During Implementation of Remedial Alternatives

The current monitoring program described above and detailed in the SAP (as amended) will be included in each of the remedial alternatives evaluated in this FS. Additional elements that will be a part of the monitoring program are described below.

Health and safety plans will be prepared to ensure the protection of human health and the environment as each remedial alternative is implemented. These plans will conform to the requirements of WAC 173-340-810. The unique health and safety issues associated with each remedial alternative are discussed in the section of the FS devoted to that alternative.

Confirmational monitoring will be conducted to confirm the long-term effectiveness of the remedial measures (e.g., integrity testing of a low-porosity cap) or to confirm that a remedial action has been effectively implemented (e.g., contamination has been effectively removed from a source area excavation). The confirmational monitoring required for each alternative are discussed in the section of the FS devoted to that alternative.

There may be short-term risks associated with execution of the monitoring plans that should be considered. Short-term risks may include the following:

- Exposure of Facility workers to media containing COCs;

- Physical hazards associated with sampling equipment (e.g., drilling rig hazards); and

- Hazards associated with the industrial activities taking place at various locations within the Facility (e.g., burn hazards in the Remelt/Hot Line area).

Monitoring Estimated Costs

The estimated cost of the ongoing protection and performance monitoring of groundwater at the Kaiser Facility is summarized in Table A-2 in Appendix A and totals approximately $60,000 per year and $300,000 per year, respectively.

To simplify the cost estimating process, it is assumed that the existing monitoring program described in the SAP will not change significantly during implementation of the selected remedial alternative(s). It is assumed that any changes in the existing monitoring program will have a negligible effect on the total estimated cost for Alternative A1.

2.1.1.3 Monitored Natural Attenuation

Near-surface soil at the Kaiser Facility has been sampled and analyzed over a number of years. In some instances, as discussed in the FSTM (Hart Crowser 2012c), analytical results showed that the concentration of COCs (e.g., SVOCs) has declined over time without any known human intervention. This indicator of potential natural attenuation will be monitored as part of each potential near-surface soil remedial alternative. The monitoring plan for natural attenuation is discussed below and summarized in Table 2-3. The monitoring of the natural attenuation process required for each alternative is discussed in the section of the FS devoted to that alternative.

Description of Natural Attenuation

Natural attenuation is defined as the variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of hazardous constituents in the environment. These *in situ* processes include natural biodegradation, dispersion, dilution, sorption, volatilization, transformation, or destruction of hazardous substances (WAC 173-340-200).

Target contaminants for natural attenuation in near-surface and vadose zone soils are VOCs, SVOCs, and fuel hydrocarbons. Fuel and halogenated VOCs are commonly evaluated for natural attenuation. Additionally, natural attenuation may be appropriate for some metals when natural attenuation processes result in a change in the valence state of the metal that results in immobilization (e.g., arsenic, chromium).

The O&M duration is determined from natural attenuation evaluation and regulatory requirements. The process is typically expected to continue for several years until desired degradation levels are achieved. The duration of O&M is dependent on the data and information collected during the monitoring period, as described below.

Advantages and Disadvantages of MNA

Compared with other remediation technologies, natural attenuation has the following advantages:

- Less generation or transfer of remediation wastes.
- Less intrusive, as few surface structures are required.
- May be applied to all or part of a given site, depending on site conditions and cleanup objectives.
- Natural attenuation may be used in conjunction with, or as a follow-up to, other (more active) remedial measures.
- Overall cost will likely be lower than active remediation.

Factors that may limit applicability and effectiveness of MNA include:

- Data used as input parameters for modeling must be collected.
- Intermediate degradation products may be more mobile and more toxic than the original contaminant.
- Natural attenuation is not appropriate where imminent site risks are present.
- Some contaminants may migrate before they are degraded.
- Institutional controls are required, and the site may not be available for reuse until contaminant levels are reduced.
- If free product exists, it may have to be actively removed.

- Some inorganics, such as mercury, can be immobilized but they will not be degraded.

- Long-term monitoring and associated costs may be relatively high.

- Longer time frames may be required to achieve remediation objectives, compared to active remediation.

- The hydrologic and geochemical conditions amenable to natural attenuation are likely to change over time and could result in renewed mobility of previously stabilized contaminants and may adversely impact remedial effectiveness.

- More extensive outreach efforts may be required to gain public acceptance of natural attenuation.

Data Requirements for MNA

The extent of contaminant degradation depends on a variety of parameters, such as contaminant types and concentrations, temperature, moisture, and availability of nutrients and electron acceptors (e.g., oxygen, nitrate).

The evaluation of natural attenuation is often not straightforward and requires expertise in several technical areas including microbiology/bioremediation, hydrogeology, and geochemistry. When available, information to be obtained during data review includes:

- Soil and groundwater quality data:

  - Three-dimensional distribution of residual, free, and dissolved phase contaminants. The distribution of residual and free phase contaminants is used to define the dissolved phase plume source area.

  - Historical water quality data showing variations in contaminant concentrations through time.

  - Chemical and physical characteristics of the contaminants.

  - Geochemical data to assess the potential for biodegradation of the contaminants.

- Location of potential receptors:

- Groundwater wells.

- Surface water discharge points.

- Surface soil (direct contact and/or consumption/uptake by humans and ecological receptors).

Kaiser Facility MNA Plan for Near-Surface Soil

A simplified and straightforward MNA approach is proposed for near-surface soil at the Kaiser Facility (Table 2-3). MNA will be implemented for the near-surface soil remedial alternatives in which COCs will remain in place (such as in alternatives that involve capping of contamination). MNA will be applied to near-surface soil COCs that fall under VOC, SVOC, and other petroleum hydrocarbon categories. MNA monitoring locations will be based on AOCs where MNA-amenable COCs remain in place, with a spatial sampling frequency sufficient to monitor AOCs that meet this criterion. It is assumed that monitoring will occur every 5 years. The quantity of monitoring locations and samples to be collected per location are based on the following criteria:

- Monitoring locations will be determined based on a density of one location per 10,000 square feet (sq ft) of AOC. AOCs that are currently beneath existing pavement and floor slabs are excluded, since soils underneath pavement or floor slabs were assumed to comply with cleanup standards under the requirements of WAC 173-340-740(6)(f).

- Soil explorations will be advanced at these locations to a maximum depth of 20 feet.

- Soil samples for laboratory analysis will be collected every 10 feet of impacted soil depth at each location.

Soil samples will be submitted for laboratory analysis of gasoline-, diesel-, and/or oil-range petroleum hydrocarbons and/or analysis of PAHs.

2.1.1.4 Alternative A1 Estimated Cost

Assuming an operating period of 30 years and a discount rate of 7 percent (OMB 2009), the total NPV cost of Alternative A1, which includes institutional controls, monitoring, and MNA, is estimated to be $13.6 million (Table A-2).

2.1.2 Alternative A2: Institutional Controls, Monitoring, Monitored Natural Attenuation, and Containment

Alternative A2 adds the additional protection of containment to Alternative A1. The containment technologies judged appropriate for near-surface soil include asphalt, concrete, and multi-layer caps (refer to the FSTM Section 2, Hart Crowser 2012c). The first step in describing these containment elements is to identify the footprint of the near-surface soil that will be capped. The development of this footprint is discussed in Section 2.1.2.1. The performance characteristics (e.g., permeability) and the design cross section of the asphalt, concrete, and multi-layer cap envisioned for near-surface soil at the Kaiser Facility are described in Section 2.1.2.2. The performance and confirmational monitoring associated with the installation and long-term maintenance of asphalt, concrete, and multi-layer caps is described in Section 2.1.2.3.

Multi-layer capping technology will be used to extend the footprint of the existing multi-layer cap in the Hoffman Tank area. As can be seen on Figure 2-5, the SVOC AOC boundary in the Hoffman Tank area appears to extend beyond the edge of the existing multi-layer cap in this area. Since the estimated boundary of the AOC is approximate, the edge of the AOC boundary may actually reside entirely beneath the existing cap, or it may extend beyond the edge of the cap. It is conservatively assumed that the existing multi-layer cap in the Hoffman Tank area will be extended as a contingency in the event that the SVOC AOC in this area does extend beyond the existing cap. The necessity of this measure will be further assessed during the remedial design phase of the preferred alternative identified in Section 6 of this FS.

2.1.2.1 Footprint of the Containment Cap for Near-Surface Soil

The AOCs for each near-surface soil COC were defined in Section 2 of the FSTM. These COC-specific AOCs are consolidated on Figure 2-3 of this FS, which depicts the COC-specific AOCs for near-surface soil that are present in each of the operating areas of the Facility. Figure 2-3 and detail Figures 2-4 through 2-10 indicate areas where capping or excavation may potentially be implemented, in addition to areas where only capping may be implemented (e.g., within 20 feet of existing buildings). Figure 2-3 also shows near-surface soil AOCs that are entirely beneath existing paved areas or beneath building floor slabs, which, for the purposes of this section, are assumed to be suitable as containment caps in their current condition. Excavation of near-surface soil is discussed in Sections 2.1.4 through 2.1.6 for Alternatives A4 through A6 and is not discussed further in this section.

The lateral area of near-surface soil that could be contained for the purposes of Section 2 of the FS was estimated as follows: (1) Start with the overall areal footprint of the consolidated near-surface soil AOCs shown on Figure 2-3; then (2) subtract the area of existing floor slab and pavement to estimate the area of potential new cap. This approach assumes that existing floor slabs, roads, and other paved surfaces at the Facility are acceptable as containment caps in their current condition, as described above. It is likely that some of the existing paved surfaces at the Facility will need to be upgraded to act as effective containment, however. This issue will be addressed as part of remedial design.

The area of near-surface soil AOCs totals approximately 128,000 sq ft, of which approximately 35 percent (45,300 sq ft) is located below existing floor slabs or pavement within the operating areas. Thus, the total area of potential new cap is approximately 82,700 sq ft. In addition, the multi-layer cap extension in the Hoffman Tank area will add approximately 1,800 sq ft to the existing cap in this area, which results in a total potential new cap area of approximately 84,500 sq ft. As described in Section 2.1.2.2, the three types of cap construction considered in this FS are asphalt, concrete, and multi-layer cap construction, which are assumed to have respective surface areas of approximately 51,700, 9,100, and 23,700 sq ft.

The footprint of this additional capping is not indicative of the final footprint of capping that will be recommended for the Facility. This final footprint will depend on the remedies selected for the other segments of the Facility (e.g., deep vadose zone soil, petroleum groundwater plume) as described in Sections 3 through 6 of this FS. The potential new cap area of approximately 84,500 sq ft and respective areas of the different types of cap were used to estimate the cost of this capping alternative.

2.1.2.2 Description of the Containment Cap

Containment caps are horizontal barriers used to physically isolate contaminated areas from direct human or terrestrial ecological contact, and to prevent the infiltration of rainfall and surface water that could potentially leach and transport contaminants from the impacted area. A wide variety of low-permeability capping materials are available. Asphalt, concrete, clay, and multi-layer caps (usually concrete or soil and a synthetic liner) are frequently used to isolate contaminants. Asphalt, concrete, and multi-layer caps are judged to be appropriate for the Kaiser Facility. These caps are described in the sections below.

Caps for isolation of contaminated soil are typically designed to achieve a permeability of less than 10^{-6} centimeters per second (cm/s). The capability to monitor performance over time and provisions for maintenance as needed to prevent increased permeability resulting from deterioration or changes in site use will need to be established. Monitoring to assure performance of the cap will typically need to be based on a written plan that will be consistent with monitoring requirements for other remedial components (EPA 2004a).

In areas that are to be paved, caps that satisfy performance standards (for example, maximum conductivity of 10^{-6} cm/s) generally consist of a suitable subgrade, a base course, an impervious layer, and a protective surface layer(s). Generally, the imperviousness of the new pavement section is not the main concern; design needs to address adequacy of the subgrade and paving materials to resist pavement cracking over time. Another area for design to focus on is sealing the pavement edges around catch basins, monitoring wells, light pole foundations, and other Facility features in the cap location. In addition, construction quality control for containment caps is significantly more restrictive than for basic paving, and written monitoring and maintenance procedures are typically required.

Asphalt Pavement Caps

Asphalt paving is typically composed of several layers of material arranged in order of descending load-bearing capacity, with the highest load-bearing capacity material on the top and the lowest load-bearing capacity material on the bottom.

A typical pavement structure consists of the following components from the surface downward:

- **Surface Layer Components.** The pavement proper that comes in contact with traffic typically consists of several layers of hot-mix asphalt (HMA) that are designed as discussed below.

- **Base Course.** This is the layer directly below the HMA layer and generally consists of densely compacted aggregate that provides support to limit deflection of the surface layers. The base course may or may not need to be stabilized with a cementitious admixture, depending on the support required.

- **Subbase.** The subbase may consist of the native subgrade soil or compacted fill used to achieve the desired subgrade elevation, improve drainage, and/or provide needed support to the base course.

The asphalt surface layer usually contains three layers (or lifts):

- **Base Layer.** Typically, this layer has higher asphalt content than other layers to provide low permeability and to resist cracking. The additional asphalt content, lift thickness, compacted density, and aggregate size are designed to achieve the low permeability required for asphalt caps.

- **Intermediate Layer.** This layer is designed to carry most of the traffic load. Stability is provided by using the appropriate coarse aggregate and binder. Washington State Department of Transportation (WSDOT) Class B asphalt is often used for this layer.

- **Wearing Surface.** This top layer is designed to be durable and to resist surface cracking and rutting under wheel loads. WSDOT Class B asphalt is often used for this layer.

The base layer consists of HMA designed to provide low permeability rather than durability or structural support. In general, permeability of the base layer will decrease as the thickness of the lift and the asphalt content in the mix increases, and as the aggregate size and volume of air voids decreases.

For normal pavement design, the thickness of the lift is typically a function of the loads that will be applied, and construction requirements (to maintain temperature control during placement and compaction). A 2- to 3-inch-thick layer of asphalt pavement will usually provide a permeability of less than 10^{-7} cm/s (Audibet et al. 1992, Smith 1996, Glade and Nixon 1997). As lift thickness increases, permeability decreases.

Provided that the subgrade is adequate to prevent cracking of the impermeable lift at the base of the pavement section, only a single impermeable layer is typically needed. The overall pavement section may include more than one intermediate layer to provide adequate support for wheel loads. Typically, the wearing surface and intermediate layers are 2 to 2-1/2 inches thick.

Joints occur where adjacent sections of pavement are placed separately and where the pavement abuts existing structures or concrete paving. Typically, HMA pavement joints are sealed with liquid asphalt. Sealing the lowest (impermeable) layer in adjacent pavement sections may also incorporate a strip of asphalt-impregnated geotextile, to reduce the risk of reflective cracking extending through the overlying layers.

Concrete Pavement Caps

Typical mixtures of uncracked Portland cement concrete (PCC) are reported to have a permeability of less than 10^{-7} cm/s. Concrete pavement designed to act as a cap is typically designed with special provisions to prevent cracking, and with joint details to prevent infiltration between adjacent sections and between the pavement and structures.

Crack prevention includes rebar detailing, and impervious slabs typically include a higher area of steel to area of concrete ratio than conventional structures. Crack control relies on good mix design to minimize the water/cement ratio; the aggregate gradation; and the relative proportion of paste to aggregate. Air entrainment has little effect on permeability, but special admixtures are available to reduce permeability.

Joint detailing typically includes use of dowels, water stops, and checkerboard placement. Where new concrete abuts existing structures, or where embedded water stops are not an option, joints can be filled with a backer rod and appropriate sealant.

Impermeability of PCC caps is affected by limiting the size of each pour to limit shrinkage cracking, and good concrete placement to avoid aggregate paste segregation (honeycombing) and other voids. Some admixtures that reduce permeability also reduce workability, but the addition of water after mixing (retempering) should be avoided. Adequate moist curing is required to achieve low permeability.

Multi-Layer Caps

Similarly to asphalt and concrete caps, multi-layer caps are designed to prevent exposure of contaminated subsurface media to human or ecological receptors and to prevent infiltration of surface water that could result in leaching and transport subsurface contamination to potential receptors. Multi-layer caps consist of one or more impermeable layers combined with additional layers that provide protection of the impermeable layer and to provide drainage. EPA-recommended multi-layer cap design for hazardous waste landfills and surface impoundments consists of the following in order from top to bottom layers (EPA 1989):

- A top layer consisting of two components: a vegetated or armored surface component with the purpose of minimizing erosion and provided proper surface drainage, and a soil component consisting of topsoil or fill soil as appropriate;

- A soil drainage layer beneath the top layer to convey any infiltrated water away from the low-permeability layer below; and

- A low-permeability layer consisting of a flexible membrane liner on top of a compacted soil component with a maximum hydraulic conductivity of 10^{-7} cm/s.

In addition to design of the cap layers, the design should include site grading specifications to provide the necessary topography for proper drainage. Additionally, the cap design should include provisions for potential settlement and subsidence, which can disrupt the integrity and function of the multi-layer cap by creating depressions and cracks. Quality assurance monitoring will be conducted during construction of multi-layer caps to confirm that construction follows the cap design specifications. Quality assurance monitoring is discussed further in the monitoring section below.

Multi-layer caps have been implemented in contaminated areas at the Kaiser Facility. As described in Appendix A of the FSTM, and mentioned above, the Hoffman Tank area at the Facility has an engineered multi-layer cap placed over contaminated soil that could not be safely excavated. The cap consists of a 50-mil polyvinyl chloride (PVC) liner installed as an impermeable surface over the regraded area. The PVC liner is covered by a 12-inch layer of coarse sand and a topsoil layer to protect the liner from abrasion and UV light degradation. A catch basin and stormwater collection system to collect surface water runoff over the membrane and direct it into a catch basin for treatment in the Wastewater Treatment (WWT) facility was also installed (Hart Crowser 1991, 1992a and 1992b).

Criteria for Selecting a Cap

Several criteria should be considered in selecting the type of cap to implement at an AOC. These criteria include:

- Expected loading and abrasion in the area to be capped;
- Degree of impermeability required;
- Geometry of the AOC (e.g., flat level surface versus an uneven sloped surface);
- Toxic Substances Control Act (TSCA) requirements for PCB-impacted AOCs; and
- Cost.

Generally, areas requiring greater load-bearing capacity and abrasion resistance (such as in high-traffic areas) call for a concrete cap. Areas where less load-bearing capacity and less abrasion resistance are needed are suited for an asphalt cap. Areas that have an uneven geometry, as opposed to a flat and level geometry, and where the need for load-bearing capacity and abrasion resistance is minimal, are better suited for a multi-layer cap because of its greater flexibility as compared to concrete or asphalt caps. Multi-layer caps also provide added restorative benefit, in that their top layers, though designed for management of water drainage, typically consist of topsoil and vegetation, which help to return the capped area to the natural condition of its surroundings.

PCB-impacted soil at low concentrations may be left in place under TSCA; however, remediation requirements such as institutional controls, capping, and cleanup must be met, as discussed in FSTM Section 2.3. These requirements depend further on future land use of the AOC. These requirements are summarized in the table below:

TSCA Capping Requirements

Occupancy Level (see 40 CFR §761 .61(a))	PCB Concentration	Action Required by TSCA
High	≤ 1 mg/kg	Cleanup verification
	> 1 mg/kg but ≤ 10 mg/kg	Cover area with an appropriate cap and cleanup verification
Low	≤ 25 mg/kg	Institutional control and cleanup verification
	> 25 mg/kg but ≤ 50 mg/kg	Site is marked with fence and sign (refer to PCB guideline under TSCA Figure 1, p. 7), implement institutional control and cleanup verification
	> 25 mg/kg but ≤ 100 mg/kg	Cover area with appropriate cap, implement institutional control and cleanup verification

Since most near-surface soil at Kaiser contains less than 1 mg/kg of PCBs, no additional treatment or containment of this soil would be required by TSCA. A small quantity of soil at the Facility does contain PCBs at concentrations above the soil criteria for the protection of human health (Oil House French Drain area), and above the soil criteria for the protection of groundwater (Discharge Ravine areas, Remelt/Casting areas). For the purpose of describing and evaluating Alternative A2 in this section of the FS, it is assumed that all PCB-impacted near-surface soil AOCs that are not located beneath existing paved areas or building slabs will be capped. However, this is not indicative of the final capping footprint that will be recommended for the Facility, which will depend on the remedies selected for the other segments of the Facility (e.g., deep vadose zone soil and the petroleum-impacted groundwater plume), as described in Sections 3 through 6 of this FS.

Cap Locations

Capping materials would be selected for the near-surface soil AOCs based on the criteria listed above. Multi-layer caps are proposed for the West Discharge Ravine (WDR), South Discharge Ravine (SDR), and Field Constructed Tank (FCT) areas, in addition to the proposed extension of the existing multi-layer cap in the Hoffman Tank area. The need for high load-bearing capacity and abrasion resistance in these low-traffic areas is minimal, and restoration of the vegetated surfaces in these areas would be appropriate.

The remainder of AOCs will likely be candidates for either asphalt or concrete containment caps. For the purpose of estimating costs for Alternative A2, it is assumed that 85 percent of the remaining AOCs will be capped with asphalt and 15 percent with concrete. Some AOCs that are covered by existing pavement may require repair or replacement to implement a cap. Areas of potential pavement repair, essentially existing paved areas that overlie a near-surface soil AOC, are shown on Figures 2-3 through 2-10. For the purpose of estimating costs in this section, it is assumed that pavement repair will not be required for these areas; however; pavement repair will be considered during remedial design of the area-based alternative selected for the Facility in Section 6.

2.1.2.3 Monitoring Requirements for Alternative A2

Monitoring will be required during installation of the cap in addition to subsequent monitoring during the O&M period of the cap. These monitoring requirements are discussed below.

Monitoring During Cap Installation

A written Construction Quality Assurance Plan (CQAP) will be prepared by the contractor installing the cap(s). The CQAP will include monitoring to verify the quality of construction materials and the construction practices used in their placement, with the ultimate goal of confirming that the final cap system meets or exceeds the design criteria and specification. One focus of this plan is documentation of the measures taken to assure that the design asphalt or concrete mix is actually produced and installed as defined in the construction specifications. This documentation is necessary to assure that the in-place hydraulic conductivity of the pavement will meet design requirements. Sample cores will be obtained and analyzed for permeability in the lab using standard methods. Quality assurance monitoring for multi-layer caps will confirm that the layers of the cap are uniform and undamaged, that the materials for each layer are as specified per the cap design, and that each layer is constructed as specified in design.

On-site inspection and tests during construction and supporting documentation requirements will be more extensive than routine costs associated with placing pavement materials. These on-site tests are summarized in Table 2-4. For example, construction of low permeability HMA for environmental capping is similar to construction of conventional HMA pavements, but requires extra monitoring to maintain quality control. Typical quality assurance for HMA pavements during construction includes temperature checks on each truckload of HMA at the time of placement, and asphalt extraction and gradation tests at minimum specified intervals. Testing frequency should be variable and adjusted as needed to assure consistency. In-place density and air voids tests should be checked on a tightly spaced grid after compaction. A simple indication that air voids approach 0 percent is the tendency for asphalt to bleed slightly at the surface following compaction (Audibert and Lew 1992).

Health and safety monitoring during cap installation will be required to address the short-term risks discussed above. A HASP will be required to define the potential hazards associated with cap installation and to define procedures necessary to maintain worker safety.

Operation, Maintenance, and Monitoring after Cap Installation

A long-term monitoring plan (MP) to assess cap integrity can be used to document the long-term effectiveness (low permeability) of the cap and conform to the general requirements of MTCA (WAC 173-340-410). The key element of the MP is the development of a Sampling and Analysis Plan (SAP) that contains the elements defined in WAC 173-340-820. The SAP will define the measures used to measure the initial and long-term performance of the cap.

The long-term MP for asphalt, concrete, or multi-layer caps will focus on periodic visual inspections to catalog visual signs of deterioration such as cracking, other physical or chemical deterioration or erosion, and differential settling that could impair the ability of the pavement to minimize the infiltration of water or that could potentially damage the flexible membrane liner of a multi-layer cap. The MP will contain detailed inspection, repair, and maintenance protocols and specify the documentation necessary to assure the protocols are implemented.

After installation of the cap, initial permeability typically is measured by collecting asphalt and/or concrete cores at a sampling density agreed to with Ecology. Cores are not collected from a multi-layer cap because the sample collection process will impair the integrity of the cap. To estimate costs for cap installation for Alternative A2, it is assumed that initially permeability samples will be collected from asphalt or concrete caps at a frequency of one sample per 10,000 sq ft of cap area. The cost estimates further assume that cap integrity will be visually monitored on an annual basis. If visual inspection indicates a breach of asphalt or concrete cap integrity, the damaged pavement will be further assessed and subsequently removed and replaced at that location, if warranted. Similarly, if a breach of multi-layer cap integrity is detected, the damaged section of cap will be assessed and accordingly repaired. It is estimated that the lifespan of asphalt, concrete, and multi-layer caps is approximately 20 years. For the purpose of cost estimation, it is assumed that the caps will require repair of 5 percent of their areas per year.

2.1.2.4 Alternative A2 Estimated Cost

Assuming an operating period of 30 years and a discount rate of 7 percent (OMB 2009), the total NPV cost of the unique elements of Alternative A2 (which excludes the elements of Alternative A1 that are included in this alternative) is approximately $2.2 million. The combined estimated NPV cost of Alternative A2 totals approximately $15.8 million (refer to Table A-3 in Appendix A).

2.1.3 Alternative A3: Alternative A2 Plus Soil Vapor Extraction with Off-Gas Treatment

Alternative A3 adds soil vapor extraction (SVE) to Alternative A2 for those areas of the Facility where VOCs are present in near-surface soil at concentrations above SLs.

2.1.3.1 Near-Surface Soil Areas Where SVE Will Be Implemented

There are five AOCs with VOC contamination above the SLs in the near-surface soil horizon at the Kaiser Facility. The AOC boundaries and the concentration of VOCs present in the AOCs were estimated in Section 2.6 of the FSTM. The method used to estimate the concentration of VOCs present in each AOC provided a very conservative overestimate of the concentration of VOCs that are present in each AOC.

Because of accessibility issues, only four of the five AOCs are considered for SVE treatment. For the purposes of this discussion these four AOCs are described as AOC-1, AOC-2, AOC-3, and AOC-4. AOC-1, AOC-2, and AOC-3 are in the ORB area and are contaminated with Stoddard solvent or gasoline (refer to Figure 2-11). The VOCs present in AOC-1, AOC-2, and AOC-3 are comingled with SVOCs. AOC-4 is located in the Oil House area (refer to Figure 2-12) and is contaminated with gasoline.

The fifth area of VOC impact is in the Truck Shop area (refer to Figure 2-10). The average concentration of Stoddard solvent in this AOC is approximately 700 milligrams per kilogram (mg/kg). The surface area is approximately 860 sq ft and contamination extends vertically from about 13 to 20 feet in depth. SVE treatment of this area is not considered because of accessibility issues. The area is adjacent to high-voltage power lines that are critical to operations at the Kaiser Facility. These power lines pose a safety concern and interruption of service would be detrimental to Facility production rates. Note that the HHERA showed no indoor air risk for this area (Pioneer 2012), and groundwater data from monitoring wells in this area have shown no SL exceedances (Hart Crowser 2012a).

Figure 2-11 outlines the VOC AOCs in the ORB area. AOC-1 is located at the southeast corner of the ORB. The average concentration of gasoline in this area is approximately 240 mg/kg. This AOC is approximately 440 sq ft, and the total mass of gasoline is approximately 100 pounds. AOC-2 is located in the former G1 Transfer Line area approximately 100 feet to the west of the ORB. The size of this AOC is approximately 960 sq ft. The average concentration of Stoddard solvent is approximately 330 mg/kg, and the mass of Stoddard solvent is approximately 320 pounds. The VOCs in AOC-1 and AOC-2 are comingled with heavy oil and diesel; the average concentration of heavy oil and diesel are approximately 5,700 and 2,800 mg/kg, respectively.

AOC-3 is located above the former East and Small Depressions in the Man-Made Depressions area. The average concentration of Stoddard solvent is approximately 360 mg/kg, and the area of the AOC is approximately 450 sq ft. The mass of Stoddard solvent present is approximately 140 pounds. This area is also impacted by cPAHs. The average cPAH concentration is approximately 0.73 mg/kg.

The depth of contamination extends the entire 20 feet of the near-surface soil horizon for AOC-1, AOC-2, and AOC-3.

AOC-4 is located in the Oil House area (Figure 2-12). The AOC is contaminated with gasoline. The average concentration of gasoline is approximately 1,700 mg/kg. The AOC footprint is approximately 200 sq ft, with contamination extending vertically from about 18 to 20 feet below ground surface. The mass of gasoline present in AOC-4 is approximately 30 pounds. AOC-4 is to the northeast of the Oil House building near where a 20,000-gallon gasoline UST was once located.

The areas described above are in the vicinity of Facility operating areas, so it is assumed that utilities (e.g., electricity, natural gas) needed to implement an SVE system are readily available. Mobilization costs will be incurred to tap into these existing utilities for SVE treatment.

2.1.3.2 Description of the SVE Process

Soil vapor extraction (SVE) is a process that extracts contaminants from soil in vapor form. The process involves applying a vacuum within the vadose zone through a system of underground wells to enhance volatilization and pull COC vapors from the soil to the surface. Typically, prior to discharge, the vapor stream is treated to remove contaminants. SVE systems are designed to remove contaminants that volatilize or evaporate easily. SVE is the most frequently selected treatment for VOCs at Superfund sites (EPA 1996a). SVE can be used to remove VOCs and some SVOCs from unsaturated soil (Federal Remediation Technologies Roundtable [FRTR] 1998). SVE is considered to be one of the most cost-effective remediation processes for soil contaminated with gasoline, solvents, or other VOCs (Johnson et al. 1990). In fact, SVE is the preferred presumptive remedy for sites with VOCs present in soil where treatment is necessary (EPA 1993b and 1996a).

SVE Process Principles

During SVE, VOCs move or volatilize into fresh air being introduced into the subsurface by an applied vacuum. In the soil matrix, contamination sometimes can exist in the vapor phase, dissolved phase (in pore water), liquid phase or as non-aqueous phase liquids, and adsorbed on particulates. At Kaiser, data indicate VOC contamination is likely to exist in the vapor and dissolved phases and adsorbed to particulates. Mass transfer occurs as a result of the concentration gradient between the soil matrix and vapor stream; the greater the gradient, the greater the rate of transfer between matrices. Eventually, soil concentrations will become too low for mass transfer to be an effective means of contaminant removal. It is at this point that no significant change in VOC concentrations will occur (Wong 1997).

SVE System Well Placement

Typically, SVE wells are placed in the area of contamination, and the number of wells depends on the air permeability of the soil matrix. Well length is determined by the depth of contamination. The well screen interval should coincide with the location of contamination. Well diameters range from 2 to 12 inches, although diameters between 2 and 4 inches are more commonly used. Wells have sand or gravel packing to induce optimal gas flow and cement bentonite grout to seal the annular space from the surface (EPA 1991; Suthersan 1997).

In general, near-surface soil at the Facility is poorly sorted sand and gravel (Hart Crowser 2012c). Based on the porous nature of the soil, it is conservatively assumed that SVE wells will be placed 10 feet apart. Field testing can be performed prior to installation to determine the actual radius of influence and well spacing. AOC-1 will have five wells based on this well spacing, the area of the AOC, and the accessibility of the AOC. A significant portion of AOC-1 is underneath the ORB building and its SPCC area; therefore, three SVE wells are placed adjacent to the AOC, with two additional wells within the AOC. The remaining AOCs are relatively accessible. AOC-2 will have four wells. AOC-3 will have 7 wells, and AOC-4 will have three wells. Potential well locations are shown on Figures 2-11 and 2-12. For costing purposes, it is assumed 2-inch-diameter wells will be used (Zvibleman, B., Onion Equipment, personal communication, 2010, and Sumrack, C., Schrader Environmental Services, personal communication, 2010).

In the ORB area, the depth of contamination extends the entire 20 feet for these AOCs. It is assumed the well screen interval will extend between 5 to 20 feet bgs (the top 5 feet of well casing will be sealed with bentonite and concrete). In the Oil House area, contamination extends from 18 to 20 feet bgs. For this area, wells will extend to 20 feet bgs, and the final 2 feet will be screened.

To summarize, 19 wells will be installed in AOC-1 through AOC-4, with a diameter of 2 inches and depth of 20 feet. The screen interval for 16 of the wells will extend from 5 to 20 feet bgs and for three of the wells the screen interval will be 18 to 20 feet bgs.

SVE System Equipment and Location

The SVE system consists of conveyance, treatment, and disposal systems. Figure 2-13 presents a process flow diagram of a typical SVE system that uses carbon adsorption to remove VOCs from the effluent stream. In this alternative, extracted soil vapor will be conveyed from the extraction wells, using a blower, to an off-gas treatment system that uses catalytic oxidation or carbon adsorption to treat or remove VOCs from the off-gas stream (refer to the FSTM Section 2.5.2.1). Before entering the blower, the extracted vapor will pass through a moisture separator, which protects the blower from material in the vapor stream that could otherwise damage its internal workings. If carbon beds are used for off-gas treatment, contaminants in the influent vapor stream will be adsorbed onto the carbon so that the effluent stream can meet air quality limits. Typically, carbon treatment consists of two beds in series. After the carbon is exhausted, it will need to be replaced. Spent carbon will be sent to the appropriate treatment facility for reactivation. Typically, treatment systems consisting of blowers, air/water separators, and carbon treatment are available as mobile units. The unit will also have a control panel where parameters such as pressures and flow rates from the extraction wells can be monitored and controlled.

A catalytic oxidation system would require the installation of a thermal oxidation unit rather than a carbon adsorption bed. In catalytic oxidation, off-gas is heated and then destroyed on a catalyst bed. For treatment to work, incoming off-gas is preheated to 600 to 900°F and may be diluted with air depending on influent concentrations. Since the catalytic reaction is exothermic, dilution prevents overheating and exhaustion of the catalyst bed (EPA 1991).

Carbon adsorption and catalytic oxidation were assessed based on implementability and reliability to identify the most appropriate technology for use at Kaiser. Since both treatment methods are available as mobile units, implementation of these technologies at the Facility pose the same challenges. However, carbon adsorption is judged to be a more reliable vapor treatment option since it is easier to operate and maintain. The operation and maintenance of catalytic oxidation equipment is more complex since treatment relies on monitoring and maintaining influent concentrations and system temperatures and ensuring fuel and air are always available. Spent catalyst has to be replaced and disposed of properly and incineration also poses a safety hazard.

On the other hand, the O&M requirements of carbon adsorption systems are less complex. Continuous operation depends on continued operation of the SVE blower. Concentrations at the inlet and outlet of the carbon beds will be monitored to ensure the beds are not exhausted and air quality limits are being met. It is assumed that one SVE mobile treatment unit with a vacuum blower (150 to 200 millimeters of mercury [mmHg] vacuum and 600 standard cubic feet per minute [scfm] flow rate) and two 2,000-pound GAC beds will be brought to the Facility and used to treat the four AOCs. The mobile unit will also be equipped with an appropriately sized moisture separator and system control panel. The system control panel will consist of pressure gauges, flow meters, and an autodialer that notifies staff in the event of emergencies (Zvibleman, B., Onion Equipment, personal communication, 2010, and Sumrack, C., Schrader Environmental Services, personal communication, 2010).

In the ORB area, based on the close proximity of AOC-2 and AOC-3, piping will be installed so that these areas can be treated simultaneously. Then the SVE mobile treatment unit will be moved to AOC-1 (southeast corner of the ORB building) for treatment and then to AOC-4 in the Oil House area. The proposed mobile unit locations are shown on Figures 2-11 and 2-12.

An impermeable surface seal will be used to minimize inflow from the surface, reducing the chance of short circuiting. An impermeable surface seal also prevents the infiltration of rainfall, reducing the amount of water extracted from the well and preventing fugitive VOC emissions. Typical surface seal materials include flexible membrane lining (e.g., HDPE) or a clay or bentonite layer, but the most common material is concrete or asphalt (EPA 1991). For the purpose of the cost estimate for this alternative, an asphalt cap will be used for those areas of the VOC AOCs that are not currently under pavement or floor slabs. Section 2.1.2 describes asphalt capping and containment of the remaining AOCs at the Facility for Alternative A2.

SVE Treatment Time Frame and Effectiveness

Alternative A3 is expected to decrease the concentrations of VOCs in the soil significantly. In areas where SVOCs are present, the final concentration of VOCs will likely be higher than VOC-only areas, since the attractive forces between SVOC and VOC compounds will cause greater retention of VOCs in these locations. Efficiency of treatment depends on the characteristics of the contaminant, properties of the soil, and site conditions (Wong 1997). Based on relatively low concentrations of contaminants and the porous soil matrix, it is assumed that SVE will be a relatively effective treatment method, and final VOC concentrations remaining in treated near-surface soil will be below SLs.

It is assumed that treatment will last approximately 12 months for AOC-1 and about 12 months for AOC-2 and AOC-3 (in the ORB area), which will be treated simultaneously. For AOC-4, a duration of approximately 24 months is assumed, since initial concentrations of VOCs are higher in this AOC. Based on a carbon usage rate of 0.25 pound COC/pound GAC, carbon will have to be replaced once while AOC-2 and AOC-3 are being treated and once while AOC-1 is being treated. At the end of treatment for AOC-4, the carbon will need to be disposed of (Zvibleman, B., Onion Equipment, personal communication, 2010, and Sumrack, C., Schrader Environmental Services, personal communication, 2010).

2.1.3.3 Monitoring Requirements for Alternative A3

Per WAC 173-340-410, compliance monitoring includes protection, performance, and confirmational monitoring during installation, while operating, and at the end of cleanup efforts. Table 2-5 summarizes elements of the performance and confirmational monitoring judged appropriate for the SVE portion of Alternative A3. (Monitoring requirements for Alternatives A1 and A2 are presented in Tables 2-3 and 2-4.)

During installation of the SVE system, air monitoring will occur during ground disruption activities. It is assumed that dust emissions and VOC concentrations will be monitored on a daily basis. Dust emissions will be monitored by visual observation, and VOC concentrations will be monitored using a Multirae detector or similar photoionization detection equipment.

Protection and performance monitoring will be performed during SVE system operation. Monitoring schedules during operation will differ during startup and normal operation. It is assumed that startup will last approximately two weeks and that the frequency of system checks will be higher during this period than during normal operation. During startup, it is assumed Hart Crowser staff will be on site to perform monitoring, but, during normal operation, monitoring will be performed by trained Facility staff. As part of system performance monitoring, air pressures and flow rates at extraction wells will be observed and recorded and cap integrity inspections will also be performed based on the sampling schedule shown in Table 2-5. Protection monitoring will be dictated by air permitting limits as described below.

SVE System Air Emission Monitoring

The Spokane Regional Clean Air Agency (SRCAA) is the lead regulatory agency for air quality issues in the Spokane area. The air emissions threshold for soil and groundwater remediation operations is greater than 0.5 tons (1,000 pounds) per year of combined toxic air pollutants (TAPs) and volatile organic compound emissions (based on SRCAA Regulation I, Article IV, Exhibit R, Item 9). For the Kaiser Facility, the total mass of VOCs in the AOCs that are proposed for SVE treatment is less than the threshold (approximately 600 pounds), and air quality permitting should not be triggered. However, for conservative cost estimation, it is assumed that SVE treatment will require an air quality permit. Air quality permitting will require submittal and approval of a Notice of Construction (NOC) or Notice of Intent (NOI) application, depending on the duration of the project.

The air quality permit defines the anticipated emissions and the best available control technology (BACT) standards that have to be met. BACT is usually evaluated on a case-by-case basis; however, some technologies are generally accepted as BACT. In past reviews of SVE projects, carbon adsorption (or equivalent), capable of approximately 95 to 99 percent (and greater) control efficiency, has been approved as BACT. Emission standards will depend on whether the constituents of Stoddard solvent and gasoline are considered to be

TAPs in Chapter 173-460 WAC. A preliminary investigation indicates that the TAPs in gasoline are benzene and toluene, and in Stoddard solvent the only TAP is benzene. For the purpose of cost estimation, we assumed that the treatment system effluent stream will be monitored for one or both of these compounds (depending on the AOC being treated) using Summa canister sampling methodology and laboratory analysis on a quarterly basis. It is also assumed that these compounds will be monitored along the treatment train as part of system performance monitoring.

SVE System Performance and Confirmational Monitoring

For cost estimating purposes, it is assumed that concentrations of toluene and benzene will be monitored at four sampling locations. Monitoring locations will be at location (1) vapor inlet of the moisture separator; location (2) vapor inlet of the first GAC bed; location (3) effluent of the first GAC bed; and location (4) effluent of the second GAC bed. These locations are shown on a process flow diagram of the system (Figure 2-14). Vapor samples will be collected using Summa canister sampling methods, or vapor concentration measurements will be collected in the field using colorimetric tubes. During the first two weeks of startup, it is assumed that colorimetric tubes will be used for system monitoring purposes. During normal operation, colorimetric tubes will be used at monitoring locations (1), (2), and (3). Since location (4) is monitored to ensure regulatory compliance, Summa canisters will be used to collect samples on a quarterly basis at this location for laboratory analysis. Summa canister sample analysis will provide results with greater accuracy for this assessment. Laboratory analysis will be provided by a third party.

The inlet and outlet of each carbon bed will be monitored to track carbon bed breakthrough. Breakthrough is defined as occurring when concentrations at the bed inlet and outlet are the same. Concentrations will also be monitored at location (1) to track VOC vapor recovery from the subsurface. When concentrations at this location remain unchanged and relatively low over time, it may indicate that VOC concentrations in soil have reached a point of diminishing return. This point occurs when VOC concentrations in the soil are too low to maintain sufficient mass transfer and treatment becomes no longer cost-effective.

At the end of treatment, confirmational soil samples will be collected from the near-surface soil VOC AOCs. Ecology's Guidance for Site Checks and Site Assessments for Underground Storage Tanks (Ecology 2003) was used to estimate the number of soil samples that should be collected for confirmational sampling. Table 5-3 in this Ecology guidance document defines the minimum number of soil characterization samples that should be collected from an excavated stockpile volume. Since soil treated by SVE will not be excavated, the number of confirmational samples is based on the initial volume of impacted soil. We assumed 13 soil borings will be drilled and two soil samples will be collected from each boring.

As mentioned above, based on the relatively low initial concentrations of VOCs in the AOCs and the permeable soil matrix, it is assumed that, after treatment, concentrations of VOCs will be below SLs. In areas where VOCs are comingled with SVOCs, it is likely that SVOC concentrations will remain above SLs. In these areas, the asphalt cap will remain in place and long-term monitoring will consist of cap integrity inspections (refer to Alternative A2).

In the FSTM, excavation and mechanical screening were eliminated for VOC AOCs based on physical and chemical criteria because it was conservatively assumed that most VOCs will be emitted during the excavation and screening process (see Table 2-5 of the FSTM).

Recently, during the development of this FS, the SRCAA was contacted to determine how excavation and off-site disposal would be treated in the Spokane area for VOC-impacted soil. As discussed above, the permitting threshold is greater than 0.5 ton per year of combined toxic air pollutants and VOC emissions (based on SRCAA Regulation I, Article IV, Exhibit R, Item 9). If excavated soil is not screened (to remove larger diameter cobbles) and the excavation process for the VOC AOCs extends over two years, the permitting threshold would not be exceeded. Excavation activities still need to comply with SRCAA's general requirements on emissions given in SRCAA Regulation I, Article VI, which include air quality limits for visible emissions, odors and nuisances, and particulate matter and prevention of airborne particulate matter. At this time, for the purposes of this FS and consistent with the FSTM, excavation of near-surface VOC AOCs is not considered.

2.1.3.4 Alternative A3 Estimated Cost

Cost estimates for Alternative A3 are provided in Appendix A, Table A-4 and Tables A-14 through A-18. As mentioned above, it is assumed that one SVE mobile treatment unit with a blower capacity of 600 scfm and two 2,000-pound carbon beds will be used for treatment. Based on the time it will take to treat the four areas (up to approximately 48 months), it is assumed that the enclosed mobile unit will be rented.

Capital costs associated with the SVE treatment system include contractor mobilization and demobilization of the SVE mobile treatment unit; installation of asphalt cap, wells, and piping for the conveyance system; connection to utilities (such as electricity) for system operation; and off-site treatment costs for drill cuttings. Capital costs also include monitoring during construction and system startup (details in Section 2.1.3.3). Other capital costs include submittals, plans, and site preparation items, such as permits and utility location, and professional and technical services costs, such as project management.

Annual costs include O&M, monitoring (as described in Section 2.1.3.3 above), and professional and technical services. Periodic costs include assumed costs for equipment replacement, moving the SVE mobile treatment unit to different AOCs, GAC replacement, and confirmational soil and air monitoring.

Periodic costs for the first two years of operation are assumed to include one carbon change-out (based on a carbon usage rate of 0.25 pound COC/pound GAC), costs for moving the SVE mobile treatment unit, and sampling associated with system startup and end of treatment periods. Based on the low mass loading expected from AOC-4 (approximately 30 pounds of gasoline) no carbon change-out will be required during the approximately two years of treatment assumed for this AOC. Since treatment will last up to approximately 48 months, periodic costs for Year 5 include final demobilization costs (e.g., SVE mobile treatment unit removal), confirmational soil sampling and analysis, and final carbon disposal.

The goal of SVE treatment is to decrease soil concentrations of VOCs to below SLs (100 mg/kg for Stoddard solvent and gasoline). However, as mentioned above, this technology depends on the mass transport mechanism between the soil and vapor matrices, so a point of diminishing returns will eventually be reached. It is assumed that for the four VOC-impacted AOCs that are treated, final VOC concentrations will be below SLs, since site conditions (such as high soil permeability and low initial contaminant concentration) are good for SVE treatment. Conservatively, it is assumed that post-treatment concentrations will be slightly below SLs; therefore, the total quantity of VOCs removed from AOC-1 through AOC-4 is estimated to total approximately 410 pounds.

The NPV of implementing Alternative A3 over a 30-year time period is estimated to total approximately $16.3 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 2.1.3 above and listed in the cost tables contained in Appendix A. The portion of this cost that is directly applicable to the operation of the SVE system in the four AOCs that are treated is estimated to total approximately $500,000 (refer to Table A-4).

2.1.4 Alternative A4: Alternative A1 or A2 Plus Excavation and Off-Site Disposal

Alternative A4 adds excavation and off-site disposal to Alternative A1 or A2 for those AOCs where there are no VOCs at concentrations above SLs in near-surface soil. Alternative A4 is judged to be the most practicable permanent cleanup action for metals in near-surface soil.

Excavation and off-site disposal will be added to Alternative A1 for those AOCs where no COCs at concentrations above the SLs will remain in the near-surface and deep vadose zone (Alternative A4a). Excavation and off-site disposal will be added to Alternative A2 for those AOCs where one or more COC will remain in deep vadose zone soil at concentrations above the SLs (Alternative A4b). The determination of whether COCs will be present at concentrations greater than SLs in the deep vadose zone is made in Section 3. Area-based remedial alternatives are summarized in Section 6.

2.1.4.1 Near-Surface Soil Areas of Excavation

The AOCs for each COC for near-surface soil are defined in Section 2 of the FSTM. The AOC boundaries and the concentration of COCs present in the AOCs were estimated in Section 2.6 of the FSTM. The method used to estimate the concentration of VOCs present in each AOC provided a very conservative overestimate of the concentration of COCs that are present in each AOC.

These COC-specific AOCs are consolidated on Figures 2-3 through 2-10 of this FS. These figures depict the soil COC-specific AOCs that are present in each of the operating areas of the Kaiser Facility. Many of the AOCs are located below floor slabs or existing pavement within the operating areas.

The lateral area of near-surface soil that could be excavated for the purposes of this FS was estimated as follows: (1) start with the overall areal footprint of the consolidated AOCs shown on Figures 2-3 through 2-10; (2) subtract the area of existing floor slab or pavement to estimate the maximum area of new excavation; (3) subtract the areas where VOCs are present at concentrations above SLs (excavation for these areas will not be considered, see Section 2.1.3.3 for more detail); and (4) subtract areas that fall within 20 feet of a building. The lateral area of near-surface soil that can be excavated is approximately 75,000 sq ft. This is approximately 60 percent of the estimated total lateral area (128,000 sq ft) of the near-surface soil AOCs.

The FSTM (Section 2.5.1.2) established a 45-degree rule for excavations near foundations. For instance, the bottom of a 20-foot-deep excavation could not be excavated closer than 20 feet from the foundation (i.e., 1H:1V setback). We assumed that 50 percent of the near-surface soil within the 20-foot zone will slough off into the excavation and be removed. If an AOC is completely within the 20-foot zone we assumed that the material will not be excavated.

The depth interval for each AOC is discussed in the FSTM (Appendix B) and presented in Table 2-17 of the FSTM. The total volume of soil that could be excavated based upon these assumptions is approximately 33,000 CY or 47,000 tons (assuming a bulk density of 1.4 ton/CY). An additional estimated 6,000 CY or 8,000 tons of clean overburden will need to be excavated to access impacted material. The clean overburden will be temporarily stockpiled and then used as clean backfill. These volumes do not include sloping back the excavation side walls, which will be necessary to reach impacted soil and preserve the integrity of the excavation.

The footprint of the excavation is not indicative of the footprint of the final excavation that will be recommended for the area. The final excavation footprint will depend on the remedies selected for the other segments of the Facility (e.g., deep vadose zone soil, petroleum groundwater plume) as described in Sections 3 through 6 of this FS. The potential volume of soil that is excavated (approximately 33,000 CY) will be used to calculate the cost of this excavation and off-site disposal alternative.

2.1.4.2 Description of the Excavation and Off-Site Disposal Process

The purpose of this alternative is to remove near-surface soil (top 20 feet) to eliminate human health direct contact pathways, and to remove source areas containing COCs at concentrations above SLs to eliminate the potential for the COCs to migrate to groundwater. The area of excavation is estimated to total about 75,000 sq ft, or 2,800 sq yards, and the estimated disposal volume is approximately 23,000 CY. The disposal volume assumes that 30 percent of the excavated volume is cobbles and will remain on site after mechanical screening. This estimated area and volume includes AOCs impacted by SVOCs, PCBs, and metals. The determination of excavation areas is described in Section 2.1.4.1.

Material will be excavated from various AOCs around the Facility and transported by dump truck to a central area for mechanical screening (see Figure 2-15). Based on grain size distribution analysis and knowledge of the typical soil on site, it is expected that approximately 30 percent of the soil contains gravel and cobbles greater than 2 inches. The materials that will be excavated will be screened to separate gravel and cobbles from the finer grained material. The gravel and cobbles will be stockpiled and reused on site as backfill. COCs present in the soil are associated with the finer grained material. This finer grained material will be sent off site for disposal at a permitted facility. Mechanical screening will significantly reduce the volume and cost for disposal.

The stockpile screening operations are located in a flat, undeveloped area in the western half of the Facility adjacent to an existing access road and near the north end of the WWT facility that has previously been used for soil screening activities (see Figure 2-15). Stockpile screening operations will be contained inside an earthen berm that is approximately 150 by 100 feet.

The stockpile screening area remains from previous screening operations. It was constructed by excavating approximately 12 inches below existing ground surface, leveling and smoothing the area, placing a continuous reinforced HDPE liner, and placing clean soil over the liner to protect it.

The shaker screen plant as well as a loader will be placed inside the bermed area. The loader will be used for feeding the shaker screen plant, stockpile management, and eventual delivery of screened materials to dump trucks for transport for off-site disposal. The shaker screen plant will contain a 2-inch screen to capture the gravel and cobbles. Using gravity and vibration, the shaker screen will send gravel and cobbles to a stockpile adjacent to the screen plant. The less than 2-inch-diameter materials will fall through the screen to a large catch pan. From there the materials will be delivered to stockpiles via a movable conveyor belt system or a rubber-tired front-end loader.

If additional space is needed in the screening area, the greater than 2-inch material may be moved prior to completion of the screening process. Soil less than 2 inches in diameter will be stockpiled, sampled and analyzed as necessary to characterize the soil, and shipped off site for proper disposal based on the analytical results. In some cases, there will already be sufficient site investigation data on soil from specific AOCs to provide data necessary to characterize soil for proper disposal. In such cases, the less that 2-inch-diameter soil that remains after screening will not need to be sampled prior to off-site disposal. Material will be excavated and screened by like constituents to prevent cross contamination between constituents with different disposal requirements. Material containing PCBs or lead will be segregated as necessary and stockpiled until sufficient analytical results are available.

Soil will be delivered to the stockpile screening area via an access ramp on the east berm of the area to allow the dump trucks to deliver soil without entering the bermed area. This minimizes the potential for trucks to track contaminated materials from within the contaminant area to adjacent roadways. Export of the screened material for disposal is anticipated to be on the north end of the bermed area with an interior loader transferring material over the berm and into transport containers.

In addition to providing protection against material loss from stormwater runoff, the earthen berm will act as a segregation line, which will prevent vehicles from tracking contamination from the site. Spilled material outside of the bermed area will be promptly removed and transferred to the containment area or an awaiting truck for off-site disposal, if applicable.

Stormwater controls relating to stockpile management include stabilizing soil. If necessary, screened soil will be stabilized at the end of the shift before a holiday or weekend based on the weather forecast throughout the life of the project. Screened soil will be maintained inside the bermed stockpile screening area throughout the project. Plastic sheeting will be used to stabilize unworked soil stockpiles generated during this project, as needed. If necessary, based on field observations, water misting of stockpiles will be used to suppress dust.

Following completion of the soil processing, the stockpile screening area will be dismantled. The soil berm, material delivery ramps, and protection material will be removed to permit access to the HDPE liner. Material that came in contact with contaminated soil will be disposed of off site with the less than 2-inch-diameter material. In the event that breaches of the liner are noted during removal, an approximate 6-inch lift of soil will be removed from the area adjacent to any breach. This material will be disposed of off site with the less than 2-inch material.

Soil with concentrations of PCBs greater than 50 mg/kg will be disposed of at a RCRA/TSCA-permitted landfill. The closest such landfill is Chemical Waste Management located in Arlington, OR. This facility has a composite HDPE liner and leachate collection and removal system. The only area of the Kaiser Facility with PCB concentrations exceeding 50 mg/kg is the Oil House Drum Storage and French Drain area. This area is not included as an area to be excavated for the purpose of Section 2 because it is currently contained under existing pavement. If the soil in this area is not excavated, there is not likely to be soil that exceeds TSCA regulatory limits that would require management during implementation of the remediation alternative. If soil with TSCA-regulated concentrations of PCBs is identified during implementation of the Cleanup Action Plan (CAP), it will be managed per TSCA requirements.

Excavated soil that could potentially be classified as dangerous waste (DW) will also be disposed of at Chemical Waste Management located in Arlington, OR. Soil concentrations of lead in the Man-Made Depressions area exceed threshold SLs and, therefore, if excavated might have the potential to be designated as

DW based on the toxicity characteristic leaching procedure (TCLP). Final determination of a disposal facility will be made based on soil stockpile results after screening or from pre-excavation soil characterization data.

2.1.4.3 Monitoring Requirements for Alternative A4

Long-term performance monitoring will be conducted and will have the objectives and scope described above for Alternative A1. Cap integrity monitoring for the areas of the Facility that are currently paved or under a floor slab will have the same objectives and scope described above for Alternative A2. In addition, protection monitoring for Alternative A4 will contain the monitoring elements prescribed by the HASP, and include dust monitoring during excavation and material screening processes.

Performance monitoring will include the visual inspection of the screening stockpiles to confirm that the screening operations are working correctly. Additional soil samples will be collected below tears in the liner of the mechanical screening area, if needed, to confirm that the contaminants did not migrate to the soil below the liner.

Confirmational monitoring will include the collection and analysis of soil samples from excavations to confirm that the COCs in the AOC have been removed. See Table 2-6 for a summary of monitoring requirements for Alternative A4.

2.1.4.4 Alternative A4 Estimated Cost

For cost estimation purposes in this section, we assumed approximately 2,000 CY of soil will be disposed of as hazardous waste.

It is expected that the remaining excavated soil will require disposal at a Subtitle D (non-hazardous) landfill. The nearest Subtitle D landfill to the Kaiser Facility that will accept PCBs at the low concentrations expected in near-surface soil is located in Roosevelt, WA. The HDPE liners from stockpiles and the screening/stockpile area will be disposed of with soil that is shipped off site to a Subtitle D landfill. Approximately 30,000 CY will be excavated under Alternative A4 and sent to a Subtitle D landfill for disposal.

Excavating the above quantities of soil will remove approximately 143,000 pounds of SVOCs, 8 pounds of PCBs, 3,200 pounds of lead, and 140 pounds of arsenic. Approximately 110,000 pounds of SVOCs, 1,200 pounds of PCBs, and 1,200 pounds of metals will remain in place under buildings, under existing pavement, within areas with VOCs exceeding SLs, or within 20 feet of the buildings.

The NPV of implementing Alternatives A4a and A4b over a 30-year time period are estimated (-35 to +50 percent) to be $18.7 million and $20.9 million, respectively (see Appendix A, Tables A-5 and A-6). The incremental cost of excavation and disposal is estimated to total approximately $5.1 million.

2.1.5 Alternatives A5a and A5b: Alternative A1 or A2 Plus Excavation and On-Site Treatment (Biotreatment or Thermal Treatment)

Alternative A5 adds excavation and on-site treatment (biotreatment or thermal desorption) of SVOCs to Alternative A1 or A2 for those AOCs where VOCs are not present in near-surface soil at concentrations above SLs. Excavation and on-site treatment will be added to Alternative A1 for those AOCs where no COCs at concentrations above the SLs will remain in deep vadose zone. Excavation and on-site treatment will be added to Alternative A2 for those AOCs where one or more COC will remain in the deep vadose zone soil at concentrations above the SLs. Biotreatment and thermal treatment are not applicable technologies for AOCs that contain PCBs or metals. The determination of whether COCs are present at concentrations greater than SLs in the deep vadose zone is made in Section 3. Area-based alternatives are summarized in Section 6.

2.1.5.1 Near-Surface Soil Areas of Excavation

The AOC boundaries and the concentration of COCs present in the AOCs for near-surface soil were estimated in Section 2.6 of the FSTM. The method used to estimate the concentration of COCs present in each AOC resulted in a very conservative overestimate of the quantity of COCs that are present in each AOC.

These COC-specific AOCs are consolidated on Figures 2-3 through 2-10 of this FS. These figures depict the soil COC-specific AOCs that are present in each of the operating areas of the Kaiser Facility. Many of the AOCs are located below floor slabs or existing pavement within the operating areas.

As discussed in Section 2.1.4.1, the lateral area of near-surface soil that could be excavated for the purposes of Section 2 of this FS was estimated as follows: (1) start with the overall areal footprint of the consolidated AOCs shown on Figures 2-3 through 2-10; (2) subtract the area of existing floor slab or pavement to estimate the maximum area of new excavation; (3) subtract the areas where VOCs are present at concentrations above SLs (excavation for these areas will not be considered, see Section 2.1.3.3 for more detail); and (4) subtract areas that fall within 20 feet of a building.

As discussed in Section 2.1.4.1, the depth interval of excavation was taken from the FSTM. The total volume of soil that could be excavated based on these assumptions is approximately 23,000 CY (assuming that the 30 percent cobbles will remain on site) or 47,000 tons (assuming a bulk density of 1.4 tons/CY). An additional estimated 6,000 CY, or 8,000 tons, of clean overburden will need to be excavated to access impacted material. The clean overburden will be temporarily stockpiled and then used as clean backfill. These volumes do not account for the need to slope excavation side walls to maintain the integrity of the excavation, which will be necessary to reach impacted soil.

The footprint of the excavation is not indicative of the footprint of the final excavation that will be recommended for the Facility. The FSTM concluded that Alternative A5 was appropriate for SVOCs, and not appropriate for VOCs, PCBs, or metals. Containment and excavation with off-site disposal were considered to be appropriate remedies for PCBs and metals present in near-surface soil. High concentrations of metals can inhibit biodegradation of other COCs. The final excavation footprint associated with Alternative A5 will depend upon the remedies selected for the other segments of the Facility (e.g., deep vadose zone soil, petroleum groundwater plume) as described in Sections 3 through 6 of this FS. The potential volume of soil that is excavated, approximately 33,000 CY, will be used to calculate the cost of this excavation and on-site treatment alternative.

2.1.5.2 Description of Excavation and On-Site Biotreatment Process

As was the case for Alternative A4, one purpose of Alternative A5 is to remove impacted near-surface soil (top 20 feet) to eliminate human health direct contact and ingestion pathways, and to remove source areas containing COCs at concentrations above SLs to eliminate the potential for the COCs in near-surface soil to migrate to groundwater. Alternative A5a adds on-site biotreatment to destroy SVOCs that are excavated.

Excavated material will be transported to a single location for mechanical screening as described above in Section 2.1.4.2. Material less than 2 inches will be transported to an open area north of the screening area to be landfarmed.

Based on the mineral sandy nature of the soil, amendments will likely be needed to promote biodegradation of the SVOCs. These amendments could include a microbial inoculum (which typically can be done by adding sewage sludge or manure), nutrients (nitrogen and phosphorus), and moisture. The Spokane River has a total maximum daily load (TMDL) for phosphorus, which is an essential nutrient for bacterial growth; care will be taken to not add phosphorus in excess of what is required based on biological needs.

The landfarm will be constructed on an HDPE liner to prevent infiltration of contaminants into the subsurface. The depth of the landfarm will be 12 to 18 inches depending on the capabilities of the tilling equipment used. The approximate size of the land farm for the 23,000 CY of soil at a 12-inch thickness is approximately 630,000 sq ft (14.5 acres); see Figure 2-15 for the approximate landfarm footprint. The landfarm will be contained within a berm to prevent run-on and collect runoff. The landfarm will be constructed at a slight slope to prevent water from accumulating below the soil. The leachate will be collected and pumped to temporary storage tanks to be to be treated by the Kaiser wastewater treatment facility (WWT). Leachate will be sampled for phosphorus to confirm that water will not exceed the Spokane River TMDL. During the summer months, leachate may be added back to the pile to maintain the appropriate moisture content. A typical landfarm design is shown on Figure 2-16.

The landfarm will need to be periodically tilled with a roto-tiller or equivalent piece of equipment to aerate the soil. Typically, treatment times for landfarming range from 6 months to 2 years (EPA 1994). Landfarming has been used at numerous full-scale sites where contaminant concentrations were successfully reduced. Removal efficiencies are a function of contaminant type and concentrations, temperature, moisture, aeration, and other factors (FRTR 2010). Landfarming generally cannot achieve removal efficiencies above 95 percent; however, landfarming should be able to achieve reductions in soil SVOC concentrations to below 2,000 mg/kg (EPA 1994).

After confirmational sampling and analysis indicates that the material in the landfarm is below SLs, we have assumed that it can be reused on site as fill.

2.1.5.3 Description of Excavation and On-Site Thermal Treatment Process

As was the case for Alternative A4, one purpose of this Alternative A5 is to remove impacted near-surface soil (top 20 feet) to eliminate human health direct contact pathway, and to remove source areas containing COCs at concentrations above SLs to eliminate the potential for the COCs in near-surface soil to migrate to groundwater. Alternative A5b adds on-site thermal treatment to destroy SVOCs that are excavated.

Excavated material will be transported to a single location for mechanical screening as described above in Section 2.1.4.2. Material less than 2 inches in size will be transported and loaded onto a truck-mounted mobile thermal desorption unit located north of the screening area. A typical footprint needed for a truck-mounted thermal treatment unit, and for loading and stockpile areas, is approximately 125 by 125 feet. See Figure 2-17 for approximate treatment footprints and locations.

Screened soil will be loaded into a thermal desorber. The thermal desorber can use direct or indirect flame to heat the soil and volatilize the SVOCs. The treated soil is rehydrated and cooled with fresh water before being stockpiled. The vaporized contaminants flow through a baghouse that collects dust and fine particulates. The collected dust is rehydrated and added to the clean soil stockpile. The dust-free vaporized SVOCs continue to an afterburner, where they are thermally oxidized to destroy them and create harmless end products like carbon dioxide and water. A process flow diagram for the thermal desorption process envisioned for the Facility is shown on Figure 2-18.

A typical desorber uses a rotary kiln that operates at temperatures from 900 to 1,200°F. The temperature used depends on the chemical composition of the material (the longer-chain hydrocarbons may require higher temperatures) and moisture content. Chemical composition and moisture content will also affect the feed rate of the material. The thermal oxidizers typically operate from 1,400 to 1,800°F. Thermal oxidizers are generally not designed to destroy chlorinated compounds, including PCBs, but systems are available to treat these compounds. Thermal desorption for PCBs in near-surface soil at Kaiser was eliminated in the FSTM because the process option was judged to be unreliable for PCBs based on the generally low concentration of PCBs in near-surface soil (i.e., most concentrations are less than 1 mg/kg) and because of the high level of operational and maintenance effort, and regulatory approvals, needed to operate the system when a thermal oxidizer designed to destroy dioxins and furans is added to the thermal desorption unit.

A treatability study will be conducted to determine the optimum system parameters needed to reach SLs for SVOCs. Thermal desorption has been proven to meet SLs of 2,000 mg/kg for diesel and heavy oil at sites similar to the Kaiser Facility. Thermal desorption units typically have overall removal efficiencies of 90 to 99 percent (NFESC 1998). Emission testing from active thermal desorption units have shown that air emissions meet air quality standards. Afterburners typically can achieve removal efficiencies of 95 percent (FRTR 2010). Typical treatment periods for thermal desorption are less than one year (FRTR 2010).

2.1.5.4 Monitoring Requirements for Alternative A5

Long-term performance monitoring will be conducted and will have the objectives and scope described above for Alternative A1. Cap integrity monitoring for the areas of the Facility that are currently paved or under a floor slab, will have the same objectives and scope described above for Alternative A2. In addition, protection monitoring for Alternative A5 will contain the monitoring elements prescribed by the HASP, and include dust monitoring during excavation and material screening processes.

Performance monitoring will include the visual inspection of the screening stockpiles to confirm that the screening operations are working correctly. Additional soil samples will be collected below tears observed in the liner of the mechanical screening area, if necessary, to confirm that the contaminants did not migrate to the soil below the liner.

Performance monitoring for Alternative A5a (landfarming) will include quarterly sampling for pH, moisture content, nutrients (including phosphates), and concentrations of COCs. Additional amendments may be added to improve performance based on sample analytical results. Performance monitoring for Alternative A5b (thermal desorption) will include sampling the COC concentrations in the processed soil and sampling air emissions from the afterburner to make sure both are in compliance.

Confirmational monitoring will include the collection and analysis of soil samples from excavations to confirm that the COCs in the AOC have been removed and to confirm that SLs have been reached. Confirmational monitoring for Alternative A5a (landfarm) will include sampling the soil in the landfarm to verify that SLs have been reached. The HDPE liner will be repaired if tears are observed in the liner. Confirmational monitoring for Alternative A5b (thermal desorption) will include collection and analysis of the treated soil stockpile.

Air emissions will be sampled to verify that air quality standards are being reached. See Tables 2-7 and 2-8 for a summary of monitoring requirements for Alternatives A5a and A5b, respectively.

2.1.5.5 Alternative A5a and A5b Estimated Cost

Excavating and biologically treating the quantities of soil described for Alternative A5b above are expected to remove approximately 143,000 pounds of SVOCs. Assuming a 95 percent destruction rate, approximately 135,000 pounds of SVOCs will be destroyed by landfarming. Approximately 110,000 pounds of SVOCs will remain in place under buildings, existing pavement, or within 20 feet of the buildings. Alternative A5a was not developed to address PCBs or metals. Other alternatives were judged to be more appropriate for these COCs.

The NPV of implementing Alternative A5a (biotreatment) combined with Alternative A1 over a 30-year time period is estimated to total approximately $19.1 million (-35 to +50 percent). Implementation of Alternative A5a combined with Alternative A2 over the same time period is estimated to total approximately $21.4 million (-35 to +50 percent) (see Appendix A, Table A-7).

The incremental cost of the excavation and biotreatment elements of Alternative A5a is estimated to total approximately $5.5 million to $5.6 million (Table A-1).

Excavating and thermally treating the quantities of soil assumed above for Alternative A5b are expected to remove approximately 143,000 pounds of SVOCs. Assuming a 95 percent destruction rate, approximately 135,000 pounds of SVOCs will be destroyed by thermal desorption. Approximately 110,000 pounds of SVOCs will remain in place under buildings, existing pavement, or within 20 feet of the buildings. Alternative A5b does not address PCBs or metals.

The NPV of implementing Alternative A5b (thermal treatment) combined with Alternative A1 over a 30-year time period is estimated to total approximately $19.9 million (-35 to +50 percent). Implementation of Alternative A5b combined with Alternative A2 over the same time period is estimated to total approximately $22.2 million (-35 to +50 percent) (refer to Table A-8 in Appendix A).

The incremental cost of the excavation and thermal treatment elements of Alternative A5b is approximately $6.3 million to $6.4 million (Table A-1).

2.1.6 Alternative A6: Alternative A1 or A2 Plus Excavation and Off-Site Incineration

Alternative A6 adds excavation and off-site incineration to Alternative A1 or A2 for those AOCs where VOCs are not present in near-surface soil at concentrations above SLs. Alternative A6 is considered to be the most permanent treatment alternative for SVOCs and PCBs in near-surface soil (refer to FSTM Section 2.7.2). The incineration of near-surface soil containing SVOCs and PCBs is expected to result in the destruction of more COC mass than Alternatives A1 through A5, as discussed below. Alternative A6 assumes that all of the excavated soil with SVOC and PCB concentrations above SLs will be incinerated.

Excavation and off-site treatment will be added to Alternative A1 for those AOCs where no COCs at concentrations above the SLs will remain in deep vadose zone soil. Excavation and off-site treatment will be added to Alternative A2 for those AOCs where one or more COCs will remain in deep vadose zone soil at concentrations above the SLs. Soil that cannot be excavated from the near-surface soil includes areas that are within 20 feet of a building or that contain VOCs (for VOC AOCs see Section 2.1.3.3 for more detail). The determination of whether COCs will be present at concentrations greater than SLs in the deep vadose zone is made in Section 3. Area-based alternatives are summarized in Section 6.

2.1.6.1 Near-Surface Soil Areas of Excavation

The AOC boundaries and the concentration of COCs for near-surface soil were estimated in Section 2.6 of the FSTM. The method used to estimate the concentration of COCs present in each AOC resulted in a very conservative overestimate of the quantity of COCs that are present in each AOC.

The COC-specific AOCs are consolidated on Figures 2-3 through 2-10 of this FS. These figures depict the soil COC-specific AOCs that are present in each of the operating areas of the Facility. Many of the AOCs are located below floor slabs or existing pavement within the operating areas.

The AOCs that will be excavated in Alternative A6 are the same areas identified for excavation in Alternative A4 (refer to Section 2.1.4.1). The total volume of soil that could be excavated based on these assumptions is approximately 33,000 CY or 47,000 tons (assuming a bulk density of 1.4 tons/CY). An additional estimated 6,000 CY, or 8,000 tons, of clean overburden will need to be excavated to access impacted material. The clean overburden will be temporarily stockpiled and then used as clean backfill. These volumes do not account for sloped excavation side walls, which will be necessary to preserve the integrity of the excavation and to reach impacted soil.

The footprint of the excavation is not indicative of the footprint of the final excavation that will be recommended for the Facility. The final excavation footprint associated with Alternative A6 will depend on the remedies selected for the other segments of the Facility (e.g., deep vadose zone soil, petroleum groundwater plume) as described in Sections 3 through 6 of this FS. The potential volume of soil that is excavated (approximately 33,000 CY) will be used to calculate the cost of this excavation and off-site treatment alternative (incineration).

2.1.6.2 Description of the Excavation and Off-Site Treatment Process (Incineration)

Excavated material will be transported to a single location for mechanical screening as described above in Section 2.1.4.2. Screened material will be transported off site for incineration. Alternative A6 assumes that all of the excavated soil with SVOC and PCB concentrations above SLs will be incinerated. The closest off-site treatment facility that is permitted to incinerate PCBs is Clean Harbors in Aragonite, UT. Clean Harbors is located approximately 800 miles from the Facility. Clean Harbors is permitted to accept nearly all waste codes, including PCB waste. The incinerator is a rotary kiln with a vertical afterburner with a wet scrubber. A process flow diagram is provided on Figure 2-19. The ash created from the kiln and afterburner is sampled, manifested, and transported to a Clean Harbors permitted and lined landfill for disposal. Metals will not be destroyed in the incineration process and will remain in the ash.

Excavation with off-site incineration of the above quantities of soil is expected to remove approximately 143,000 pounds of SVOCs, 8 pounds of PCBs, 3,200 pounds of lead, and 140 pounds of arsenic. Assuming a 99.99 percent reduction rate for SVOCs and PCBs, approximately 143,000 pounds of SVOCs and 8 pounds of PCBs will be destroyed. Approximately 110,000 pounds of SVOCs, 1,200 pounds of PCBs, and 1,200 pounds of metals will remain in place under buildings, existing pavement, or within 20 feet of Facility buildings.

2.1.6.3 Monitoring Requirements for Alternative A6

Long-term performance monitoring will be conducted and will have the objectives and scope described above for Alternative A1. Cap integrity monitoring for the areas of the Facility that are currently paved or under a floor slab, will have the same objectives and scope described above for Alternative A2. In addition, protection monitoring for Alternative A6 will contain the monitoring elements prescribed by the HASP, and include dust monitoring during excavation and material screening processes.

Performance monitoring requirements will be specified in the O&M Plan for the screening plant and will include the visual inspection of the screening stockpiles to confirm that the screening operations are working correctly. Additional soil samples will be collected below tears in the liner of the mechanical screening area, if necessary, to confirm that the contaminants did not migrate to the soil below the liner. Performance monitoring during the operation of the off-site incinerator will be conducted by Clean Harbors. Clean Harbors will provide a report certified by a professional engineer that provides a summary of operating parameters as the soil was treated and provides the evidence required to assure Kaiser that the treatment goals for near-surface soil have been achieved.

Confirmational monitoring will include the collection and analysis of soil samples from excavations to confirm that the COCs in the AOC have been removed and to confirm that SLs have been reached. Clean Harbors will provide a report certified by a professional engineer as evidence to document for Kaiser that the material has been treated.

See Table 2-9 for a summary of monitoring requirements for Alternative A6. The incineration facility follows its own Quality Assurance and O&M Plan.

2.1.6.4 Alternative A6 Estimated Cost

Incineration will result in the destruction of more SVOC and PCB mass than any other alternative. This is the only alternative that destroys the 8 pounds of PCBs present in the near-surface soil that we have assumed will be excavated for the purpose of Section 2. Incineration will not destroy lead or other metals in the soil, but these COCs will be removed from the Facility, and the ash will be placed in a permitted landfill by Clean Harbors.

The NPV of implementing Alternative A6 combined with Alternative A1 over a 30-year time period is estimated to total approximately $39.0 million (-35 to +50 percent). Implementation of Alternative A6 combined with Alternative A2 over the same time period is estimated to total approximately $41.3 million (-35 to +50 percent) (see Appendix A, Table A-9).

The incremental cost of the excavation and thermal treatment elements of Alternative A6 is estimated to be $25.4 million to $25.5 million (Table A-1).

2.2 EVALUATION OF REMEDIAL ALTERNATIVES FOR NEAR-SURFACE SOIL

Ecology has identified criteria that are used to evaluate remedial technologies and alternatives (WAC 173-340-360). These evaluation criteria are described in Section 2.2.1, and remedial action objectives (RAOs) are defined in Section 2.2.2. The criteria are applied to Alternatives A1 through A6 in Sections 2.2.3 through 2.2.8, respectively. A comparative analysis of alternatives is conducted in Section 2.3 to identify the most appropriate remedial alternative for each near-surface soil COC group. The comparative analysis assesses the relative capability of each alternative to meet threshold requirements, to use permanent solutions to the maximum extent practicable, and to achieve a reasonable restoration time frame.

2.2.1 Description of the Evaluation Criteria

WAC 173-340-360(2) dictates the minimum requirements for cleanup actions:

- Threshold requirements:
  - Protect human health and the environment;
  - Comply with MTCA cleanup standards;
  - Comply with applicable state and federal laws; and
  - Provide for compliance monitoring.

- Other requirements:
  - Use permanent solutions to the maximum extent practicable to be determined in accordance with WAC 173-340-360(3)(f) for the following criteria:
    - Protectiveness;
    - Permanence;
    - Cost;
    - Effectiveness over the long term;
    - Management of short-term risks;
    - Technical and administrative implementability; and
    - Consideration of public concerns.

  - Provide for a reasonable restoration time frame to be determined in accordance with the factors listed in WAC 173-340-360(4)(b).

These criteria are discussed below.

2.2.1.1 Threshold Requirements

Protect Human Health and the Environment

This criterion is defined in WAC 173-340-360(3)(f)(i) and is used to measure how an alternative will achieve and maintain human health and environmental protectiveness. It assesses whether the risk posed to potential receptors is eliminated, reduced, or controlled through each exposure pathway by natural attenuation, treatment, engineering, or institutional controls. The overall protectiveness of a candidate remedy must be considered in light of the results found in the Final Human Health and Ecological Risk Assessments (HHERA) (Pioneer 2012).

An assessment of potential risks to human health and ecological receptors was conducted, and SLs were established for on-property soil and groundwater, in Section 1 of the FSTM (Hart Crowser 2012c). The expected outcome of each alternative described in this FS will be compared to the proposed SLs and the potential points of compliance that were identified in Section 1 of the FSTM.

Comply With Cleanup Standards

The remediation alternatives presented in this FS are assessed to determine whether they comply with MTCA cleanup standards (WAC 173-340-700 through WAC 173-340-760). These standards were summarized in Section 1 of the FSTM and were used to establish the SLs identified for the Kaiser Facility. Cleanup standards were later used by Ecology to establish preliminary cleanup levels (PCULs) for the Facility (Ecology 2010a and 2010b). Applicable or relevant and appropriate requirements (ARARs) for the Kaiser Facility are identified and evaluated in Appendix G, which discusses three types of ARARs—contaminant-specific, location-specific, and action-specific ARARs.

According to WAC 173-340-200 and 173-340-700(3), the establishment of cleanup standards requires specification of cleanup levels for hazardous substances present at the site and the location where these cleanup levels must be met (point of compliance). Contaminant-specific ARARs were considered in the establishment of the PCULs by Ecology (Ecology 2010a). It should be noted that Ecology has allowed the continued use of the SLs established in the FSTM for assessing alternatives in this FS (Ecology 2010b). The PCULs developed by Ecology for the Facility are used as appropriate as the estimated restoration time frames for each alternative are evaluated. The PCULs will also be applied in the CAP if Ecology determines they are appropriate after public review. The CAP will be prepared by Ecology following selection of the preferred remediation alternative.

In addition to contaminant-specific ARARs, establishing cleanup standards per MTCA requires specification of other regulatory requirements that apply to the site because of the type of remedial action that is anticipated and/or the location of the site. These requirements are categorized as action- or location-specific ARARs.

For the purposes of this FS, the evaluation of compliance with cleanup standards focuses on applicable contaminant-specific requirements (i.e., SLs, PCULs, and points of compliance). Compliance with action- and location-specific ARARs is addressed separately for each alternative in the section that immediately follows.

Comply with Applicable State and Federal Laws

The remediation alternatives presented herein are assessed to determine whether they comply with other applicable state and federal laws (WAC 173-

340-710). These action- or location-specific ARARs are identified and evaluated in Appendix G, in addition to the contaminant-specific ARARs from which the cleanup standards for the Kaiser Facility are being established.

Provide for Compliance Monitoring

Compliance Monitoring requirements are defined in WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.

Alternatives A1 through A6 each include institutional controls and compliance monitoring. The institutional controls and long-term performance monitoring associated with Alternative A1 are also a part of Alternatives A2 through A6. As a result, compliance monitoring and institutional controls incorporated as part of each alternative are not included as evaluation criteria in this section. The cost associated with institutional controls and compliance monitoring is included in the conceptual level cost estimate prepared for each alternative.

2.2.1.2 Other Requirements

Other requirements that remedial alternatives must fulfill once they meet threshold requirements are defined by WAC 173-340-360(2)(b) to include the use of permanent solutions to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame WAC 173-340-360(4).

Use of Permanent Solutions to the Maximum Extent Practicable

The use of permanent solutions to the maximum extent practicable is a primary evaluation criterion for the remedial alternatives being considered for near-surface soil. The specific criteria that must be addressed are specified in WAC 173-340-360(3)(f) and are discussed below.

Protectiveness. The overall protectiveness provided by the alternative to human health and the environment, including the degree to which existing risks are reduced, the time required to reduce risk at the Facility and attain cleanup standards, the on-site and off-site risks resulting from implementing the alternative, and the improvement of the overall environmental quality provided by the alternative, are addressed by this criterion.

Permanence. This criterion addresses the degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment processes, and the characteristics and quantity of treatment residuals generated.

Cost. This criterion addresses the costs associated with the alternative, including direct capital costs (e.g., construction, equipment, land, services), indirect capital costs (e.g., engineering, supplies, contingency), long-term monitoring costs, O&M costs, and total net present value (NPV). To evaluate the relative cost for the remedial alternatives, various cost estimating resources were used. This is necessary so that the relative cost of each alternative can be evaluated to help identify the most practicable cleanup alternative using the Disproportionate Cost Analysis procedures presented in WAC 173-340-360(3)(e).

Actual historical costs for similar work tasks completed at the Kaiser Facility were used when possible. Historical costs were adjusted to 2010 dollars as needed. When historical costs were not available, local contractor quotes were requested or cost information was researched in the most recent RSMeans cost guide (RSMeans 2009). RSMeans cost data, which are based on national averages, were adjusted to reflect regional cost variability relative to the national average for Spokane, WA. Other costing resources included FS cost estimation guidance prepared by the EPA (EPA 2000a). These cost resources are provided as references in Section 7. The cost tables presented in Appendices A through D are annotated to reflect the cost resources for each line item. Estimated costs for remedial alternatives that span many years were converted to NPV costs using a discount rate of 7 percent and an assumed operating period of 30 years. This discount rate is based on the recommended discount rate for private industry presented in EPA's guidance on cost estimating for FSs (EPA 2000a).

A 30-year operating period was assumed for each of the alternatives to provide an equivalent time basis for comparing estimated NPV costs for each alternative. Some of the remedial alternatives contain elements that would be first incurred only after 30 years. Such elements (for example, well abandonment or treatment system decommissioning conducted at the end of a remedial action) are excluded from the cost estimates if they occur after the 30-year period. Additionally, the remedial alternatives may contain elements that have a duration of less than 30 years or that occur only periodically. The estimated NPV costs account for the shorter durations and periodicity of these elements.

Cost estimates for use in evaluation of cleanup alternatives necessitate making various assumptions. This includes assumptions on the number of years needed to achieve goals (i.e., restoration time frame) and the mass and surface area of environmental media that have constituent concentrations above an identified action level. For example, as discussed in detail in Section 2.6 of the FSTM (Hart Crowser 2012c), the calculation of the average concentration of the COCs present in an AOC represents an overestimate of the concentration that is actually present at a sample location for a number of reasons. The soil matrix at Kaiser consists mostly of gravel and cobbles (Hart Crowser 2012b). The COCs in the sample were associated with the sand and organic material (if any) that was present in the sample. The gravel and cobble portion of the sample was not sent to the lab for analysis since cobbles would not fit in the sample jar and gravel would have to be pulverized in the lab prior to analysis. The cobble portion of the soil matrix alone composes about 30 percent of the soil mass. As a result, the concentration of COCs reported by the lab is an overestimate of the actual *in situ* concentration of the soil contaminant.

The areas of concern presented in the FSTM were developed by using a "half the distance" rule to define a boundary between sample locations that are known to contain contaminants at concentrations above potential SLs, and sample locations where concentrations are known to be at concentrations that are below potential SLs. The "half the distance" rule was applied blindly to define each AOC. In instances where the number of sample locations are few and located far apart, it is inevitable that the application of this rule results in an overestimate of the size of the AOC. We used a similar approach to estimate depth of contamination.

One of the primary goals in developing cost estimates for alternative evaluation is to ensure that costing procedures and assumptions are consistent between alternatives to reduce the potential for bias in one alternative assumption compared to other alternative assumptions. This approach presents a level playing field when evaluating the cost of one alternative versus costs for other alternatives. This cost estimating approach is appropriate for FS costs. However, because of the conservative approach to estimating mass and area, FS cost estimates are not appropriate for use in other applications. Cost estimates that are more accurate will be developed during remedial design as part of the bidding and contractor selection process.

Effectiveness over the Long Term. Long-term effectiveness includes the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes. The following types of cleanup action components can be used as a guide, in descending order, when assessing the relative degree of long-term effectiveness: reuse or recycling; destruction or detoxification; immobilization or stabilization; on-site or off-site disposal in an engineered, lined and monitored facility; on-site isolation or containment with attendant engineering controls; and institutional controls and monitoring.

Management of Short-Term Risks. This criterion addresses the risk to human health and the environment associated with the alternative during construction and the effectiveness of measures taken to manage such risks.

Technical and Administrative Implementability. This criterion assesses the ability of the alternative to be implemented, including consideration of whether the alternative is technically possible; availability of necessary off-site facilities, services, and materials; administrative and regulatory requirements; scheduling; size; complexity; monitoring requirements; access for construction operations and monitoring; and integration with existing Facility operations and other current or potential remedial actions.

Consideration of Public Concerns

Public concerns will ultimately be considered during the public comment period for this FS. Public acceptance was not used as a criterion to distinguish among the remediation alternatives evaluated in this FS. Selection of the preferred remediation alternative may be revised based on the results of the public review process. This criterion is not further addressed in this report.

Restoration Time Frame

Cleanup actions must provide for a reasonable restoration time frame. The process used to determine whether an alternative provides for a reasonable restoration time frame is outlined in WAC 173-340-360(4). The factors that are assessed include:

- The potential risks posed by the site to human health and the environment;
- The practicability of achieving a shorter restoration time frame;
- Current uses of the site, surrounding areas, and associated resources that are or may be affected by releases from the site;
- Potential future uses of the site, surrounding areas and associated resources that are or may be affected by, releases from the site;
- Availability of alternative water supplies;
- Likely effectiveness and reliability of institutional controls;
- Ability to control and monitor migration of hazardous substances from the site;

- Toxicity of the hazardous substances; and

- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions.

2.2.2 Remedial Action Objectives for Near-Surface Soil

Remedial action objectives (RAOs) are broad, administrative goals for a cleanup action that address the overall MTCA cleanup process, including:

- Implementation of administrative principles for cleanup (WAC 173-340-130);
- Meeting requirements, procedures, and expectations for conducting an FS and developing cleanup action alternatives (WAC 173-340-350 through 173-340-370); and
- Developing cleanup levels (CULs) (WAC 173-340-700 through 173-340-760).

In particular, RAOs must include the following threshold requirements from WAC 173-340-360(2)(a):

- Protect human health and the environment;
- Comply with CULs;
- Comply with applicable state and federal laws; and
- Provide for compliance monitoring.

The RAOs for near-surface soil at the Kaiser Facility must address the COCs identified for near-surface soil, and the pathways by which these COCs can reach receptors on and off the Facility. The following COCs were identified for soil:

- VOCs (gasoline and Stoddard solvent);
- SVOCs (diesel, heavy oil, and cPAHs);
- PCBs (total); and
- Metals causing potential human or ecological health risk (arsenic, chromium, and lead).

The HHERA (Pioneer 2012) identified three areas of the Kaiser Facility that may currently pose a human health risk above the benchmark risk level of 1.0×10^{-5}. These areas include the Hoffman Tank area where the assumed incidental ingestion and dermal contact with diesel/fuel oil may occur, the Oil House area Drum Storage French Drain area where the assumed incidental ingestion of Aroclor 1248 may occur, and the ORB Man-Made Depression area where the assumed incidental ingestion of lead may occur.

The ecological risk assessment in the HHERA (Pioneer 2012) determined that near-surface soil at the Facility does not pose a hazard to wildlife.

Another pathway by which COCs in near-surface soil can potentially reach receptors is the soil to groundwater pathway. This potential pathway assumes that rainwater could mobilize COCs in soil and carry them to the groundwater at concentrations that cause an exceedance of groundwater SLs. Soil SLs for this pathway were derived using the Fixed Parameter 3-Phase Partitioning Model (WAC 173-340-747[4] and MTCA Method B CULs, or MCLs established by the CWA or the SDWA, whichever is lower for groundwater). This pathway was determined to have the most impact on the SLs and PCULs established for soil at the Kaiser Facility.

Calculated SLs for the soil to groundwater pathway were exceeded for arsenic, PCBs, cPAHs, and for total petroleum hydrocarbons (TPH) (gasoline, Stoddard solvent, diesel, and heavy oil).

The RAOs for near-surface soil AOCs at the Facility are guided by specific MTCA requirements defined in WAC 173-340-740. Specifically, soil that is contained as a part of the remedy will be deemed to meet CULs if certain requirements set out in WAC 173-340-740(6)(f) are met. The MTCA requirements are as follows:

> *(f) The department recognizes that, for those cleanup actions selected under this chapter that involve containment of hazardous substances, the soil cleanup levels will typically not be met at the points of compliance specified in (b) through (e) of this subsection. In these cases, the soil cleanup action may be determined to comply with cleanup standards, provided:*
>
> *(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;*
>
> *(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;*
>
> *(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;*
>
> *(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;*

(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and

(vi) The types, levels, and amount of hazardous substances remaining on site and the measures that will be used to prevent migration and contact with those substances are specified in the draft cleanup action plan (CAP).

The following RAOs are judged to apply to near-surface soil AOCs at the Kaiser Facility:

- Meet the overall MTCA threshold requirements under WAC 173-340-360(2)(a), as defined by WAC 173-340-740(6)(f) for containment remedies;

- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]); and

- Protect Facility workers and visitors from direct contact (and/or ingestion) with contaminated near-surface soil containing lead, PCBs, and SVOCs, and protect groundwater and surface water quality.

The ways in which each remedial alternative will meet these RAOs for near-surface soil are discussed in Sections 2.2.3 through 2.2.6.

2.2.3 Evaluation of Remedial Alternative A1: Institutional Controls, Monitoring, and Monitored Natural Attenuation

Alternative A1 uses the institutional controls, monitoring, and MNA actions described in Section 2.1.1. The institutional controls include physical measures (e.g., fences and controlled access to the Facility), BMPs (e.g., operating practices designed to prevent spills and leaks of chemicals and lubricants and SPCC Plans), and administrative measures (e.g., a restrictive covenant). An extensive groundwater monitoring plan at the Facility has been in place for many years. This plan contains a wide range of protection and performance monitoring for groundwater at the Facility, and is included as an element of Alternatives A2 through A6 to allow for evaluation of whether soil concentrations are protective of the soil to groundwater and groundwater to surface water pathways.

Historical soil sampling and analysis has provided evidence that the concentration of SVOCs has declined over the years in some locations without human intervention, and it is likely that VOCs have also naturally attenuated over time.

Alternative A1 does not employ any active remedial measures to reduce the toxicity, mobility, or volume of the COCs that are present in near-surface soil at the Facility. The capability of Alternative A1 to meet the cleanup requirements established by MTCA is summarized below.

2.2.3.1 Threshold Requirements

Protect Human Health and the Environment

Physical and administrative controls and BMPs are used to reduce the potential for worker exposure to COCs.

Approximately 35 percent of the near-surface soil AOCs at the Facility are currently located under pavement or floor slabs (refer to Section 2.1.2.1). The pavement and floor slabs prevent Facility workers and visitors from direct contact with COCs in these areas, and prevent rainwater from conveying COCs from near-surface soil to groundwater.

This alternative will not actively work to reduce the concentration of the COCs in near-surface soil at the Facility, or actively work to meet the SLs that have been established for these COCs, other than through natural attenuation processes. While some natural attenuation of SVOCs and VOCs in near-surface soil has occurred, and is expected to continue, this process will not result in a significant reduction in risk to human health and the environment in a reasonable restoration time frame.

Comply with MTCA Cleanup Standards

The implementation of Alternative A1 will not result in compliance with MTCA cleanup requirements. The SLs developed for the Facility were based on the requirements of MTCA plus state and federal contaminant-specific ARARs. These SLs are currently exceeded in the near-surface soil AOCs identified on Figure 2-3.

Alternative A1 will not break the near-surface soil human direct contact or ingestion pathway, or the soil to groundwater pathway, that present current risks to Facility workers and visitors and potential future risk to groundwater. Although the natural attenuation processes that are occurring at the Facility may reduce the concentrations of organic compounds and help to immobilize metals in Alternative A1, it will take a long time to attain cleanup requirements, and reduction in risk to human health and the environment is not expected to occur within a reasonable period of time.

Thus, Alternative A1 will not meet existing MTCA cleanup requirements and does not meet the minimum cleanup requirements established by WAC 173-340-360(2).

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. Location-specific and action-specific ARARs were not identified for Alternative A1 (refer to Appendix G, Tables G-3 and G-4).

2.2.3.2 Other Requirements

Use of Permanent Solutions to the Maximum Extent Practicable

Protectiveness. Alternative A1 will not actively reduce the concentration of the COCs in near-surface soil AOCs at the Facility to meet the SLs that have been established for these COCs, other than by natural attenuation processes. While some natural attenuation of SVOCs in near-surface soil has occurred, and is expected to continue, this process will not result in a significant reduction in risk to human health and the environment in a reasonable time frame. Alternative A1 will not break the current Facility worker/visitor direct contact or ingestion pathway or the soil to groundwater pathway. Thus, Alternative A1 will not meet existing MTCA cleanup standards or ARAR standards promulgated by state and federal laws.

Permanence. The BMPs in place at the Facility will reduce the release of hazardous substances to the environment. Facility access controls will reduce the opportunity for visitors at the Facility to come in contact with the COCs contained in near-surface soil. Existing pavement and floor slabs prevent Facility workers and visitors from direct contact with COCs in these areas.

While the natural attenuation processes that appear to be active in near-surface soil will reduce SVOC concentrations over time, Alternative A1 will not actively reduce the toxicity, mobility, or volume of COCs present in near-surface soil. Natural attenuation will require a long time to attain SLs.

Cost. The NPV of implementing Alternative A1 over a 30-year time period is estimated to total approximately $13.6 million (-35 to +50 percent) (see Appendix A, Table A-2). The assumptions used to prepare this estimate are described in Section 2.1.1, above, and in the cost tables contained in Appendix A. Since the institutional controls, monitoring and MNA described in Section 2.1.1 will be a part of Alternatives A2 through A6, the estimated NPV of Alternative A1 will be a component of the estimated cost of implementing each of these alternatives.

Effectiveness over the Long Term. This alternative will not reduce the concentration of COCs currently present in near-surface soil to concentrations below SLs in a reasonable restoration time frame. The overall risk to human health and the environment will not be significantly reduced by this alternative.

Management of Short-Term Risks. This alternative uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create any new or additional risk to human health and the environment.

The short-term risks that are associated with implementation of existing and future institutional controls include:

- Potential exposure of Facility workers and visitors to media containing COCs;

- Potential exposure of Facility workers and visitors to hazardous materials (e.g., handling items containing hazardous waste as part of executing BMPs); and

- Hazards to workers associated with the industrial activities taking place at various locations within the Facility.

Technical and Administrative Implementability. The actions associated with the implementation of Alternative A1 are already in place at the Kaiser Facility.

Restoration Time Frame

The factors used to determine whether an alternative provides for a reasonable restoration time frame are summarized in Section 2.2.1.2. One of the factors to consider is the potential risk posed by the impacted area to human health and the environment (WAC 173-340-360[4][b][i]). The potential risks posed by the near-surface soil AOCs at the Facility include direct contact and ingestion exposure pathways for human and ecological receptors. The soil to groundwater exposure pathway potentially exists in AOCs where infiltrating rainwater could convey COCs from near-surface soil to the water table. Although the natural attenuation processes that are occurring at the Facility will reduce the concentrations of organic compounds and help to immobilize metals in Alternative A1, it will take a long time to meet cleanup requirements. A reduction in risk to human health and the environment is not expected to occur within a reasonable time frame, and thus the restoration time frame for Alternative A1 is judged to be excessive because of the lack of risk reduction when compared to other viable alternatives for near surface soil. As such, the other factors to consider in assessing the reasonableness of restoration time frame are not expounded for this alternative.

2.2.4 Evaluation of Remedial Alternative A2: Institutional Controls, Monitoring, Monitored Natural Attenuation, and Containment

Alternative A2 adds the additional protection of containment to Alternative A1. Many of the AOCs for near-surface soil COCs are located below existing floor slabs or pavement within the operating areas. Alternative A2 assumes that existing foundations, floor slabs, roads, and other paved surfaces at the Facility are acceptable as containment caps in their current condition. Alternative A2 includes installation of additional asphalt, concrete, or multi-layer surfaces as shown on Figures 2-3 through 2-10. These containment surfaces will isolate Facility workers and visitors from the COCs present in near-surface soil and prevent the infiltration of rainwater through near-surface soil and thus the migration of COCs from near-surface soil to groundwater.

2.2.4.1 Threshold Requirements

Protect Human Health and the Environment

Physical and administrative controls, BMPs, and containment will be used to reduce the potential for worker exposure to COCs and to reduce the potential for COCs in near-surface soil to migrate to groundwater.

A containment surface (existing pavement and floor slabs, and new asphalt, concrete, or multi-layer cap) will be placed above each near-surface soil AOC in Alternative A2. A stormwater collection system will be installed along with the new containment surfaces to direct stormwater to soil areas that are not contaminated and allowed to infiltrate, or to the Kaiser WWT facility. The natural attenuation processes discussed in Section 2.1.1.3 will continue and will be monitored for progress.

The containment surfaces will prevent Facility workers and visitors from direct contact with COCs in these areas, and prevent rainwater from conveying COCs from near-surface soil to groundwater.

Alternative A2 will not actively reduce the concentration of the COCs in near-surface soil at the Facility to meet the SLs that have been established for these COCs, except through natural attenuation processes. Some natural attenuation of SVOCs in near-surface soil has occurred and is expected to continue; however, this process alone will not result in a significant reduction in risk to human health and the environment in a reasonable restoration time frame.

Groundwater quality that currently exceeds SLs below the containment surfaces is not expected to be improved by Alternative A2. Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative A2 is not expected to cause the concentration of COCs in groundwater to fall below SLs for quite some time. However, the caps will reduce the potential for COCs to migrate from the unsaturated soil above the smear zone to the water table.

Comply with MTCA Cleanup Standards

The SLs developed for near-surface soil, which are currently exceeded in the AOCs identified on Figure 2-3, were based on the requirements of MTCA and contaminant-specific state and federal ARARs. Although Alternative A2 is not expected to directly reduce the concentration of COCs that are present in these AOCs, it adds the additional protection of containment to Alternative A1. Soil that is contained can be deemed to meet SLs if certain requirements set out in WAC 173-340-740(6)(f) are met:

(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;

The practicability assessment for Alternative A2 is summarized in Section 2.3, which is conducted for soil that contains VOCs, SVOCs, PCBs, and metals. The permanence of Alternative A2 is compared to Alternatives A1 and A3 (for VOCs), to Alternatives A1, A4, A5, and A6 (for SVOCs), to Alternatives A1, A4, and A6 (for PCBs), and to Alternatives A1 and A4 (for metals).

(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;

Alternative A2 will cut the human health direct contact and ingestion exposure pathways that were identified in the HHERA (Pioneer 2012), and eliminates the risk posed by the COCs to Facility workers and visitors.

The containment surfaces will prevent rainwater from continuing to mobilize COCs present in near-surface soil to groundwater.

Alternative A2 can be judged to meet MTCA requirements for near-surface soil if it is determined to be the most practicable alternative by the analysis that is conducted in Section 2.3.

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative A2 alone is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time. The SLs were established to prevent risk to human health resulting from the ingestion of water or organisms from the Spokane River. Additional treatment alternatives for deep vadose zone soil (Section 3), for smear zone soil (Section 4), and for groundwater (Sections 4 and 5) are discussed later in this FS. Alternative A2, together with the alternatives selected in Sections 3, 4, and 5, are expected to protect receptors in the Spokane River.

(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;

The Kaiser ecological risk assessment in the HHERA (Pioneer 2012) determined that the COCs present in near-surface soil do not pose an unacceptable risk to wildlife.

(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;

A restrictive covenant on the Kaiser property will be prepared and will contain the restrictions as described in WAC 173-340-440(9).

(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and

The protection and performance monitoring aspects of compliance monitoring, as defined by MTCA, have been underway at the Facility for many years. This monitoring is guided by a SAP (Hart Crowser 2007a), as amended (Kaiser 2010a), that has been approved by Ecology. Protection and performance monitoring are discussed in Section 2.1.1.2.

(vi) The types, levels, and amount of hazardous substances remaining on site and the measures that will be used to prevent migration and contact with those substances are specified in the draft Cleanup Action Plan.

This information will be included in the CAP. In summary, Alternative A2 is judged to meet MTCA cleanup standards for near-surface soil alone. Alternative A2 together with the alternatives judged appropriate in Sections 3 through 5 are expected to meet regulatory requirements for the Kaiser Facility as a whole (incorporating near-surface soil, vadose zone soil, smear zone soil, petroleum-contaminated groundwater, and PCB-contaminated groundwater).

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. The identified action-specific ARARs for Alternative A2 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3), which include capping requirements defined by TSCA (see Section 2.1.2.2) and construction-related requirements, such as the substantive requirements of grading permits. Location-specific ARARs consist of potential restrictions related to construction near the shoreline of the Spokane River, such as in the WDR. These ARARS are judged to be attainable for all near-surface soil remedial alternatives and do not affect the alternative selection process.

2.2.4.2 Other Requirements

Use of Permanent Solutions to the Maximum Extent Practicable

Protectiveness. Alternative A2 will not actively reduce the concentration of the COCs in near-surface soil AOCs at the Facility to meet the SLs that have been established for these COCs, except by naturally occurring attenuation processes. Some natural attenuation of SVOCs in near-surface soil has occurred, and is expected to continue; however, the time to reduce SVOC concentrations to SLs by these processes will be long.

Implementation of Alternative A2 will sever the pathways by which Facility workers and visitors can directly contact and/or ingest near-surface soil within the near-surface soil AOCs. Thus, the risk to Facility workers and visitors from direct contact or ingestion of near-surface soil will be eliminated by Alternative A2.

Alternative A2 will also reduce the future transport of COCs from near-surface soil to the groundwater.

Permanence. The BMPs in place at the Facility are reducing the release of hazardous substances to the environment. Facility access controls are reducing the opportunity for visitors to the Facility to come into contact with the COCs contained in near-surface soil.

The existing pavement and floor slab and the additional containment provided by Alternative A2 will prevent Facility workers and visitors from directly contacting COCs in these areas. Thus, Alternative A2 will eliminate the risk to Facility workers and the public because of the potential for direct contact or ingestion of contaminated near-surface soil.

The natural attenuation processes that appear to be active in near-surface soil will reduce SVOC concentrations over time. Since Alternative A2 will eliminate the human health risk to Facility workers and visitors of contact with near-surface soil, and will sever the near-surface soil to groundwater pathway, it is judged to meet MTCA requirements for near-surface soil.

Cost. The NPV of implementing Alternative A2 over 30 years is estimated to total approximately $15.8 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 2.1.2 and in the cost tables contained in Appendix A (see Table A-3).

Effectiveness over the Long Term. This alternative will require a long time to reduce the existing concentration of COCs in near-surface soil to concentrations below SLs. The existing pavement and floor slabs and new containment surfaces provided in Alternative A2 will protect Facility workers and visitors from direct contact with COCs in these areas, and will prevent rainwater from conveying COCs to groundwater.

Institutional controls will be put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system. An inspection and maintenance plan that will assure the integrity of the existing pavement, floor slabs, and new containment surfaces will be prepared and implemented. The containment surfaces are expected to remain effective for an extended period of time.

Alternative A2 will not generate treatment residues or waste materials. Surface water runoff from the containment surfaces will be either collected, directed to areas of the Facility without soil contamination and allowed to infiltrate, or will be conveyed to the Kaiser WWT facility for treatment.

Management of Short-Term Risks. This alternative will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces will be mitigated by their adherence to the HASP.

The short-term risks associated with the installation of containment surfaces include the following:

- Exposure of Facility workers to media containing COCs;

- Exposure of Facility workers to hazardous materials (e.g., exposure to hot-mix asphalt resulting in burn injuries);

- Construction area hazards (e.g., working near heavy equipment); and

- Hazards associated with the industrial activities taking place at various locations within the Facility.

The procedures contained in the HASP and the inspection and maintenance plan have been shown to effectively manage the limited risk associated with these activities.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place at the Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years.

Restoration Time Frame

The risks to Facility workers and visitors from direct contact or ingestion of COCs in near-surface soil will be eliminated once the containment surfaces have been installed. Natural attenuation processes at the Facility will continue, but the time frame needed for the concentration of COCs amenable to attenuation in near-surface soil to fall below SLs is expected to be long. However, contaminated soil under a cap may be determined to meet cleanup levels if the requirements under WAC 173-340-740(6)(f) are met, as described above for Alternative A2. The restoration time frame for Alternative A2 is approximated by the estimated time required to complete cap construction (about 1 year).

The factors used to determine whether Alternative A2 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) are assessed below:

(i) Potential risks posed by the site to human health and the environment;

The potential risks posed by the near-surface soil AOCs at the Facility include direct contact and ingestion exposure pathways for human and ecological receptors. The soil to groundwater exposure pathway potentially exists in AOCs where infiltrating rainwater could convey COCs from near-surface soil to the water table. Alternative A2 addresses these risks and is judged to be protective of human health and the environment (see discussion above).

(ii) Practicability of achieving shorter restoration time frame;

The restoration time frame that Alternative A2 provides for the various near-surface soil COC groups is compared to the other remedial alternatives for near-surface soil in Section 2.3. These other alternatives have similar or longer restoration time frames compared to Alternative A2 for the various near-surface soil COC groups. Alternative A2 (and alternatives with similar restoration time frames) provides the shortest practicably achievable restoration time frame.

(iii) Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

Releases from the Kaiser Facility may pose risks to human and ecological receptors, and may potentially affect groundwater and the Spokane River. Alternative A2 includes physical and administrative controls, BMPs, and containment to reduce the potential for worker exposure to COCs and to reduce the potential for COCs in near-surface soil to migrate to groundwater.

(iv) Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

A restrictive covenant will limit future uses of the site. The Spokane River is likely to continue to be a potential source of receptors for releases from the Kaiser Facility. Currently, SVOCs are not reaching the river at concentrations above SLs.

(v) Availability of alternative water supplies;

Alternative water supplies are abundant. A considerable amount of groundwater exists at the Kaiser Facility that is outside of the footprint of the existing AOCs at the Facility. Kaiser also has secured access to this groundwater for domestic and industrial use through a water right.

(vi) Likely effectiveness and reliability of institutional controls;

The institutional controls implemented in Alternative A2 (refer to Sections 2.1.1.1 and 2.1.1.2 and Table 2-2) have been shown to be effective and reliable at the Kaiser Facility. Most of these measures have been successfully used at the Facility for many years.

(vii) Ability to control and monitor migration of hazardous substances from the site;

The groundwater monitoring program at the Kaiser Facility is governed by a Sampling and Analysis Plan (Hart Crowser 2007a), as amended (Kaiser 2010a), that has been approved by Ecology.

(viii) Toxicity of hazardous substances at the site; and

VOCs, SVOCs, PCBs, and metals have been identified as COCs for near-surface soil at the Facility. The toxicity of these COCs depends on their concentration and the duration of exposure to them. The implementation of Alternative A2 will reduce the possibility that these COCs will reach potential human or ecological receptors in the future.

(ix) Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar conditions.

Near-surface soil at the Facility has been sampled and analyzed over a number of years. As discussed in the FSTM (Hart Crowser 2012c), analytical results have shown that in some instances the concentration of COCs has declined over time without any known human intervention, which indicates that natural attenuation processes are active at the Facility.

The restoration time frame for Alternative A2 is judged to be reasonable, as defined by WAC 173-340-360(4).

2.2.5 Evaluation of Remedial Alternative A3: Institutional Controls, Monitoring, Monitored Natural Attenuation, Containment, and SVE

Alternative A3 adds the additional treatment step of SVE to Alternative A2 for those near-surface soil AOCs that contain VOCs at concentrations above SLs. COC-specific AOCs are consolidated on Figure 2-3, which depict the COC-specific AOCs that are known to be present in each of the operating areas of the Facility.

The AOCs that contain VOCs concentrations above SLs are located in the vicinity of the ORB (three AOCs), in the Oil House area (one AOC), and in the Truck Shop area (one AOC). The characteristics of these AOCs are summarized in Section 2.1.3.1. The AOC located near the Truck Shop area is relatively small and is adjacent to both a building foundation and high-voltage power lines. This FS assumes that installation of SVE wells in this location will not be practicable.

The SVE process envisioned for the Facility is summarized in Section 2.1.3.2. A process flow diagram is included on Figure 2-13. The SVE process will remove VOCs from near-surface soil and will capture them on carbon beds. The VOCs will be destroyed when the carbon is regenerated.

Alternative A3 also employs containment to reduce direct exposure of Facility workers and visitors to COCs in near-surface soil, reduce the mobility of the COCs that are present in near-surface soil, and to enhance the performance of the SVE process. The capability of Alternative A3 to meet the cleanup requirements established by MTCA is summarized below.

2.2.5.1 Threshold Requirements

Protect Human Health and the Environment

Physical and administrative controls, BMPs, and containment will be used to reduce the potential for worker exposure to COCs and to reduce the potential for COCs in near-surface soil to migrate to groundwater.

A containment surface (existing pavement and floor slabs and new asphalt, concrete, or multi-layer cap) will be placed over each near-surface soil AOC containing VOCs along with the requisite stormwater collection system designed to direct stormwater away from AOCs. Some natural attenuation of VOCs in near-surface soil has occurred, and is expected to continue below the containment surface. While the time to reduce VOC concentrations to SLs by natural attenuation processes would be long, SVE system operation is expected to reduce VOC concentrations below SLs in approximately 4 years (excluding the Truck Shop area).

Alternative A3 will actively remove and destroy VOCs in near-surface soil at the Facility, and is expected to meet the SLs that have been established for VOCs in near-surface soil (100 mg/kg for gasoline and Stoddard solvent). This will eliminate the risk of direct contact of Facility workers and the public to near-surface soil in the VOC AOCs. The VOCs will be removed and destroyed in a relatively short time (about 4 years).

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative A3 is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time.

Comply with MTCA Cleanup Standards

Alternative A3 adds an SVE system to the containment, MNA, monitoring, and institutional controls provided by Alternative A2. The SVE system removes and destroys VOCs, once spent carbon is regenerated. This alternative will directly reduce the concentration of VOCs that are present in four of the five near-surface soil VOC AOCs. It is expected that SVE treatment will reduce the concentration of VOCs to below SLs. The SLs developed for near-surface soil, which are currently exceeded in the AOCs identified on Figure 2-3, were based on the requirements of MTCA and contaminant-specific state and federal ARARs.

Alternative A3 includes the additional protection of containment of impacted near-surface soil, which can be deemed to meet SLs if certain requirements set out in WAC 173-340-740(6)(f) are met. The evaluation of these requirements conducted for Alternative A2 in Section 2.2.3.2 also applies to the containment provided in Alternative A3.

Containment provided in Alternative A3 will cut the human health direct contact and ingestion pathways that were identified in the HHERA (Pioneer 2012), and will eliminate the risk posed by the COCs to Facility workers and visitors. Containment surfaces will also prevent rainwater from conveying COCs from near-surface soil to groundwater.

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative A3 alone is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time. The SLs were established to prevent risk to human health resulting from the ingestion of water or organisms from the Spokane River. Additional treatment alternatives for smear zone soil (Section 4) and for groundwater (Sections 4 and 5) are discussed later in this document. Alternative A3 together with the alternatives selected in Sections 3, 4, and 5 are expected to provide protection of groundwater.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. The identified action-specific ARARs for Alternative A3 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These include construction-related requirements (for example, grading permit acquisition) and regulations related to SVE system operation that would require use of best available technology to control potential air emissions of the treatment system. Location-specific ARARs consist of potential restrictions related to construction near the shoreline of the Spokane River, such as in the WDR. These ARARS are judged to be attainable for all near-surface soil alternatives and do not affect the alternative selection process.

2.2.5.2 Other Requirements

Use of Permanent Solutions to the Maximum Extent Practicable

Protectiveness. Alternative A3 will directly reduce the concentration of VOCs that are present in four near-surface soil AOCs. Alternative A3 includes an SVE system that will remove and destroy VOCs to the containment, MNA, monitoring, and institutional controls provided by Alternative A2. Containment and SVE will eliminate the risk associated with the direct contact of Facility workers and the public to near-surface soil in the AOCs by installing a containment surface. The VOCs will be removed in a relatively short time frame, about 4 years.

Alternative A3 will reduce the future transport of COCs from near-surface soil to the groundwater. Natural attenuation of organic COCs is expected to continue to occur below the containment surfaces; however, the time needed to reduce COC concentrations to SLs by natural attenuation processes will be long.

As discussed above, Alternative A3 is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time.

Spent carbon used in the off-gas treatment system containing VOCs will be shipped off site to be regenerated. The VOCs released from the carbon during the regeneration process will be destroyed. The spent carbon will be sent to a regeneration facility that holds the environmental and other permits needed to operate a carbon regeneration process.

Permanence. Containment surfaces provided by Alternative A3 will prevent Facility workers and visitors from direct contact with COCs in these areas and prevent rainwater from conveying COCs from near-surface soil to groundwater. The natural attenuation processes that appear to be active in near-surface soil will reduce COC concentrations over time.

Since Alternative A3 destroys approximately 410 pounds of VOCs, it is the most permanent alternative being considered to remediate VOCs.

Cost. The NPV of implementing Alternative A3 over 30 years is estimated to total approximately $16.3 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 2.1.3 above and listed in the cost tables contained in Appendix A (see Table A-4). The portion of total cost of Alternative A3 that represents SVE treatment is approximately $500,000 (Table A-1).

Effectiveness over the Long Term. Alternative A3 will reduce the concentration of VOCs in near-surface soil in the four AOCs that will be treated to concentrations below SLs within about 4 years. Spent carbon containing VOCs from off-gas treatment will be handled and disposed of by an experienced contractor. SVE will not reduce the concentration of other COCs such as SVOCs, PCBs, and metals currently present in near-surface soil to concentrations below SLs in a reasonable restoration time frame. Over a long period of time, it is expected that the concentration of other organic COCs will decrease, or COC mobility will be reduced (such as for metals), through natural attenuation.

Existing and new containment surfaces provided by Alternative A3 will protect Facility workers and visitors from direct contact with COCs in these areas, and prevent rainwater from conveying COCs to groundwater. Institutional controls will be put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system and alert future Facility workers to the presence of contaminated soil below the cap so they can implement appropriate HASP procedures. The containment surfaces are expected to remain effective for a long time.

Management of Short-Term Risks. This alternative will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces and SVE system will be mitigated by adherence to the HASP.

Short-term risks to workers operating the SVE system will be mitigated by adherence to the SVE HASP and O&M plan. An experienced subcontractor will manage the removal, transportation, and regeneration of spent carbon.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. SVE is a presumptive remedy for the removal of VOCs from soil and is considered to be an implementable conventional technology but will require technical expertise for design and execution. Regeneration of spent carbon (and incineration of VOCs released from the carbon) is a complex process that must be conducted in a facility designed and permitted for this purpose. The nearest carbon regeneration facility to the Kaiser Facility is located in Cattlesburg, KY (York, T., Calgon, personal communication 2010).

Restoration Time Frame

The risks to Facility workers and visitors from direct contact or ingestion of COCs will be eliminated once the containment surfaces have been installed. Contaminated soils under a cap may be determined to meet cleanup levels if the requirements under WAC 173-340-740(6)(f) are met (refer to Section 2.2.4 above). The concentration of VOCs in near-surface soil in the four AOCs that are treated using SVE will be reduced below SLs within approximately 4 years. The time frame needed for the concentration of other organic COCs (for example, SVOCs) in near-surface soil to fall below SLs, or to become immobilized (such as metals), from natural attenuation is expected to be long. However, the restoration time frame for Alternative A3 is approximated by the estimated time required to complete construction of the containment surfaces (about 1 year), which eliminates the risk posed by these COCs.

An assessment of the factors used to determine whether Alternative A3 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) is generally the same as the assessment presented for Alternative A2 (Section 2.2.4.2). The practicability of achieving a shorter restoration time frame is addressed in the comparative analysis of remedial alternatives for each deep vadose zone soil COC group in Section 3.3, which concludes that the restoration time frame for Alternative A3 is considered to be reasonable, as defined by WAC 173-340-360(4). Thus, Alternative A3 is judged to provide for a reasonable restoration time frame.

2.2.6 Evaluation of Alternative A4: Institutional Controls, Monitoring, Monitored Natural Attenuation, Excavation, and Off-Site Disposal

Alternative A4 adds excavation and off-site disposal to Alternative A1 or A2 for those AOCs where VOCs are not present in near-surface soil at concentrations above SLs. Alternative A4 is judged to be the most practicable permanent cleanup action for metals such as arsenic, lead, and chromium in near-surface soil (refer to FSTM Section 2.7.2).

Excavation and off-site disposal will be added to Alternative A1 (no additional containment) for those AOCs where no COCs at concentrations above the SLs will remain in deep vadose zone soil after this soil has been remediated (Alternative A4a). Excavation and off-site disposal will be added to Alternative A2 (with additional containment) for those AOCs where one or more COC will remain in deep vadose zone soil at concentrations above SLs following remediation of the near-surface soil AOC (Alternative A4b).

Soil that cannot be excavated from the near-surface soil AOCs includes soil that is present below existing pavement or floor slabs, or is within 20 feet of a building, or contains VOCs at concentrations above SLs (refer to Section 2.1.4.1). Under this alternative, approximately 60 percent of the total area of the near-surface soil AOCs is expected to be excavated and disposed of off site (refer to Section 2.1.4.1).

The purpose of Alternative A4 is to remove near-surface soil to eliminate existing Facility worker and visitor direct contact (dermal or ingestion) exposure pathways, and to eliminate the potential for the COCs to migrate to groundwater. The estimated area of excavation is about 8,400 square yards, and the estimated disposal volume is approximately 23,000 CY (assuming 30 percent cobbles). This estimated area and volume includes AOCs impacted by SVOCs, PCBs, and metals. The method used to estimate excavation volumes and the limitations of this method are described above in Section 2.1.4.1.

2.2.6.1 Threshold Requirements

Protect Human Health and the Environment

Approximately 33,000 CY of near-surface soil will be excavated and mechanically screened on site to remove cobbles. The cobble-free excavated soil (approximately 23,000 CY) will be analyzed and transported to a RCRA or Subtitle D landfill, depending on whether it is designated as dangerous or non-dangerous solid waste. The landfills being considered are lined, monitored, and permitted to accept this soil.

The excavation and off-site disposal of the excavated soil removed from the near-surface soil AOCs impacted by SVOCs, PCBs, and metals, will prevent Facility workers and visitors from directly contacting COCs in these AOCs, and will prevent rainwater from conveying COCs from near-surface soil to groundwater.

Alternative A4 will remove SVOCs, PCBs, and metals in near-surface soil and is expected to meet the SLs that have been established for near-surface soil. COCs at concentrations above SLs will still be present in near-surface soil below existing roads and floor slabs and adjacent to building foundations.

Groundwater quality that currently exceeds SLs below containment surfaces is not expected to be appreciably improved by Alternative A4 alone, since the COCs currently present in smear zone soil will continue to contact groundwater.

Physical and administrative controls, BMPs, and existing paved surfaces will reduce the potential for worker exposure to residual COCs and to reduce the potential for remaining COCs in near-surface soil to migrate to groundwater.

Comply with MTCA Cleanup Standards

Alternative A4 will directly reduce the concentration of COCs that are present in the near-surface soil AOCs shown on Figure 2-3. Both Alternatives A4a and A4b will reduce the concentration of COCs in near-surface soil AOCs that are excavated, to concentrations below SLs when the excavated soil is replaced with clean fill. The SLs developed for near-surface soil were based on the requirements of MTCA and contaminant-specific state and federal ARARs. The removal of contaminated near-surface soil will cut the current Facility worker and visitor direct contact and ingestion pathways that were identified in the HHERA (Pioneer 2012), and will eliminate the risk posed by the COCs to Facility workers and visitors.

Alternative A4 will remove COCs at concentrations above SLs from the portion of the near-surface soil AOCs that is excavated and thus will eliminate the possibility that these COCs could be carried by rainwater to groundwater below the AOCs. Under Alternative A4a, COCs that may be present in deep vadose zone soil below the near-surface soil AOCs could still be carried by rainwater to groundwater.

Alternative A4b adds containment to the AOCs where COCs at concentrations above SLs are expected to remain in deep vadose zone soil (refer to Section 3.1.2). The containment surfaces will prevent rainwater from conveying COCs from vadose zone soil to groundwater. Since the COCs currently in smear zone soil will continue to contact groundwater, Alternative A4 alone is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. The identified action-specific ARARs for Alternative A4 consist of requirements associated with implementation of the alternative (see Appendix G). Meeting the substantive requirements of grading permits, for example, would be required for excavation work, and the management of excavated contaminated soil would be governed by state waste regulations. Location-specific ARARs consist of potential restrictions related to construction near the shoreline of the Spokane River, such as in the WDR. These ARARS are judged to be attainable and do not affect the alternative selection process.

Both Alternatives A4a and A4b are judged to meet the threshold requirements for near-surface soil established by WAC 173-340-360(2).

2.2.6.2 Other Requirements

Use of Permanent Solutions to the Maximum Extent Practicable

Protectiveness. The excavation and off-site disposal of the excavated soil removed from the near-surface soil AOCs impacted by SVOCs, PCBs, and metals, is protective to human health and the environment because the COCs are removed.

Institutional controls will also be used as protective measures for workers and visitors and will be designed to reduce the potential for residual COCs in near-surface soil to migrate to groundwater.

Alternative A4b adds containment to the AOCs where COCs at concentrations above SLs are expected to remain in vadose zone soil (e.g., within 20 feet of structures) providing an additional level of protection. The containment surfaces will prevent rainwater from conveying COCs from vadose zone soil to groundwater.

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative A4 alone is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time

Permanence. There is a medium degree of permanence with this alternative because it will significantly reduce the volume and quantity of SVOCs, PCBs, and lead in near-surface soil on the Facility but will not destroy them. A permitted lined landfill provides more protection for human health and the environment than leaving the soil on site. There is high certainty that the alternative will be successful but it relies on COC disposal in a lined, monitored facility and containment rather than COC destruction. This alternative will not remove COCs in near-surface soil in all areas of the Facility. This alternative relies on containment of those areas that are currently paved, under a floor slab, or within 20 feet of a foundation. Over time, natural attenuation is expected to reduce concentrations of organic COCs.

Cost. The NPV of implementing Alternatives A4a and A4b over a 30 years is estimated (-35 to +50 percent) to be $18.7 million and $20.9 million, respectively. The assumptions used to prepare this estimate are described in Section 2.1.4 above and listed in the cost tables contained in Appendix A (refer to Tables A-5 and A-6). The incremental cost of excavation and disposal is approximately $5.1 million (Table A-1).

Effectiveness over the Long Term. Alternative A4 will remove SVOCs, PCBs, metals in near-surface soil in the AOCs within a relatively short (one year) time period. As mentioned above, approximately 33,000 CY of near-surface soil will be excavated and mechanically screened to remove gravel and cobbles on site. The cobble-free excavated soil (approximately 23,000 CY) will be analyzed and transported to a RCRA or Subtitle D landfill depending on whether it is considered dangerous waste. These landfills are lined, monitored, and permitted, and risks to the environment and human health are controlled.

Institutional controls will be put in place that prohibit or limit activities that could interfere with the long-term integrity of the containment system and alert future Facility workers to the presence of contaminated soil below the pavement and buildings so they can implement appropriate HASP procedures. The containment surfaces are expected to remain effective for an extended period of time.

Management of Short-Term Risks. Short-term risks associated with the excavation, screening, transport, and off-site treatment processes include worker exposure to contaminants during excavation and mechanical screening. The HASP will be implemented during construction activities to protect on-site workers. Additional human health and environmental risks are associated with the transport of the material from the Facility to the landfill for disposal. Transport containers will be covered and take the appropriate measures to reduce risk to the communities that they travel through. Only properly licensed material haulers will be used. The material greater than 2 inches in diameter will remain on site and is assumed to pose little risk to human health and the environment, since the contamination in soil at the Facility is associated with the finer grained material.

Technical and Administrative Implementability. Excavation and disposal activities are conventional activities and can be easily implemented. These activities have been performed at the Kaiser Facility previously. Reduction of COC volume is expected to take place in a short time frame, since the reduction will occur during implementation of the remedial action. The contained area will likely need to be monitored in perpetuity, and a restrictive covenant will need to be in place.

Restoration Time Frame

Excavation and off-site disposal is expected to reduce the COC volume in near-surface soil in a short time frame (about 1 year). COCs at concentrations above SLs will still be present in near-surface soil below existing roads and floor slabs and adjacent to building foundations. Organic COC concentrations and metal COC mobility in near-surface soil that is not excavated are expected to decrease over time because of natural attenuation. Contaminated soil under a cap may be determined to meet cleanup standards if the requirements under WAC 173-340-740(6)(f) are met, as discussed in Section 2.2.4 above. The restoration time frame for AOCs that are capped is approximated by the estimated time to construct the containment surfaces (about 1 year).

An assessment of the factors used to determine whether Alternative A4 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) is generally the same as the assessment presented for Alternative A2 (Section 2.2.4.2). The practicability of achieving a shorter restoration time frame is addressed in the comparative analysis of remedial alternatives for each deep vadose zone soil COC group in Section 3.3, which concludes that the restoration time frame for Alternative A4 is considered to be reasonable, as defined by WAC 173-340-360(4). Thus, Alternative A4 is judged to provide for a reasonable restoration time frame.

2.2.7 Evaluation of Alternative A5: Alternative A1 or A2 Plus Excavation and On-Site Treatment (Biotreatment or Thermal Treatment)

Alternative A5 adds excavation and on-site treatment to Alternative A1 or A2 for those AOCs containing SVOCs that can be excavated. Alternative A5a adds on-site biotreatment, and Alternative A5b adds on-site thermal treatment.

Soil that cannot be excavated from the near-surface soil AOCs includes soil that is present below existing pavement or floor slabs, is within 20 feet of a building, or contains VOCs at concentrations above SLs. Approximately 60 percent of the total area of the near-surface soil AOCs is expected to be excavated and treated on site (refer to Section 2.1.4.1).

The purpose of Alternative A5 is to remove and treat near-surface soil containing SVOCs at concentrations above SLs to eliminate existing Facility worker and visitor direct contact (dermal or ingestion) exposure pathways that were identified in the HHERA (Pioneer 2012) and to eliminate the potential for the SVOCs to migrate from near-surface soil to groundwater. The estimated area of excavation is estimated to total about 75,000 sq ft or 8,300 sq yards. This estimated area includes AOCs impacted by SVOCs, PCBs, and metals. The

FSTM concluded that Alternative A5 was appropriate for SVOCs and not appropriate for VOCs, PCBs, or metals in near-surface soils. Containment and excavation with disposal were considered to be appropriate remedies for PCBs and metals present in near-surface soil. The method used to estimate excavation volumes and the limitations of this method are described above in Section 2.1.4.1.

Approximately 33,000 CY of near-surface soil will be excavated and screened to remove cobbles. The cobble-free excavated soil (approximately 23,000 CY) will be treated on site to reduce SVOC concentrations.

2.2.7.1 Threshold Requirements

Protect Human Health and the Environment

Excavation under Alternative A5 will physically remove SVOCs from accessible AOCs at the Facility and will destroy approximately 95 percent of the SVOCs either by biotreatment or thermal treatment. This will reduce the long-term risk of exposure to SVOCs for Facility workers and visitors (although short-term risk of exposure exists during excavation and treatment processes), and will sever the soil to groundwater exposure pathway by removing SVOCs from these AOCs.

Physical and administrative controls, BMPs, and existing paved surfaces, as discussed for Alternative A1, will be used to reduce the potential for worker exposure to SVOCs and to reduce the potential for SVOCs in near-surface soil to migrate to groundwater.

Alternative A5 will actively remove and destroy SVOCs in near-surface soil on the Facility, and is expected to meet the SLs that have been established for SVOCs in near-surface soil. Alternative A5 will remove approximately 143,000 pounds of SVOCs and destroy approximately 95 percent (135,000 pounds) of the SVOCs. SVOCs at concentrations above SLs will still be present in near-surface soil below existing roads and floor slabs and adjacent to building foundations (110,000 pounds of SVOCs). Alternative A5 does not address VOCs, PCBs, and metals. In areas where SVOCs are co-located with other COCs, the ultimate disposition of the treated soil will depend on the concentrations of the COCs not treated by the technologies employed in Alternative A5.

Some natural attenuation of SVOCs in near-surface soil has occurred and is expected to continue in portions of AOCs that are below existing roads, floor slabs, or adjacent to building foundations. The time needed to attenuate SVOCs to SLs by natural attenuation will be long.

The risk posed by near-surface SVOCs is expected to be reduced in 1 to 2 years. Short-term risks are manageable. The technologies employed by this alternative have been successfully demonstrated at sites similar to the Kaiser Facility.

Groundwater quality that currently exceeds SLs below the SVOC AOCs is not expected to be appreciably improved by Alternative A5 since the SVOCs currently present in smear zone soil will continue to contact groundwater. However, soil excavated and treated under this alternative will eliminate the COC mass in the near-surface soil from being available to migrate to groundwater.

Comply with MTCA Cleanup Standards

Alternative A5 is expected to directly reduce the concentration of SVOCs that are present in the near-surface soil AOCs, where excavation is possible, as shown on Figures 2-3 through 2-10.

Both Alternatives A5a and A5b will reduce the concentration of SVOCs in the portion of the near-surface soil AOCs that are excavated to concentrations below SLs. The SLs developed for near-surface soil were based on the requirements of MTCA and contaminant-specific state and federal ARARs.

Alternative A5 will cut the current Facility worker and visitor direct contact and ingestion pathways that were identified in the HHERA (Pioneer 2012), will eliminate the risk posed by the SVOCs to Facility workers and visitors, and will eliminate the possibility that these SVOCs could be carried by rainwater to groundwater below the AOCs.

Since the SVOCs currently present in smear zone soil will continue to contact groundwater, Alternative A5 alone is not expected to cause the concentration of SVOCs in groundwater to fall below SLs for a long time.

Comply with Applicable State and Federal Laws.

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A5.

The identified action-specific ARARs for Alternative A5 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These requirements include, for example, the acquisition of grading permits associated with the excavation work, and requirements necessitating the use of best available technologies to control potential air emissions from the soil treatment systems. Actions that result in the generation of water that contains phosphorous (e.g., biotreatment) will be restricted if these waters are discharged to the Spokane River because of the TMDL imposed by state surface water quality standards. These ARARS are judged to be attainable and do not affect the alternative selection process.

Alternative A5 is judged to meet the threshold requirements established by WAC 173-340-360(2) for near-surface soil.

2.2.7.2 Other Requirements

Use of Permanent Solutions to the Maximum Extent Practicable

Protectiveness. Alternative A5 will actively work to remove and destroy SVOC mass from near-surface soil AOCs that are accessible to excavation.

Alternative A5 will eliminate the risk associated with the direct contact exposure pathway in near-surface soil AOCs identified as posing human health risks to Facility workers and the public in the HHERA (Pioneer 2012), by removing and treating this soil. Alternative A5 will remove approximately 143,000 pounds and treat 110,000 pounds of SVOCs.

The SVOCs will be removed and treated in the relatively short time frame of about 1 to 2 years. Short-term risks are manageable.

SVOCs currently present in smear zone soil will not be addressed by this alternative and it is not expected to cause the concentration of SVOCs in groundwater to fall below SLs for a long time.

Permanence. Alternative A5 will result in a high degree of permanence. Excavation and on-site treatment is expected to result in destroying approximately 95 percent of the SVOCs in the AOCs that are treated.

The gravel and cobbles that are separated by screening will be stockpiled and reused on site as backfill. COCs present in the soil are associated with the finer grained material. Soil from the biotreatment or thermal treatment systems will also be reused on site after treatment and sampling and analysis.

The existing BMPs in place at the Facility are reducing the release of hazardous substances to the environment. Existing access controls are reducing the opportunity for visitors to the Facility to come in contact with residual SVOCs contained in near-surface soil (e.g., next to buildings).

Approximately 35 percent of the near-surface soil AOCs present at the Facility are currently located under pavement or floor slabs. The natural attenuation processes that appear to be active in near-surface soil are expected to reduce SVOC concentrations in these areas over time.

Alternative A5a will generate potentially impacted leachate that will be collected and conveyed to the WWT facility for treatment. Phosphorus at concentrations exceeding the Spokane River TMDL from nutrient additions could potentially be present. Phosphate removal technologies will be used if needed to meet TMDL requirements. Leachate will be monitored before being conveyed to the WWT facility.

Since the SVOCs in smear zone soil will continue to contact groundwater, Alternative A5 is not expected to cause the concentration of SVOCs in groundwater to fall below SLs for a long time.

Cost. The NPV of implementing Alternative A5a (biotreatment) combined with Alternative A1 over a 30-year time period is estimated to total approximately $19.1 million (-35 to +50 percent). Implementation of Alternative A5a combined with Alternative A2 over the same time period is estimated to total approximately $21.4 million (-35 to +50 percent) (see Appendix A, Table A-7). The incremental costs of the excavation and biotreatment elements of Alternative A5a is estimated to be $5.5 million to $5.6 million (Table A-1).

The NPV of implementing Alternative A5b (thermal treatment) combined with Alternative A1 over a 30-year time period is estimated to total approximately $19.9 million (-35 to +50 percent). Implementation of Alternative A5b combined with Alternative A2 over the same time period is estimated to total approximately $22.2 million (-35 to +50 percent) (see Table A-8 in Appendix A). The incremental costs of the excavation and thermal treatment elements of Alternative A5b is approximately $6.3 million to $6.4 million (Table A-1).

The assumptions used to prepare this estimate are described in Section 2.1.5 above and listed in the cost tables contained in Appendix A.

Effectiveness over the Long Term. Alternative A5 will reduce the concentration of SVOCs in near-surface soil in the treated AOCs to below SLs within 1 to 2 years. The existing pavement and floor slabs will protect Facility workers and visitors from direct contact with SVOCs in the areas that are not excavated, and will prevent rainwater from conveying SVOCs to groundwater.

Institutional controls will be put into place that prohibit or limit activities that could interfere with the long-term integrity of the containment system and alert future Facility workers to the presence of contaminated soil below the pavement and buildings so that they can implement appropriate HASP procedures. An inspection and maintenance plan that will assure the integrity of the existing pavement and floor slabs will be prepared and implemented. The containment surfaces are expected to remain effective for an extended period of time.

Surface water runoff from the containment surfaces will be collected and directed to areas that do not have soil contamination for infiltration, or will be conveyed to the Kaiser WWT facility for treatment.

Management of Short-Term Risks. Short-term risks associated with Alternative A5 include worker exposure to contaminants during excavation and screening processes. Controls to protect workers will be defined in the HASP and implemented during the construction and remediation activities. The gravel and cobbles will remain on site and is assumed to pose little risk to human health and the environment because the SVOCs in near-surface soil are associated with the finer-grained material.

Short-term risks to workers operating the biotreatment or thermal treatment system will be mitigated by worker adherence to the HASP.

For Alternative A5b, there are additional environmental risks from the potential for air emissions from the afterburner. The air emissions will be monitored to assure compliance with permit requirements as described in Section 2.1.5.4.

Technical and Administrative Implementability. Biological and thermal treatment technologies are presumptive remedies for the removal of SVOCs from soil and are considered to be implementable conventional technologies (EPA 1995). Permitting and administrative requirements are straightforward.

BMPs, groundwater monitoring, and institutional controls are already in place at the Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years (for alternatives that include A2).

Restoration Time Frame

The risks to Facility workers and visitors from direct contact or ingestion of SVOCs will be eliminated once soil has been excavated and treated. These risks will be reduced within about 1 to 2 years. Natural attenuation processes at the Facility will continue for SVOCs for AOCs that remain under pavement or building slabs. The time frame needed for the concentration of organic COCs (e.g., SVOCs, VOCs, PCBs) in near-surface soil that is not excavated to fall below

SLs is expected to be long. Contaminated soil under a cap may be determined to meet cleanup levels if the requirements under WAC 173-340-740(6)(f) are met, as discussed in Section 2.2.4 above. The restoration time frame for AOCs that are capped is approximated by the time required to install the containment surfaces (about 1 year).

An assessment of the factors used to determine whether Alternative A5 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) is generally the same as the assessment presented for Alternative A2 (Section 2.2.4.2). The practicability of achieving a shorter restoration time frame is addressed in the comparative analysis of remedial alternatives for each deep vadose zone soil COC group in Section 3.3, which concludes that the restoration time frame for Alternative A5 is considered to be reasonable, as defined by WAC 173-340-360(4). Thus, Alternative A5 is judged to provide for a reasonable restoration time frame.

2.2.8 Evaluation of Remedial Alternative A6: Institutional Controls, Monitoring, Monitored Natural Attenuation, Excavation, and Off-Site Incineration

Alternative A6 combines excavation and off-site incineration with Alternative A1 or A2 for those AOCs where VOCs are not present in near-surface soil at the Facility at concentrations above SLs. Alternative A6 is considered to be the most permanent treatment alternative for SVOCs and PCBs in near-surface soil (refer to FSTM Section 2.7.2). The incineration of near-surface soil containing SVOCs and PCBs is expected to result in the destruction of more COC mass than Alternatives A1 through A5, as discussed in Section 2.1.6.

In Alternative A6, excavation and off-site incineration will be combined with Alternative A1 for those AOCs where no COCs at concentrations above the SLs will remain in the near-surface and deep vadose zone soil. Excavation and off-site incineration will be combined with Alternative A2 for those AOCs where one or more COC will remain in the near-surface or deep vadose zone at concentrations above SLs. Soil that cannot be excavated from near the surface includes soil that is within 20 feet of a building, is beneath the floor slab of a building, or that contains VOCs. The determination of whether COCs will be present at concentrations greater than SLs in the deep vadose zone is made in Section 3. Area-based alternatives are summarized in Section 6.

2.2.8.1 Threshold Requirements

Protect Human Health and the Environment

Excavation under Alternative A6 will physically remove COCs from accessible AOCs at the Facility, which will be either destroyed (SVOCs and PCBs) via off-site incineration or disposed of (metals) with the incinerator ashes in an off-site regulated landfill. This will reduce the long-term risk of exposure to COCs for Facility workers and visitors by severing the direct contact and ingestion exposure pathways (although short-term risk of exposure will exist during the excavation process). Additionally, Alternative A6 will cut the soil to groundwater exposure pathway by removing COCs from these AOCs, which will prevent rainwater from conveying COCs from near-surface soil to groundwater.

Alternative A6 is expected to meet the SLs that have been established for COCs in near-surface soil in the AOCs where soil will be excavated. COCs at concentrations above SLs will still be present in near-surface soil beneath existing paved areas and building floor slabs and adjacent to building foundations. Some natural attenuation of SVOCs in near-surface soil has occurred, and is expected to continue; although, the time needed for SVOC concentrations in soils that are not excavated to attain SLs will be long.

Groundwater quality that currently exceeds SLs below the containment surfaces is not expected to be substantially improved by Alternative A6 combined with either Alternative A1 or A2 since the COCs currently present in smear zone soil will continue to contact groundwater.

Comply with MTCA Cleanup Standards

The development of soil SLs for the Kaiser Facility are based on MTCA regulations and contaminant-specific state and federal laws. These SLs are currently exceeded in the AOCs identified on Figure 2-3. Alternative A6 is expected to directly reduce the concentration of COCs that are present in these AOCs, where excavation is possible. Alternative A6 will cut the current direct contact and ingestion pathways for Facility workers and visitors that were identified in the Kaiser HHERA (Pioneer 2012), which will eliminate the risk posed by COCs present in near-surface soil to Facility workers and visitors.

Alternative A6 will remove COCs at concentrations above SLs from near-surface soil AOCs, thus eliminating the possibility that these COCs could be carried by rainwater to groundwater below the AOCs. COCs that may be present in deep vadose zone soil below the near-surface soil AOCs could still be carried by rainwater to the groundwater.

In areas where COCs will remain in the deep vadose zone following excavation of near-surface soil, the combination of Alternative A2 with Alternative A6 will add the additional protection of a containment surface. However, Alternative A2 is not expected to directly reduce the concentration of COCs in these areas, although natural attenuation processes will reduce the concentration of organic COCs over a long period of time and help to immobilize metal COCs. Soil that is contained can be deemed to meet SLs if certain requirements set out in WAC 173-340-740(6)(f) are met, as discussed in detail in Section 2.2.4.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. The identified action-specific ARARs for Alternative A6 consist of requirements associated with implementation of the alternative (see Appendix G). The substantive requirements of grading permits would need to be met for the excavation work, and the management of excavated contaminated soil would be governed by state and federal waste regulations. Location-specific ARARs consist of potential restrictions related to construction near the shoreline of the Spokane River, such as in the WDR. These ARARS are judged to be attainable and do not affect the alternative selection process.

Alternative A6 is judged to meet the threshold requirements established in WAC 173-340-360(2).

2.2.8.2 Other Requirements

Use of Permanent Solutions to the Maximum Extent Practicable

Protectiveness. Alternative A6 is judged to be the most protective alternative evaluated for near-surface soil containing SVOCs and PCBs at the Kaiser Facility. Alternative A6 will actively remove COC mass from accessible near-surface soil AOCs, and destroy SVOC and PCB mass by off-site incineration. Metals contained in near-surface soil will remain in the incinerator ashes, which will be disposed of by containment in a regulated landfill.

Implementation of Alternative A6 will sever the pathways by which Facility workers and visitors could directly contact and/or ingest near-surface soil within the near-surface soil AOCs. The risk to Facility workers and visitors from direct contact or ingestion of near-surface soil will be eliminated in these areas excavated. Alternative A6 will also reduce the future transport of COCs from near-surface soil to the groundwater. Alternative A2 will isolate COC-impacted soil remaining in the deep vadose zone (beneath excavated near-surface soil

AOCs) under a containment surface, which will cut the soil to groundwater exposure pathway.

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative A6 combined with either Alternative A1 or A2 is not expected to appreciably cause the concentration of COCs in groundwater to fall below SLs.

Permanence. Alternative A6 is considered to be the most permanent treatment alternative for SVOCs and PCBs in near-surface soil at the Kaiser Facility (refer to FSTM Section 2.7.2). The incineration of excavated near-surface soil containing SVOCs and PCBs is expected to result in the destruction of more COC mass than Alternatives A1 through A5, as discussed in Section 2.1.6, but will not destroy metals, which will be disposed of at a regulated landfill.

Implementation of Alternative A6 will sever the pathways by which Facility workers and visitors could directly contact and/or ingest soil within the near-surface soil AOC areas that are excavated. Thus, the risk to Facility workers and visitors from the possibility of direct contact or ingestion of near-surface soil will be eliminated in the excavation areas. Alternative A6 will also reduce the future transport of COCs from near-surface soil to the groundwater. Alternative A2 will isolate COC-impacted soil remaining in the deep vadose zone beneath excavated near-surface soil AOCs beneath a containment surface, which will sever the soil to groundwater exposure pathway.

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative A6 combined with Alternative A1 or A2 is not expected to cause the concentration of COCs in groundwater to fall below SLs.

Cost. The NPV of implementing Alternative A6 combined with Alternative A1 over a 30-year time period is estimated to total approximately $39.0 million (-35 to +50 percent). Implementation of Alternative A6 combined with Alternative A2 over the same time period is estimated to total approximately $41.3 million (-35 to +50 percent) (see Appendix A, Table A-9). The portion of this cost estimate that is directly related to the excavation and off-site incineration of near-surface soil is estimated to total approximately $25.4 million to $25.5 million (refer to Table A-1). The assumptions used to prepare this estimate are described in Section 2.1.6 and listed in the cost tables in Appendix A.

Effectiveness over the Long Term. Removal of COCs by excavation and destruction through incineration under Alternative A6 will provide permanent reduction of COC mass in Facility AOCs, and thus is effective over the long term. However, COCs will remain in near-surface soil that is inaccessible to excavation. The remaining COCs will be addressed by combining Alternative A6 with either Alternative A1 or A2.

The containment surfaces implemented in this alternative are expected to remain effective for a long time. Institutional controls will be put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of these containment systems.

The incineration process in Alternative A6 will produce treatment residues and waste materials such as incinerator ash potentially containing metals. Treatment residues in incinerator air emissions will be captured and destroyed by emission control technology at the incineration facility before being released to the atmosphere. Incinerator ash will be disposed of through containment in a regulated landfill. Thus, treatment residues and waste products generated under Alternative A6 will be effectively controlled over the long term.

Management of Short-Term Risks. Alternative A6 shares common risk elements with the other near-surface soil remedial alternatives that involve excavation and hauling of soil off site. However, the process of incineration inherently presents more short-terms risks than the other impacted soil disposal and treatment options (i.e., landfill disposal, biotreatment, and on-site thermal treatment) Thus, it is expected that Alternative A6 will, in total, pose more short-term risks than the other alternatives proposed for remediating near-surface soil AOCs at the Facility.

Short-term risks to human health and the environment that are associated with construction activities in Alternative A6 will be managed through implementation of a HASP, prepared to guide health and safety practices during the construction work. The procedures contained in the HASP and the inspection and maintenance plan have been shown to effectively manage the limited risk associated with these activities. A work plan will be implemented that will prescribe procedures for appropriate handling of contaminated material during excavation. The transport and disposal contractors typically have similar risk management plans in place during implementation of these types of activities.

Technical and Administrative Implementability. Excavation and incineration under Alternative A6 are generally technically and administratively implementable. An off-site incineration facility for treatment of contaminated soil is fairly distant. The Clean Harbors incineration facility is located in Aragonite, UT. Construction contractor services and construction materials are available locally in the Spokane area. Project scheduling will need to consider minimizing disruption to ongoing Facility operations and will need to consider simultaneous implementation of remedial actions such as simultaneous mobilization of excavation and cap installation contractors.

The administrative and regulatory requirements associated with Alternative A6 (e.g., permitting, hazardous waste manifesting, MTCA cleanup criteria) are common protocols that Kaiser has experience with. Protection and performance monitoring are ongoing at the Facility, and confirmational monitoring associated with excavation of contaminated soil is a common practice at the Facility and has been successfully implemented in the past.

BMPs, groundwater monitoring, and institutional controls associated with the Alternative A1 and A2 aspects of Alternative A6 are already in place at the Kaiser Facility or can be easily implemented (e.g., restrictive covenant). The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years.

Restoration Time Frame

The restoration time frame associated with excavation and incineration is expected to be short. Excavation, transport of soil, and treatment at an incineration facility are relatively efficient processes that are expected to be completed in about 1 to 2 years.

Alternative A6 will decrease the restoration time frame in areas of the Facility that are accessible to excavation. However, COCs remaining in inaccessible areas are expected to require a long time frame for remediation via natural attenuation. Contaminated soil under a cap may be determined to meet cleanup levels if the requirements under WAC 173-340-740(6)(f) are met. The restoration time frame for capped areas is approximated by the time required to install the containment surfaces (about 1 year).

An assessment of the factors used to determine whether Alternative A6 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) is generally the same as the assessment presented for Alternative A2 (Section 2.2.4.2). The practicability of achieving a shorter restoration time frame is addressed in the comparative analysis of remedial alternatives for each deep vadose zone soil COC group in Section 3.3, which concludes that the restoration time frame for Alternative A6 is considered to be reasonable, as defined by WAC 173-340-360(4). Thus, Alternative A6 is judged to provide for a reasonable restoration time frame.

2.3 COMPARATIVE ANALYSIS OF ALTERNATIVES FOR NEAR-SURFACE SOIL

Alternatives A1 through A6 are evaluated individually in Sections 2.2.3 through 2.2.8, respectively, using the evaluation criteria that are established by Ecology (WAC 173-340-360). The evaluation of remedial alternatives for near-surface soil continues in this section through comparative analysis of these alternatives.

The comparative analysis assesses the relative capability of the alternatives, as applicable to the COC groups identified for near-surface soil, to meet threshold requirements, to use permanent solutions to the maximum extent practicable, and to provide a reasonable restoration time frame. A disproportionate cost analysis is used to determine whether the cleanup action uses permanent solutions to the maximum practicable extent. The procedure for disproportionate cost analysis is summarized in Section 2.3.1. The factors assessed to determine whether the restoration time frame is reasonable are summarized in Section 2.2.1.2.

The remedial alternatives judged to be potentially applicable to the COC groups present in near-surface soil at the Kaiser Facility were identified in Section 2.7.2 (Table 2-19) of the FSTM (Hart Crowser 2012c). The comparative analysis of alternatives is applied to these COC groups in the following sections:

- Section 2.3.2 – VOCs (Alternatives A1, A2, and A3);
- Section 2.3.3 – SVOCs (Alternatives A1, A2, A4, A5, and A6);
- Section 2.3.4 – PCBs (Alternatives A1, A2, A4, and A6); and
- Section 2.3.5 – Metals (Alternatives A1, A2, and A4).

2.3.1 The Disproportionate Cost Analysis Procedure

Alternatives that meet threshold requirements for cleanup actions are assessed to determine which use permanent solutions to the maximum extent practicable per WAC 173-340-360(3). This assessment is conducted by performing a disproportionate cost analysis.

To conduct the disproportionate cost analysis, the alternatives are ranked from most to least permanent. The most permanent solution is the baseline cleanup action against which the other alternatives are compared. For near-surface soil at the Kaiser Facility, the FSTM identified Alternative A3 as the most permanent cleanup action for VOCs, Alternative A4 as the most permanent cleanup action for metals, and Alternative A6 as the most permanent cleanup action for SVOCs and PCBs.

Alternatives are compared by evaluating seven cost/benefit criteria: protectiveness, permanence, cost, effectiveness over the long term, management of short-term risks, technical and administrative implementability, and consideration of public concerns. These evaluation criteria were defined in Section 2.2.1.2. The regulation gives a general discussion of the types of factors to consider when evaluating each criterion. The relevance of the factors considered varies on a site-by-site basis.

Public concerns will ultimately be considered during the public comment period. Public acceptance was not used as a criterion to distinguish among the remediation alternatives evaluated in this FS. However, the preferred remediation alternative identified in this FS may be revised based on the results of the public comment period.

When assessing whether a cleanup action uses permanent solutions to the maximum extent practicable, the test used (WAC 173-340-360[3][e][i]) is as follows:

> *Costs are disproportionate to benefits if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative.*

As stated in WAC 173-340-360(3)(3)(ii)(C):

> *The comparison of benefits and costs may be quantitative, but will often be qualitative and require the use of best professional judgment. In particular, the department has the discretion to favor or disfavor qualitative benefits and use that information in selecting a cleanup action. Where two or more alternatives are equal in benefits, the department shall select the less costly alternative provided the requirements of subsection (2) of this section are met.*

Quantitative measures of costs and benefits, if performed, must be made in units that are common among the alternatives so that the comparison can be meaningful. It is best if the units of costs and the units of benefits can be the same, such as dollars. This is rarely possible at environmental cleanup sites. Costs are estimated in dollars, but quantitative measures of benefits are usually only available in terms of mass or volume of contaminant removed or some other physical, non-monetary measure. This is the case at the Kaiser Facility.

One quantitative measure of benefits that can be assessed is the measure of the amount of contamination remaining at the Facility and the rate at which concentrations will decline with time. Another quantitative measure of benefits is the number of COC-receptor pathways that are present before and after a remedial alternative is implemented. Where benefits cannot be quantified in common units, they will be assessed qualitatively.

2.3.2 Comparative Analysis of Alternatives Applicable to VOCs

Alternatives A1 (institutional controls, monitoring, and MNA), A2 (institutional controls, monitoring, MNA, and containment), and A3 (institutional controls, monitoring, MNA, containment, and SVE) were assessed in Sections 2.2.3 through 2.2.5, respectively. The outcome of this assessment is summarized in Table 2-10.

The relative capability of Alternatives A1, A2, and A3 to meet threshold requirements, an assessment of whether they use permanent solutions to the maximum practicable extent (disproportionate cost analysis), and an assessment of whether the restoration time frames they achieve are reasonable are presented below as applicable to VOC-impacted near-surface soil AOCs.

2.3.2.1 Threshold Requirements

Threshold requirements required for cleanup actions are defined in WAC 173-340-360(2). Requirements include protection of human health and the environment, compliance with MTCA cleanup standards and applicable state and federal laws, and provisions for compliance monitoring. Since protection and performance monitoring are a part of each of the alternatives in this FS, they were not evaluated. For further discussion of threshold requirements, see Section 2.2.1.1.

Protect Human Health and the Environment

Alternatives A1 and A2 each include physical and administrative controls and BMPs that will be used to reduce the potential for worker exposure to VOCs and to reduce the potential for VOCs in near-surface soil to migrate to groundwater.

Approximately 50 percent of the five VOC AOCs present at the Facility are currently located under pavement or floor slabs. The pavement and floor slabs prevent Facility workers and visitors from direct contact with VOCs in these areas, and prevent rainwater from conveying VOCs from near-surface soil to groundwater. Alternatives A2 and A3 include additional containment surfaces to cover remaining VOC AOC surfaces; thus, these alternatives cut the pathways by which VOCs in near-surface soil can reach human or ecological receptors and eliminate the risk that the VOCs pose to these receptors. Alternatives A2 and A3 are judged to be more protective than Alternative A1.

Alternatives A2 and A3 will eliminate the risk associated with the direct contact of Facility workers and the public to VOCs in near-surface soil in the VOC AOCs by installing containment surfaces. In addition, Alternative A3 will remove and destroy approximately 410 pounds of VOCs in the AOCs, which are expected to be treated in about 4 years. This destruction will further reduce the risk of future transport of VOCs from near-surface soil to the groundwater. SVE has been successfully demonstrated, but bench- and pilot-scale tests may be needed to prove its suitability at the Facility. As discussed below, short-term risks are manageable, and Alternative A3 is judged to be more permanent and to provide a greater degree of protection than Alternative A2.

Comply with MTCA Cleanup Standards

The SLs developed for the Kaiser Facility were based on the requirements of MTCA and contaminant-specific state and federal ARARs. These SLs are currently exceeded in the near-surface soil AOCs identified on Figure 2-3. Alternative A1 will not directly reduce the concentration of VOCs that are present in these AOCs, except by natural attenuation processes, which may reduce the concentration of VOCs to SLs over a long time.

In addition, Alternative A1 will not break the existing near-surface soil direct contact or ingestion exposure pathway for Facility workers and visitors, or the near-surface soil to groundwater exposure pathway. Thus, Alternative A1 by itself will not meet existing MTCA cleanup standards.

Alternatives A2 and A3 include containment surfaces that will cut the current direct contact and ingestion exposure pathways that were identified in the Kaiser HHERA (Pioneer 2012), and will eliminate the risk posed by the VOCs to human and ecological receptors. The containment surfaces will also prevent rainwater from conveying VOCs from near-surface soil to groundwater. Thus, Alternatives A2 and A3 provide the same degree of risk reduction to Facility workers and visitors and to receptors in the Spokane River.

As discussed in Section 2.1.1.3, soil that is contained can be deemed to meet SLs and MTCA cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Alternative A2 and A3 meet these requirements, as discussed above.

Since Alternative A3 will remove and destroy VOCs (in applicable AOCs), it will directly meet the SLs that have been established for VOCs in those areas that are treated at the Kaiser Facility.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A2 and A3 for VOCs. The identified action-specific ARARs for Alternatives A2 and A3 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.

2.3.2.2. Disproportionate Cost Analysis

Alternatives A2 and A3 meet the threshold requirements established by MTCA. This disproportionate cost analysis assesses whether Alternative A2 or A3 uses permanent solutions to the maximum extent practicable.

Protectiveness

Alternatives A2 and A3 each include physical and administrative controls and BMPs that will be used to reduce the potential for Facility worker and visitor exposure to VOCs and to reduce the potential for VOCs in near-surface soil to migrate to groundwater.

Alternatives A2 and A3 include containment surfaces that will cut the current Facility worker and visitor direct contact and ingestion pathways that were identified in the HHERA (Pioneer 2012), and will eliminate the risk posed by the VOCs to Facility workers and visitors. The containment surfaces will prevent rainwater from conveying VOCs from near-surface soil to groundwater.

Natural attenuation of VOCs in near-surface soil is assumed to be occurring in Alternatives A2 and A3; however, it will take a long time for VOC concentrations to decrease below SLs.

Only Alternative A3 will permanently reduce the toxicity and volume of VOCs in near-surface soil present in AOCs that will be treated by SVE within a reasonable time frame. Alternative A3 is expected to remove and destroy approximately 410 pounds of VOCs (Stoddard solvent and gasoline) within about 4 years. Alternative A3 is judged to be more protective than Alternative A2.

Permanence

Alternative A2 will reduce the release of hazardous substances to the environment by the use of BMPs. Also, access controls will reduce the opportunity for Facility visitors to contact VOCs in near-surface soil. Existing and installed paved surfaces (e.g., floor slabs, roads) will also prevent direct contact with VOCs in near-surface soil and from rainwater conveying VOCs to groundwater. However, Alternative A2 will not actively treat VOC AOCs beyond natural attenuation.

Alternative A3 will provide more permanence than Alternative A2 since it is expected to remove and destroy VOCs in a short period of time (about 4 years).

Cost

The NPV of implementing Alternatives A2 and A3 over a 30-year time period is estimated to total approximately $15.8 million and $16.3 million (-35 to +50 percent), respectively. The assumptions used to prepare this estimate are described in Sections 2.1.2 and 2.1.3 above and listed in Tables A-3 and A-4 contained in Appendix A. Alternative A3 is expected to remove and destroy approximately 410 pounds of VOCs. Based on this mass of VOCs, the total cost per pound of VOC contained in Alternative A2 is approximately $38,500 per pound of VOC, and the total cost per pound of VOC treated in Alternative A3 is approximately $39,800 per pound.

Effectiveness over the Long Term

Alternative A3 is expected to reduce the concentration of VOCs in near-surface soil in the four AOCs that will be treated to concentrations below SLs in about 4 years. It is not expected to reduce the concentration of other COCs (e.g., SVOCs) currently present in near-surface soil to concentrations below SLs in a reasonable restoration time frame.

The existing pavement and floor slabs and new containment surfaces provided by Alternative A2 will protect human and ecological receptors from direct contact with VOCs in these areas, and thus eliminates the risk that the VOCs pose to these receptors. This alternative will not generate treatment residues or waste materials and prevents rainwater from conveying VOCs to groundwater. Surface water runoff from the containment surfaces will be collected and transported to areas of the Facility without soil contamination and allowed to infiltrate or will be sent to the Kaiser WWT facility for treatment.

Alternative A3 will protect Facility workers and visitors from direct contact with VOCs and will prevent rainwater from conveying VOCs to groundwater. Alternative A3 will generate spent carbon that will be regenerated by an experienced contractor. Surface water runoff from the containment surfaces will be managed the same as for Alternative A2. The technologies employed by this alternative have been successfully demonstrated at other locations. Bench- and pilot-scale tests may be required to demonstrate their effectiveness at this Facility. Alternative A3 is judged to be more effective in the long term than Alternative A2.

Management of Short-Term Risks

Both Alternatives A2 and A3 will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces and SVE systems will be mitigated by adherence to the HASP. The procedures contained in the HASP have been shown to effectively manage the limited risk associated with these activities.

Alternative A3 includes additional short-term risks to workers operating the SVE system, and in the transportation and regeneration of the spent carbon. These risks will be mitigated by adherence to the SVE HASP and O&M plan. The regeneration of spent carbon is a complex process. An experienced carbon contractor will manage the removal, transportation, and regeneration of spent carbon. Based on the complexity of operating the SVE system, Alternative A2 is judged to have fewer short-term risks than Alternative A3.

Technical and Administrative Implementability

BMPs, groundwater monitoring, and institutional controls employed by Alternatives A2 and A3 are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. The contained area will likely need to be monitored in perpetuity and a restrictive covenant will need to be in place.

SVE is a presumptive remedy for the removal of VOCs from soil and is considered to be an implementable conventional technology that requires technical expertise for design and execution. Regeneration of spent carbon and the incineration of VOCs released from the carbon is a complex process that must be conducted in a facility designed and permitted for this purpose. The nearest facility to Kaiser is located in Cattlesburg, KY (York, T., Calgon, personal communication, 2010). The handling and disposal of spent carbon will be performed by an experienced contractor.

Alternative A3 has a greater level of technical complexity and more administrative requirements than Alternative A2.

Summary of Disproportionate Cost Analysis

Both Alternatives A2 and A3 meet the threshold requirements established by WAC 173-340-360(2)(a). They each provide institutional controls that will reduce the potential for Facility workers and visitors to be exposed to VOCs, and for VOCs in near-surface soil to migrate to groundwater via surface water infiltration.

Alternatives A2 and A3 include containment surfaces that will cut the current Facility worker and visitor direct contact and ingestion exposure pathways that were identified in the Kaiser HHERA (Pioneer 2012), and will eliminate the current risk posed by the VOCs to Facility workers and visitors. The containment surfaces will prevent rainwater from conveying VOCs from near-surface soil to groundwater. Alternative A3 provides a higher degree of protection to human health and the environment, since it also will remove and destroy VOCs by SVE treatment. For both Alternatives A2 and A3, the reduction in current risk through the installation of containment surfaces is expected to occur in approximately 1 to 2 years.

Alternative A3 is expected to remove and destroy approximately 410 pounds of VOCs (Stoddard solvent and gasoline) within about 4 years. Alternative A3 is thus judged to provide a more permanent remedy and to have greater effectiveness over the long term than Alternative A2.

The use of SVE and spent carbon regeneration technologies included in Alternative A3 will increase the level of short-term risk and technical and administrative complexity above those associated with Alternative A2.

The greater level of permanence and long-term effectiveness provided by the destruction of an estimated 410 pounds of VOCs in Alternative A3 is estimated to cost a total of $39,800 per pound of VOC treated. This cost does not provide any greater current risk reduction (to Facility workers and visitors) or potential future risk reduction than the risk reductions provided in Alternative A2, which costs a total of $38,500 per pound of VOC contained, since both Alternatives A2 and A3 cut the pathways by which VOCs in near-surface soil can reach potential receptors and eliminate the risk posed by impacted near-surface soil to these receptors. In addition, Alternative A2 can be implemented with less short-term risk and fewer technical and administrative issues than Alternative A3. Thus, Alternative A2 is judged to use permanent solutions to the maximum extent practicable for near-surface soil containing VOCs at concentrations above SLs.

2.3.2.3 Restoration Time Frame for VOCs

Remedial alternatives must provide for a reasonable restoration time frame per WAC 173-340-360(2)(b)(ii). A number of factors are considered to determine whether an alternative provides for a reasonable restoration time frame (WAC 173-340-360[4][b]), which are assessed for the near-surface soil remedial alternatives individually in Section 2.2. This section compares the restoration time frames potentially achieved by the alternatives for VOCs in near-surface soil AOCs.

Alternatives A1 and A2 do not directly reduce the toxicity, mobility, or volume of the VOCs contained in near-surface soil; however, natural attenuation processes at the Facility will continue. The time frame needed for the concentration of VOCs in near-surface soil to fall below SLs is expected to be long; however, the containment surfaces in Alternative A2 can be installed in a relatively short time frame (approximately 1 year). Soil under the containment surfaces may be determined to comply with cleanup standards after the containment surfaces are in place if the requirements under WAC 173-340-740(6)(f) are met. Alternative A2 meets these criteria. For Alternative A3, the concentrations of VOCs in near-surface soil in the four AOCs that will be treated are expected to be reduced below SLs within a total of about 4 years. Concentrations of other organic COCs are expected to decrease over a long period of time from natural attenuation.

The containment surfaces in Alternatives A2 and A3 could be installed in approximately the same amount of time to meet the requirements under WAC 173-340-740(6)(f), and thus their restoration time frames would be approximately the same. Alternatives A2 and A3 are judged to have a shorter restoration time frame than Alternative A1. These time frames are judged to be reasonable based on the assessment conducted per WAC 173-340-360(4), which is described in Section 2.2.1.2.

2.3.3 Comparative Analysis of Alternatives Applicable to SVOCs

Alternatives A1 (institutional controls, monitoring, and MNA), A2 (institutional controls, monitoring, MNA, and containment), A4 (institutional controls, monitoring, MNA, containment, and off-site disposal), A5 (institutional controls, monitoring, MNA, containment, on-site treatment), and A6 (institutional controls, monitoring, MNA, containment, and off-site treatment) are applicable to remediation of near-surface soil AOCs impacted by SVOCs. The outcome of this assessment is summarized in Table 2-11.

The relative capability of Alternatives A1, A2, A4, A5, and A6 to meet threshold requirements, an assessment of whether they use permanent solutions to the maximum practicable extent (disproportionate cost analysis), and an assessment of whether the restoration time frames they achieve are reasonable are presented below as applicable to SVOC-impacted near-surface soil AOCs.

2.3.3.1 Threshold Requirements

Alternative A1 does not meet the threshold criteria and will not be assessed in the disproportionate cost analysis for alternatives applicable to SVOCs. The capability of Alternatives A2, A4, A5, and A6 to meet threshold and permanence (disproportionate cost) requirements is discussed below. Alternative A6 was judged to be the most permanent alternative for SVOCs by the FSTM (Section 2.7.2). Threshold requirements are defined in Section 2.2.1.1.

Protect Human Health and the Environment

Alternatives A1, A2, A4, A5, and A6 each include physical and administrative controls and BMPs that will be used to reduce the potential for worker exposure to SVOCs and to reduce the potential for SVOCs in near-surface soil to migrate to groundwater.

The AOCs for SVOCs for near-surface soil were defined in Section 2 of the FSTM. These AOCs are consolidated on Figures 2-3 through 2-10, which depict the near-surface COC-specific AOCs that are present in each of the operating areas of the Kaiser Facility.

Approximately 40 percent of the SVOC AOCs present at the Kaiser Facility are currently located under pavement or floor slabs. The pavement and floor slabs prevent Facility workers and visitors from direct contact with SVOCs in these areas and prevent rainwater from conveying SVOCs from near-surface soil to groundwater.

Alternative A2 includes additional containment surfaces to cover each of the remaining SVOC AOCs; thus, this alternative will also cut the existing direct contact, worker and visitor to near-surface soil pathway, identified as posing a human health risk in the HHERA (Pioneer 2012) and will prevent rainwater from conveying COCs from near-surface soil to groundwater. Thus, Alternative A2 provides the same degree of risk reduction to Facility workers and visitors and to receptors in the Spokane River as Alternatives A4, A5, and A6.

Alternatives A4, A5, and A6 will remove the SVOCs that are present in near-surface soil at concentrations above SLs and, therefore, will also cut the existing direct contact and soil to groundwater pathways. Alternative A4 is expected to remove approximately 143,000 pounds of SVOCs from the Facility and place them in a permitted, lined landfill. Alternative A5 is expected to remove the same mass as Alternative A4 and destroy approximately 95 percent (135,000 pounds) of the SVOCs. Alternative A6 is expected to remove and destroy approximately 143,000 pounds of SVOCs.

Alternatives A2, A4, A5, and A6 will cut the direct contact and soil to groundwater pathways. They are also expected to have similar restoration time frames, where risks to human health and the environment are expected to be reduced substantially in about 1 to 2 years (refer to Section 2.4.2).

Alternative A6 is judged to be the most protective alternative applicable to SVOCs followed by Alternatives A5, A4, and A2, in that order.

Comply with MTCA Cleanup Standards

The SLs developed for the Kaiser Facility were based on the requirements of MTCA and contaminant-specific state and federal ARARs. These SLs are currently exceeded in the near-surface soil AOCs that were identified in the FSTM and shown on Figures 2-3 through 2-10. Alternative A1 will not directly reduce the concentrations of SVOCs that are present in these AOCs, and will not break the near-surface soil, human direct contact or ingestion pathway, or the soil to groundwater pathway, that present current risks to Facility workers and visitors and potential future risk to groundwater, and, therefore, is not carried forward in the disproportionate cost analysis.

Alternative A2 adds containment surfaces that will cut the current Facility worker and visitor direct contact and ingestion pathways that were identified in the Kaiser HHERA (Pioneer 2012), and will eliminate the risk posed by the SVOCs to Facility workers and visitors. The containment surfaces will prevent rainwater from conveying SVOCs from near-surface soil to groundwater.

As discussed in Section 2.1.1.3, soil that is contained can be deemed to meet SLs if certain requirements set out in WAC 173-340-740(6)(f) are met. Alternative A2 meets these requirements.

Alternative A4 will remove SVOCs in the areas that can be excavated; the soil below the excavations will be below SLs that have been established for the Facility. The soil will be disposed of at a monitored, permitted, lined landfill.

Alternatives A5 and A6 will remove and destroy SVOCs in the soil that can be excavated. The technologies described in these alternatives (incineration, biotreatment, and thermal treatment) are expected to reduce concentrations to below SLs.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A2, A4, A5, or A6 for SVOCs. The identified action-specific ARARs for these alternatives consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.

Alternatives A2, A4, A5, and A6 are judged to comply with cleanup standards and applicable state and federal laws.

2.3.3.2 Disproportionate Cost Analysis

Alternatives A2, A4, A5, and A6 meet the threshold requirements established by MTCA. This disproportionate cost analysis identifies which alternatives use permanent solutions to the maximum extent practicable. Alternative A1 does not meet the threshold criteria and will not be assessed in this disproportionate cost analysis.

Protectiveness

Alternatives A2, A4, A5, and A6 each provide physical and administrative controls and BMPs that will be used to reduce the potential for Facility worker and visitor exposure to SVOCs (for AOCs identified in the HHERA) and to reduce the potential for SVOCs in near-surface soil to migrate to groundwater.

Alternative A2 adds containment surfaces that will cut the current Facility worker and visitor direct contact and ingestion pathways that were identified in the Kaiser HHERA (Pioneer 2012), and will eliminate the risk posed by the SVOCs to Facility workers and visitors. The containment surfaces will prevent rainwater from conveying SVOCs from near-surface soil to groundwater. Cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Alternatives A2, A4, A5, and A6 meet these requirements as discussed above.

Alternatives A4, A5, and A6 will remove the SVOCs in near-surface soil above SLs and, therefore, will cut the existing direct contact and ingestion pathway and soil to groundwater pathway. Alternative A4 is expected to remove approximately 143,000 pounds of SVOCs from the Facility and place them in a permitted, lined landfill. Alternative A5 is expected to remove approximately 143,000 pounds of SVOCs and destroy approximately 95 percent (135,000 pounds) of the SVOCs. Alternative A6 is expected to remove and destroy approximately 143,000 pounds of SVOCs.

Alternative A6 is judged to be most protective alternative applicable to SVOCs followed by Alternatives A5, A4, and A2, in that order.

Permanence

Alternative A2 will not reduce toxicity or volume of SVOCs in near-surface soil within a reasonable time frame (refer to Section 2.4.2). Alternative A4 will remove SVOCs and reduce contaminant mobility by placing the soil in a lined, permitted landfill. Alternatives A5 and A6 both will permanently reduce the toxicity and volume of SVOCs in near-surface soil. Alternative A5 is expected to reduce SVOC concentrations by approximately 95 percent. Alternative A6 is expected to reduce SVOC concentrations by 99.99 percent.

Alternative A6 is judged to be the most permanent alternative applicable to SVOCs followed by Alternatives A5, A4, and A2, in that order.

Cost

The NPV of implementing Alternative A2 over 30 years is estimated to total approximately $15.8 million (-35 to +50 percent) (Table A-3). Alternative A2 is expected to provide containment of approximately 143,000 pounds of SVOCs. Thus, the total cost of Alternative A2 per pound of SVOC contained is approximately $110.

The NPV of implementing Alternative A4a over 30 years is estimated to total approximately $18.7 million (-35 to +50 percent). Implementation of Alternative A4b over the same time period is estimated to total approximately $20.9 million (-35 to +50 percent) (see Tables A-5 and A-6). Alternative A4 is expected to remove and contain approximately 143,000 pounds of SVOCs. Based on this mass, it costs approximately $131 per pound of SVOC to excavate and dispose of SVOC-impacted near-surface soil off site in Alternative A4a, and approximately $146 per pound of SVOC to excavate and dispose of near-surface soil impacted by SVOCs, and to contain remaining SVOC-impacted deep vadose zone soil, in Alternative A4b.

The NPV of implementing Alternative A5a combined with Alternative A1 over 30 years is estimated to total approximately $19.1 million (-35 to +50 percent) (see Table A-8). Implementation of Alternative A5a combined with Alternative A2 over the same time period is estimated to total approximately $21.4 million (-35 to +50 percent). Alternative A5a is expected to remove an estimated 143,000 pounds of SVOCs and treat approximately 135,000 pounds (95 percent) of SVOCs. Thus, it costs approximately $141 per pound of SVOC to excavate and biologically treat SVOC-impacted near-surface soil in Alternative A5a combined with Alternative A1. It costs about $159 per pound of SVOC to excavate and treat SVOC-impacted near-surface soil, and to contain remaining deep vadose zone soil, in Alternative A5a combined with Alternative A2.

The NPV of implementing Alternative A5b (thermal treatment) combined with Alternative A1 over a 30-year time period is estimated to total approximately $19.9 million (-35 to +50 percent) (see Table A-8). Implementation of Alternative A5b combined with Alternative A2 over the same time period is estimated to total approximately $22.2 million (-35 to +50 percent). Alternative A5b removes and treats approximately 135,000 pounds of SVOCs. Thus, it costs approximately $147 per pound of SVOC to excavate and thermally treat SVOC-impacted near-surface soil in Alternative A5b combined with Alternative A1. It costs about $164 per pound of SVOC to excavate and treat SVOC-impacted near-surface soil, and to contain remaining deep vadose zone soil, in Alternative A5b combined with Alternative A2.

The NPV of implementing Alternative A6 combined with Alternative A1 over 30 years is estimated to total approximately $39.0 million (-35 to +50 percent) (see Table A-9). Implementation of Alternative A6 combined with Alternative A2 over the same time period is estimated to total approximately $41.3 million (-35 to +50 percent). Alternative A6 is expected to remove and destroy approximately 143,000 pounds of SVOCs through off-site incineration. Thus, it costs approximately $273 per pound of SVOC to excavate and destroy SVOC-impacted near-surface soil via off-site incineration in Alternative A6 combined with Alternative A1. It costs approximately $289 per pound of SVOC to excavate and destroy SVOC-impacted near-surface soil via off-site incineration, and to contain remaining deep vadose zone soil, in Alternative A6 combined with Alternative A2.

The assumptions used to prepare this estimate are described in Section 2.1 above and listed in the cost tables contained in Appendix A.

Effectiveness over the Long Term

The existing pavement and floor slabs will protect Facility workers and visitors from direct contact with SVOCs in these areas, and prevent rainwater from conveying SVOCs to groundwater. The new containment surfaces in Alternative A2 will also protect Facility workers and visitors from direct contact with SVOCs in these areas, and prevent rainwater from conveying SVOCs to groundwater.

Institutional controls will be put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system. An inspection and maintenance plan that will assure the integrity of the existing pavement, floor slabs, and new containment surfaces will be prepared and implemented. The containment surfaces are expected to remain effective for an extended period of time.

Alternative A4 will place soil in an engineered, lined, and monitored facility. Alternative A4 will reduce the concentration of SVOCs in near-surface soil that can be excavated within a relatively short (about 1 year) time period.

Alternative A5 is expected to remove an estimated 143,000 pounds of SVOCs and destroy approximately 135,000 pounds of SVOCs within 1 to 2 years. Alternative A6 is expected to remove and destroy approximately 143,000 pounds of SVOCs within a one-year time frame.

Per WAC 173-340-360(3)(e)(iv), Alternatives A5 and A6 are judged to have a higher degree of long-term effectiveness than Alternative A4, and Alternative A4 is judged to have a higher degree of long-term effectiveness than Alternative A2.

Management of Short-Term Risks

Alternatives A2, A4, A5, and A6 will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks for each alternative to construction workers during the installation of the containment surfaces, excavation, screening of soil, and/or treatment operations will be mitigated by their adherence to the HASP. The procedures contained in the HASP and the O&M plan have been shown to effectively manage the limited risk associated with these activities.

Alternatives A4 and A6 will result in additional short-term risks during the transport of the impacted material to the landfill or incineration facilities. Transport containers will be covered and appropriate measures will be taken to reduce risk to the communities that they travel through. Only properly licensed material haulers will be used.

Short-term risks for Alternative A6 are also associated with the operation of the incinerator. These risks will be mitigated by adherence to the health and safety procedures that the transportation, landfill, and incineration contractors typically implement as part of their operations.

Alternative A2 is judged to have the fewest short-term risks, followed by Alternative A4, Alternative A5, and then Alternative A6.

Technical and Administrative Implementability

BMPs, groundwater monitoring, and institutional controls employed by the alternatives are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years.

Excavation and off-site disposal is a common remediation alternative and has been conducted for past remedial measures at the Kaiser Facility.

Biotreatment and thermal treatment technologies prescribed in Alternative A5 are presumptive remedies for the treatment of SVOCs from soil and are considered to be implementable conventional technologies.

Excavation and incineration are generally technically and administratively implementable. An off-site permitted incineration facility is located in Aragonite, UT.

The administrative requirements will increase with the increasing complexity of the remedial alternative. The permitting and administrative requirements associated with Alternative A6 are the most complex, followed by Alternative A5, then Alternative A4, then Alternative A2.

Summary of Disproportionate Cost Analysis

Alternatives A2, A4, A5, and A6 meet the threshold requirements established by WAC 173-340-360(2)(a). They each will provide physical and administrative controls and BMPs that will be used to reduce the potential for Facility worker and visitor exposure to SVOCs and to reduce the potential for SVOCs in near-surface soil to migrate to groundwater.

Alternative A2 adds containment surfaces that will cut the current Facility worker and visitor direct contact and ingestion pathways that were identified in the Kaiser HHERA (Pioneer 2012), and will eliminate the current risk posed by the SVOCs to Facility workers and visitors. The containment surfaces will prevent rainwater from conveying SVOCs from near-surface soil to groundwater. This reduction in current risk will occur in a less than 1 year. Cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Alternative A2 meets these requirements.

Alternative A4 will remove SVOCs from the Facility near-surface soil and place them in a lined, permitted landfill. Alternative A4 is expected to remove approximately 143,000 pounds of SVOCs. Alternatives A5 and A6 will permanently reduce the toxicity and volume of SVOCs in excavated near-surface soil. Alternative A5 is expected to remove an estimated 143,000 pounds of SVOCs and destroy approximately 135,000 pounds of SVOCs. Alternative A6 is expected to remove and destroy approximately 143,000 pounds of SVOCs. Alternative A6 is thus judged to provide the most permanent remedy and to have greater effectiveness over the long term than the other alternatives that are applicable to SVOCs. This reduction in current risk will occur in a short time frame, from about 1 to 2 years.

The permanence and greater long-term effectiveness provided by the removal and destruction of SVOCs in Alternative A6 cost a total of approximately $273 per pound of SVOC, when combined with Alternative A1, and approximately $289 per pound when combined with Alternative A2.

The permanence and greater long-term effectiveness provided by the removal and on-site treatment of SVOCs in Alternative A5a cost approximately $141 per pound of SVOC, when combined with Alternative A1, and approximately $159 per pound when combined with Alternative A2. Alternative A5b costs approximately $147 per pound of SVOC, when combined with Alternative A1, and approximately $164 per pound when combined with Alternative A2.

The permanence and greater long-term effectiveness provided by the removal and off-site disposal of SVOCs in Alternatives A4a and A4b cost approximately $131 and $146 per pound of SVOC, respectively. The permanence and long-term effectiveness provided by the on-site containment of SVOCs in Alternative A2 cost a total of approximately $110 per pound of SVOC contained.

The additional permanence and long-term effectiveness provided in Alternatives A4, A5, and A6 do not provide any greater current risk reduction (to Facility workers and visitors) or potential future risk reduction (in the soil to groundwater pathway) than the risk reduction provided by Alternative A2. The additional permanence and long-term effectiveness provided in Alternatives A4, A5, and A6 comes with an additional cost of $5.1, $5.6 to $6.4, and $25.5 million, respectively. Since this substantial additional cost does not provide any additional risk reduction to current or potential future receptors on the Kaiser Facility or to users of the Spokane River, the costs are judged to be disproportionate to the additional benefits provided by these alternatives. Thus, Alternative A2 is judged to be the alternative that uses permanent solutions to the maximum extent practicable for near-surface soil containing SVOCs at concentrations above SLs.

2.3.3.3 Restoration Time Frame for SVOCs

Remedial alternatives must provide for a reasonable restoration time frame per WAC 173-340-360(2)(b)(ii). A number of factors are considered to determine whether an alternative provides for a reasonable restoration time frame (WAC 173-340-360[4][b]), which are assessed for the near-surface soil remedial alternatives individually in Section 2.2. This section compares the restoration time frames potentially achieved by the alternatives for SVOCs in near-surface soil AOCs.

The risks to Facility workers and visitors from direct contact or ingestion of SVOCs would be eliminated once the containment surfaces are installed in Alternative A2, or once the soil is excavated in Alternatives A4, A5, and A6. Alternatives A2, A4, A5, and A6 will reduce the future transport of SVOCs from near-surface soil to groundwater.

Natural attenuation processes will reduce SVOC concentrations in near-surface soil in Alternatives A1 and A2. The time frame needed for the concentration of SVOCs in near-surface soil to fall below SLs will be long. Soil under the containment surfaces installed in Alternative A2 may be determined to comply with cleanup standards after the containment surfaces are in place if the requirements under WAC 173-340-740(6)(f) are met. Alternative A2 meets these requirements.

The concentration of SVOCs in the excavated soil that is disposed of off site or treated on site is expected to fall below SLs within a relatively short time period: about 2 years for Alternative A5a and approximately 1 year for Alternatives A4 and A5b. Alternative A2 could also be installed in a relatively short time frame (about 1 year). For Alternative A6, the excavated soil to be sent off site for incineration is expected to be treated within about 1 year.

The restoration time frames for Alternatives A2, A4, A5, and A6 are judged to be reasonable based on the assessment conducted per WAC 173-340-360(4), which is described in Section 2.2.1.2.

2.3.4 Comparative Analysis for Alternatives Applicable to PCBs

The disproportionate cost analysis for PCBs applies to Alternatives A1, A2, A4, and A6. Alternative A1 includes institutional controls, monitoring, and MNA. Alternative A1 does not meet MTCA threshold criteria and is not included in the analysis that follows. Alternative A2 adds containment to Alternative A1. Alternatives A4 and A6 include excavation followed by off-site disposal and off-site incineration, respectively. These alternatives are assessed in Sections 2.2.3, 2.2.4, 2.2.6, and 2.2.8. The outcome of this assessment is summarized in Table 2-12.

The relative capability of Alternatives A1, A2, A4, and A6 to meet threshold requirements, an assessment of whether they use permanent solutions to the maximum practicable extent (disproportionate cost analysis), and an assessment of whether the restoration time frames they achieve are reasonable are presented below as applicable to PCB-impacted near-surface soil AOCs.

2.3.4.1 Threshold Requirements

MTCA threshold requirements are defined in Section 2.2.1.1 and are evaluated below for Alternatives A2, A4, and A6 for the remediation of PCBs.

Protect Human Health and the Environment

Alternatives A2, A4, and A6 each include physical and administrative controls and BMPs that will be used to reduce the potential for worker exposure to PCBs and to reduce the potential for PCBs in near-surface soil to migrate to groundwater.

The total area of the PCB AOCs present at the Facility is approximately 24,200 sq ft. Approximately 12,700 sq ft of this area lies beneath existing pavement or building floor slabs. Thus, approximately 52 percent of the PCB AOC area is currently located under containment surfaces. The pavement and floor slabs prevent Facility workers and visitors from direct contact with PCBs in these areas, and prevent rainwater from conveying PCBs from near-surface soil to groundwater. Alternative A2 includes additional containment surfaces to cover each of the PCB AOCs. Thus, Alternative A2 will cut the existing Facility worker and visitor near-surface soil direct contact pathway and cover the remaining PCB AOC area to prevent rainwater from conveying any PCBs in near-surface or deep vadose zone soils to groundwater, which eliminates the risk to receptors posed by PCBs in these AOCs.

Alternatives A4 and A6 will permanently reduce the toxicity, mobility, and volume of PCBs present in the PCB AOCs. Alternative A4 is expected to remove an estimated 8 pounds of PCBs via excavation. The PCBs will be disposed of at an off-site landfill facility. Alternative A4 is thus more protective than Alternative A2. Alternative A6 involves removal of the same mass of PCBs by excavation as Alternative A4, but includes off-site incineration of contaminated soil rather than containment in an off-site landfill. Since incineration destroys contaminant mass, rather than isolating it in a containment facility, Alternative A6 is considered more protective than Alternatives A2 and A4.

Comply with MTCA Cleanup Standards

The SLs developed for the Facility were based on the requirements of MTCA and contaminant-specific state and federal ARARs. These SLs for PCBs are currently exceeded in the near-surface soil AOCs identified on Figure 2-3.

Alternative A2 includes containment surfaces that will cut the direct contact exposure pathway that currently exists between Facility workers and visitors, which was identified in the Kaiser HHERA (Pioneer 2012). Alternative A2 will eliminate the risk posed by the near-surface soil PCBs to Facility workers and visitors. The containment surfaces will prevent rainwater from conveying PCBs from near-surface soil to groundwater. As discussed in Section 2.1.1.3, soil that is contained can be deemed to meet SLs if certain requirements that are defined in WAC 173-340-740(6)(f) are met. Alternative A2 meets these requirements.

Alternatives A4 and A6 will remove PCBs and either contain them in an off-site landfill or destroy them via incineration, in addition to installing containment surfaces in areas where deep vadose zone soils contain PCBs in concentrations above SLs. These alternatives directly meet the SLs that have been established for PCBs at the Kaiser Facility.

Alternative A2 provides the same degree of risk reduction to Facility workers and visitors and to receptors in the Spokane River as Alternatives A4 and A6.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. The identified action-specific ARARs for Alternatives A2, A4, and A6 consist of requirements associated with implementation of the alternatives (see Appendix G, Table G-3). Location-specific ARARs consist of potential restrictions related to construction near the shoreline of the Spokane River, such as in the WDR. These ARARS are judged to be attainable and do not affect the alternative selection process.

Alternatives A2, A4, and A6 are judged to comply with MTCA cleanup standards and applicable state and federal laws.

2.3.4.2 Disproportionate Cost Analysis

Alternatives A2, A4, and A6 meet the threshold requirements established by MTCA. This disproportionate cost analysis compares these three alternatives for treatment of PCBs to determine which alternative uses permanent solutions to the maximum extent practicable. Because Alternative A1 does not meet MTCA threshold requirements, it will not be included in the analysis below.

Protectiveness

Alternatives A2, A4, and A6 each include physical and administrative controls and BMPs that will be used to reduce the potential for Facility worker and visitor exposure to PCBs and to reduce the potential for PCBs in near-surface soil to migrate to groundwater.

Alternatives A2, A4, and A6 add containment surfaces that will cut the current Facility worker and visitor direct contact and ingestion pathways that were identified in the Kaiser HHERA (Pioneer 2012), and will eliminate the risk posed by the PCBs to Facility workers and visitors. The containment surfaces will prevent rainwater from conveying PCBs from near-surface soil to groundwater. Thus, each alternative provides the same degree of risk reduction to Facility workers and visitors and to receptors in the Spokane River.

Cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements defined in WAC 173-340-740(6)(f) are met. Alternatives A2, A4, and A6 meet these requirements.

Alternatives A4 and A6 will also include permanent reduction in the mass of PCBs in near-surface soil present in the PCB AOCs. Alternatives A4 and A6 are each expected to remove approximately 8 pounds of PCBs. Alternative A4 will dispose of and contain PCB-impacted soil in an off-site landfill, whereas Alternative A6 will destroy PCBs in excavated soil at an off-site incineration facility. Alternatives A4 and A6 are thus judged to be more protective than Alternative A2, and Alternative A6 is judged to be more protective than Alternative A4, since Alternative A6 destroys the PCBs.

Permanence

Only Alternatives A4 and A6 will permanently reduce the mass of PCBs in near-surface soil present in the PCB AOCs. Alternative A4 will remove and dispose of approximately 8 pounds of PCBs at an off-site landfill. Alternative A6 will remove the same mass of PCBs as in Alternative A4, but will destroy this mass of PCBs at an off-site incineration facility. Alternative A6 is thus judged to be more permanent than Alternative A4.

Cost

The total NPV of implementing Alternative A2 over 30 years, is estimated to total approximately $15.8 million (-35 to +50 percent) (see Table A-3). Alternative A2 will provide containment of approximately 8 pounds of PCBs. Thus, it costs a total of approximately $2.0 million per pound of PCBs contained in Alternative A2.

The total NPV of implementing Alternatives A4a and A4b over 30 years is estimated to total approximately $18.7 million and $20.9 million, respectively (-35 to +50 percent) (refer to Tables A-5 and A-6). Alternative A4 is expected to remove and dispose of off site approximately 8 pounds of PCBs. Thus, it costs approximately $2.3 million and $2.6 million per pound of PCBs to excavate and dispose of PCB-impacted near-surface soil off site in Alternatives A4a and A4b, respectively.

The total NPV of implementing Alternative A6, based on a 30-year time period, is estimated to be approximately $39.0 million (when combined with Alternative A1) and about $41.3 million (when combined with Alternative A2) (-35 to +50 percent) (see Table A-9). Alternative A6 is expected to remove and destroy approximately 8 pounds of PCBs through off-site incineration. Thus, it costs approximately $4.9 million per pound of PCBs (Alternative A6 combined with Alternative A1) and $5.2 million per pound (Alternative A6 combined with Alternative A2)to excavate and destroy PCB-impacted near-surface soil via off-site incineration.

Alternatives A4 and A6, compared to Alternative A2, provide the additional benefit of greater permanence in reducing the toxicity, mobility, or volume of PCBs in near-surface soil at the Facility. For the incremental benefit gained in Alternative A4 or A6, compared to Alternative A2, the additional costs for excavation and off-site disposal total approximately $5.1 million, while the additional cost of excavation and off-site treatment total approximately $25.5 million. The assumptions used to prepare this estimate are described in Section 2.1.6 and in the cost tables contained in Appendix A.

Effectiveness over the Long Term

Alternatives A4 and A6 will remove PCB mass from accessible near-surface soil AOCs via excavation, which will be either disposed of in an off-site landfill or destroyed through incineration, rather than contain PCBs in near-surface soil beneath a cap. The existing pavement and floor slabs and new containment surfaces provided by Alternative A2 will protect Facility workers and visitors from direct contact with PCBs in these areas and will prevent rainwater from conveying PCBs to groundwater.

Institutional controls will be implemented under WAC 173-340-440 that will prohibit or limit activities that could interfere with the long-term integrity of the containment system provided by Alternative A2. An inspection and maintenance plan that will assure the integrity of the existing pavement, floor slabs, and new containment surfaces will be prepared and implemented. The containment surfaces are expected to remain effective for an extended period of time.

Alternatives A4 and A6 are judged to have more long-term effectiveness than Alternative A2, and Alternative A6 is judged to have greater long-term effectiveness than Alternative A4.

Management of Short-Term Risks

The short-term risks associated with Alternatives A2, A4, and A6 to construction workers during installation of the containment surfaces and during excavation will be mitigated by their adherence to the HASP. The procedures contained in the HASP and the inspection and maintenance plan have been shown to effectively manage the limited risk associated with these activities.

Alternatives A4 and A6 will result in additional short-term risks in the transportation of PCB-contaminated soil either to a regulated landfill or to an incineration facility. Additional short-term risks are associated with handling the waste material at these facilities. Also, short-term risks are associated with the operation of the incinerator. These risks will be mitigated by adherence to the health and safety procedures that the transportation, landfill, and incineration contractors typically implement as part of their operations.

Alternative A2 is judged to have fewer short-term risks than Alternatives A4 and A6, and Alternative A4 is judged to have fewer short-term risks than Alternative A6.

Technical and Administrative Implementability

BMPs, groundwater monitoring, and institutional controls employed by Alternatives A2, A4, and A6 are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years.

Excavation and landfill disposal or incineration under Alternatives A4 and A6 are generally technically and administratively implementable. Construction contractor services and construction materials are available locally in the Spokane area. Project scheduling will need to consider minimizing disruption to ongoing Facility operations and will need to consider simultaneous implementation of remedial actions such as simultaneous mobilization of excavation and cap installation contractors.

Off-site incineration facilities and landfills are available for treatment of PCB-contaminated soil, although these facilities are distant: The nearest incineration facility is located in Aragonite, UT. The nearest RCRA-permitted Subtitle C landfill for disposal of soil containing PCBs at concentrations greater than 50 mg/kg is located in Arlington, OR. The nearest Subtitle D landfill for disposal of lower-concentration PCB-impacted soil is in Roosevelt, WA.

The administrative and regulatory requirements associated with Alternatives A4 and A6 (e.g., permitting, hazardous waste manifesting, MTCA cleanup criteria) are common protocols that Kaiser has experience managing. Protection and performance monitoring are ongoing at the Facility and confirmational monitoring associated with excavation of contaminated soil is a common practice.

Soil excavation is a relatively straightforward process with fewer complexities than containment cap construction. Landfill disposal of PCB-impacted soil is a less complex process than soil incineration; however, landfill disposal requires long-term monitoring to confirm that waste materials are not being transported out of the landfill, which has complexities similar to monitoring following cap installation at the Facility. Excavation, cap construction, landfill disposal, and incineration are all commonly used remedial practices, however, and protocols are in place for managing the complexities associated with each practice.

Alternative A2 is judged to be technically and administratively easier to implement than Alternatives A4 and A6, and Alternative A4 is judged to be easier to implement than Alternative A6.

Summary of Disproportionate Cost Analysis

Alternatives A2, A4, and A6 meet the threshold requirements established by WAC 173-340-360(2)(a). They each provide physical and administrative controls and BMPs that will be used to reduce the potential for Facility worker and visitor exposure to PCBs and to reduce the potential for PCBs in near-surface soil to migrate to groundwater. Thus, each alternative provides the same degree of risk reduction to Facility workers and visitors, and to receptors in the Spokane River.

Alternative A2 includes containment surfaces that will cut the current Facility worker and visitor direct contact and ingestion pathways that were identified in the Kaiser HHERA (Pioneer 2012), and will eliminate the current risk posed by the PCBs to Facility workers and visitors. The containment surfaces will prevent rainwater from conveying PCBs from near-surface soil to groundwater. This reduction in current risk will likely occur in a short time frame (about 1 to 2 years). Cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Alternative A2 meets these requirement.

Alternatives A4 and A6 will permanently reduce the mass of PCBs in near-surface soil present in the PCB AOCs. Alternatives A4 and A6 are expected to remove approximately 8 pounds of PCBs by excavation of near-surface soil. Alternative A4 will contain these PCBs in an off-site landfill. Alternative A6 will destroy these PCBs via off-site incineration. Alternative A6 is thus judged to provide a more permanent remedy and to have greater effectiveness over the long term than Alternatives A2 and A4.

Cap construction and excavation pose similar short-term risks during construction. However, the transport and disposal of PCB-impacted soil at an off-site landfill, and the transport and destruction of PCB-impacted soil at an off-site incineration facility, present additional short-term risks and increase the complexity of technical and administrative implementability above those associated with Alternative A2.

The additional permanence and long-term effectiveness provided by Alternatives A4 and A6 comes with an additional cost of $5.1 and $25.5 million compared to the estimated cost of Alternative A2, respectively, to remove and contain or remove and treat about 8 pounds of PCBs. Since this substantial additional cost does not provide any additional risk reduction to current or potential future receptors on the Kaiser property or to users of the Spokane River than does Alternative A2, the costs are judged to be disproportionate to the additional benefits provided by these alternatives. Thus, Alternative A2 is judged to be the alternative that uses permanent solutions to the maximum extent practicable for near-surface soil containing PCBs at concentrations above SLs.

2.3.4.3 Restoration Time Frame for PCBs

Remedial alternatives must provide for a reasonable restoration time frame per WAC 173-340-360(2)(b)(ii). A number of factors are considered to determine whether an alternative provides for a reasonable restoration time frame (WAC 173-340-360[4][b]), which are assessed for the near-surface soil remedial alternatives individually in Section 2.2. This section compares the restoration time frames potentially achieved by the alternatives for PCBs in near-surface soil AOCs.

The restoration time frame associated with excavation, transport, and incineration of PCB-impacted soil under Alternative A6 is expected to be relatively short, from 1 to 2 years. Similarly, the excavation, transport, and disposal aspects of Alternative A4 are also expected to be completed in about 1 to 2 years.

The risks to Facility workers and visitors from direct contact or ingestion of PCB-impacted soil will be eliminated once the containment surfaces have been installed in Alternative A2. Alternative A2 will reduce the future transport of PCBs from near-surface soil to the groundwater. The containment cap installed in Alternative A2 could be put into service within approximately 1 year. Soil under the containment surfaces may be determined to comply with cleanup standards after the containment surfaces are in place if the requirements under WAC 173-340-740(6)(f) are met. Alternative A2 meets these requirements.

Alternatives A2, A4, and A6 are judged to have approximately the same restoration time frames, since the three alternatives require about the same amount of time to complete cap installation or remove impacted soil via excavation. Alternative A1 is judged to have a longer restoration time frame than Alternatives A2, A4, and A6. The restoration time frames for Alternatives A2, A4, and A6 are judged to be reasonable based on the assessment conducted per WAC 173-340-360(4), which is described in Section 2.2.1.2.

2.3.5 Comparative Analysis of Alternatives Applicable to Metals

Alternatives A1 (institutional controls, monitoring, and MNA), A2 (institutional controls, monitoring, MNA, and containment), and A4 (institutional controls, monitoring, MNA, containment, and off-site disposal) are applicable to remediation of metal-impacted near-surface soil and are assessed in Section 2.2.3, Section 2.2.4, and Section 2.2.6, respectively. The outcome of this assessment is summarized in Table 2-13. Alternatives A3, A5, and A6 are not applicable to metals. Alternative A1 does not meet threshold requirements so is not included in the following comparative analysis.

There are four metal-impacted near-surface soil AOCs at the Facility. Three of the areas contain arsenic at concentrations above SLs, and one contains lead at concentrations above SLs. Two of the arsenic areas are below existing pavement or building foundations, so only two AOCs are considered for treatment in Alternatives A2 and A4. One AOC is in the FCT area and is impacted by arsenic. The total footprint of this AOC is approximately 8,800 sq ft, and the mass of arsenic present is approximately 140 pounds. The other AOC is impacted by lead and is in the Man-Made Depressions area near the ORB Building. The footprint of this AOC is approximately 2,700 sq ft, and the total mass of lead is approximately 3,200 pounds. This is one of the areas identified in the HHERA as posing a human health risk above the benchmark level for protection of adult humans based on the adult lead model.

The relative capability of Alternatives A2 and A4 to meet threshold requirements, an assessment of whether they use permanent solutions to the maximum practicable extent (disproportionate cost analysis), and an assessment of whether the restoration time frames they achieve are reasonable are presented below as applicable to metal-impacted near-surface soil AOCs.

2.3.5.1 Threshold Requirements

Threshold requirements required for cleanup actions are defined in WAC 173-340-360(2). Requirements include protection of human health and the environment, compliance with MTCA cleanup standards and applicable state and federal laws, and provisions for compliance monitoring.

Protect Human Health and the Environment

Alternatives A2 and A4 each include physical and administrative controls and BMPs that will be used to reduce the potential for worker exposure to metals and to reduce the potential for metals in near-surface soil to migrate to groundwater. As mentioned above, the lead-impacted area in the Man-Made Depressions area has been identified as posing a human health risk based on the HHERA.

Approximately 50 percent of the metal AOCs present at the Facility are currently located under pavement or floor slabs. The pavement and floor slabs prevent Facility workers and visitors from direct contact with and/or ingestion of metals and prevent rainwater from conveying metals from near-surface soil to groundwater.

Alternative A2 includes additional containment surfaces for metal AOCs that are not paved; thus, this alternative cuts the existing direct contact pathway between Facility workers and visitors and near-surface soil and reduces the potential for metals in near-surface soil to migrate to groundwater and potentially to the Spokane River. This eliminates the risk posed to receptors by the metals present in near-surface soil AOCs at the Facility.

Alternative A4 will permanently remove metals present in the near-surface soil that is excavated and disposed of at a lined and permitted landfill. Thus, A4 will reduce the volume of contaminants present in the AOCs and will reduce the mobility of the metals by placing them in a lined landfill. Alternative A4b adds containment to the AOCs where COCs at concentrations above SLs are expected to remain in vadose zone soil (refer to Section 3.1.2). However, accessible metal-impacted soil is not located above impacted deep vadose zone soil. Alternative A4 is expected to remove and contain approximately 3,400 pounds of metals (arsenic and lead). Since impacted soil will be removed from the Facility and contained in a permitted landfill, Alternative A4 is judged to be more protective than Alternative A2.

Since Alternatives A2 and A4 will block the existing direct contact pathway between Facility workers and visitors and near-surface soil, and reduce the potential for metals in near-surface soil to migrate to groundwater and potentially to the Spokane River, they provide the same degree of risk reduction to existing and potential receptors.

Comply with MTCA Cleanup Standards

Alternatives A2 and A4 will provide human health and environmental protection by breaking the direct contact and ingestion exposure pathways and preventing rainwater from conveying metals from near-surface soil to groundwater. Alternatives A2 and A4 both will provide human health protection for the lead-impacted AOC in the Man Made Depressions area identified as posing a human health concern in the HHERA (Pioneer 2012).

Both Alternatives A2 and A4 meet MTCA requirements. Alternative A2 is deemed to meet SLs since it meets the requirements of WAC 173-340-740(6)(f). Since Alternative A4 will remove and contain metal-impacted soil in a lined landfill, it will meet the SLs that have been established for metals in near-surface soil at the Facility.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A2 or A4. The identified action-specific ARARs for Alternatives A2 and A4 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.

2.3.5.2 Disproportionate Cost Analysis

Alternatives A2 and A4 meet the threshold requirements established by MTCA. This disproportionate cost analysis compares these alternatives to identify the alternative that uses permanent solutions to the maximum extent practicable. Alternative A1 does not meet threshold requirements and will not be assessed in this disproportionate cost analysis.

Protectiveness

Alternatives A2 and A4 each provide physical and administrative controls and BMPs that will be used to reduce the potential for Facility worker and visitor exposure to metals and to reduce the potential for metals in near-surface soil to migrate to groundwater.

Alternative A2 uses containment surfaces that will cut the current Facility worker and visitor direct contact and ingestion pathways that were identified in the HHERA (Pioneer 2012), thereby eliminating the risk posed by metals to human health. The containment surfaces will prevent rainwater from conveying metals from near-surface soil to groundwater.

Since Alternatives A2 and A4 will cut the existing direct contact pathway between Facility workers and visitors and near-surface soil, and reduce the potential for metals in near-surface soil to migrate to groundwater and potentially to the Spokane River, they provide the same degree of risk reduction to existing and potential receptors.

Only Alternative A4 will permanently reduce the mobility and volume of metals in near-surface soil. Alternative A4 is expected to remove approximately 3,400 pounds of metals and will dispose of the metals in a lined landfill. Alternative A4 is thus judged to be more protective than Alternative A2.

Permanence

Alternatives A2 and A4 each provide physical and administrative controls and BMPs that will be used to reduce the potential for Facility worker and visitor exposure to metals and to reduce the potential for metals in near-surface soil to migrate to groundwater.

Alternatives A2 and A4 will eliminate the risk to Facility workers and the public because of the potential for direct contact or ingestion of contaminated near-surface soil. Alternative A4 is expected to remove and contain approximately 3,400 pounds of metals in the AOCs that will be excavated. The metals will be removed in approximately 1 year. Alternative A4 provides a higher degree of permanence than Alternative A2 since Alternative A4 removes metals from the Facility and contains them in a permitted landfill.

Cost

The NPV of implementing Alternative A2 over 30 years is estimated to total approximately $15.8 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Sections 2.1.1 and 2.1.2 above and listed in the cost tables contained in Appendix A. The mass of metal (arsenic and lead) that will be capped or removed is approximately 3,400 pounds. Based on these values, the total cost of capping per pound of metal in Alternative A2 is approximately $4,600.

The NPV of implementing Alternative A4a and A4b is approximately $18.7 million and $20.9 million (-35 to +50 percent), respectively. The assumptions used to prepare this estimate are described in Section 2.1.4 above and listed in the cost tables contained in Appendix A. Alternative A4b includes capping of near-surface soil AOCs that are located above contaminated deep vadose zone soil. However, no additional capping for metal-impacted soil is needed since deep vadose zone soil located below these near-surface soil AOCs is not contaminated. The total cost of implementing Alternative A4a per pound of metal is approximately $5,500 (Alternative A4b costs approximately $6,100 per pound of metal).

Effectiveness over the Long Term

Alternative A2 will use institutional controls and containment to help protect Facility works and visitors from direct contact with metals. Concentrations of metals will not decrease over time. The paving surfaces employed by the alternative have been successfully implemented at Kaiser and other locations. Pavement will also prevent rainwater from conveying metals to groundwater.

Capping will not generate significant treatment residues or waste materials. Surface water runoff from the containment surfaces will be collected directed to soil areas that are not contaminated for infiltration or conveyed to the Kaiser WWT facility for treatment.

Alternative A4 will remove metal-impacted soil from the Facility and place it in an engineered, lined, and monitored landfill. Metals will be removed from the Facility in a short time frame (about 1 year). Removal protects Facility workers and visitors from direct contact with metals and prevents rainwater from conveying metals to groundwater. The technologies employed by this alternative have been successfully implemented at Kaiser and other locations. Excavation and off-site disposal via Alternative A4 is judged to be more effective over the long term than Alternative A2.

Management of Short-Term Risks

For both Alternatives A2 and A4, short-term risks to construction workers during the installation and/or execution of the alternative will be mitigated by their adherence to the HASP. The procedures contained in the HASP have been shown to effectively manage the limited risk associated with these activities.

Additional human health and environmental risks are associated Alternative A4 with the transport of the material from the Kaiser Facility to the landfill for disposal. Transport containers will be covered and appropriate measures will be taken to reduce risk to the communities that they travel through. Only properly licensed material haulers will be used. Material left on site (greater than 2 inches in diameter) is assumed to pose little risk to human health and the environment, since the contamination in soil at the site is associated with the finer grained material. Alternative A4 has a greater level of short-term risk than Alternative A2 because of the higher level of technical complexity of the alternative.

Technical and Administrative Implementability

BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces for Alternative A2 is a routine activity and has been employed at the Facility for many years.

Technical expertise will be required to coordinate, execute, and engineer the excavation and off-site disposal in Alternative A4. Management of soil at the landfill facility will require administrative support for tasks such as permitting, profiling, and monitoring. Alternative A4 is technically and administratively less implementable than Alternative A2.

Summary of Disproportionate Cost Analysis

Both Alternatives A2 and A4 meet the threshold requirements established by WAC 173-340-360(2)(a). They each include physical and administrative controls and BMPs that will be used to reduce the potential for Facility worker and visitor exposure to arsenic and lead, and to reduce the potential for metals in near-surface soil to migrate to groundwater. Alternatives A2 and A4 provide the same amount of risk reduction to human and ecological receptors.

Alternatives A2 and A4 will cut the current Facility worker and visitor direct contact and ingestion pathway of the lead-impacted AOC in the Man Made Depressions area that was identified as posing a human health risk in the HHERA (Pioneer 2012). Both alternatives will prevent rainwater from conveying metals from near-surface soil to groundwater by capping or excavation. For both alternatives, the reduction in current risk is expected to occur within about 1 year. However, since metal-impacted soil will be removed from the Facility and contained in a permitted landfill, Alternative A4 is judged to be more protective than Alternative A2. This additional protection comes at a cost of approximately $5.1 million.

Cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements defined in WAC 173-340-740(6)(f) are met. Both Alternatives A2 and A4 meet these requirements.

Excavation and off-site disposal of soil offers a higher degree of permanence and long-term effectiveness than Alternative A2. Only Alternative A4 permanently reduces the mass and volume of metals in near-surface soil at the Facility. Alternative A4 is expected to remove and contains approximately 3,400 pounds of arsenic and lead in approximately one year.

Due to the higher degree of complexity in Alternative A4, this alternative has greater short-term risks and is technically and administratively less implementable than Alternative A2. The greater level of permanence and long-term effectiveness provided by the removal and disposal of an estimated 3,400 pounds of metals in Alternative A4a is estimated to cost approximately $5,500 per pound of metal excavated and disposed of. Because metal-impacted soil does not exist below the near-surface soil AOCs that would be excavated, the capping provided in Alternative A4b would not be necessary, and thus Alternative A4b is not applicable to the metal-impacted AOCs.

The additional permanence and long-term effectiveness provided by Alternative A4 comes with an additional cost of approximately $5.1 million compared to the estimated cost of Alternative A2, to remove and contain about 3,400 pounds of metals. Since this substantial additional cost does not provide any additional risk reduction to current or potential future receptors on the Kaiser property or to users of the Spokane River than does Alternative A2, the costs are judged to be disproportionate to the additional benefits provided by this alternative. Thus, Alternative A2 is judged to be the alternative that uses permanent solutions to the maximum extent practicable for near-surface soil containing metals at concentrations above SLs.

2.3.5.3 Restoration Time Frame for Metals

Remedial alternatives must provide for a reasonable restoration time frame per WAC 173-340-360(2)(b)(ii). A number of factors are considered to determine whether an alternative provides for a reasonable restoration time frame (WAC 173-340-360[4][b]), which are assessed for the near-surface soil remedial alternatives individually in Section 2.2. This section compares the restoration time frames potentially achieved by the alternatives for metals in near-surface soil AOCs.

The containment cap in Alternative A2 can be installed within approximately 1 year; however, concentrations of metals will not decrease over time and will remain in soil in perpetuity. Soil under the containment surfaces may be determined to comply with cleanup standards after the containment surfaces are in place if the requirements under WAC 173-340-740(6)(f) are met. Alternative A2 met these requirements.

Alternative A4 offers a restoration time frame similar to Alternative A2. Excavation activities are expected to take approximately 1 year, and excavated soil will be transported off site to be contained in a permitted landfill facility.

Alternatives A2 and A4 are judged to have a shorter restoration time frame than Alternative A1. The restoration time frames for Alternatives A2 and A4 are judged to be reasonable based on the assessment conducted per WAC 173-340-360(4), which is described in Section 2.2.1.2.

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Table 2-1 - Soil Screening Level and Preliminary Cleanup Level Concentrations

COCs	Screening Level [a]		Preliminary Cleanup Level [b] Standard Point of Compliance [c]		Preliminary Cleanup Level [b] Conditional Point of Compliance [d]	
	Unsaturated Soil in mg/kg	Saturated Soil in mg/kg	Unsaturated Soil in mg/kg	Saturated Soil in mg/kg	Unsaturated Soil in mg/kg	Saturated Soil in mg/kg
Metals						
Arsenic	10.32	10.32	9	9	9	9
Chromium (III)	2,000 [e]	NA	NA	NA	NA	NA
Chromium (VI)	18 [f]	NA	NA	NA	NA	NA
Lead	1,000 [g]	NA	NA	NA	NA	NA
PCBs						
Total PCBs	0.272	0.014	3.97×10^{-4}, adjusted up to 0.01 (the MDL based on Method 8082) [h]	1.99×10^{-5}, adjusted up to 0.01 (the MDL based on Method 8082) [h]	1.36	0.068
PAHs						
cPAH - TEQ	0.233	0.012	0.054	0.003	1.16	0.06
TPH						
Gasoline/Stoddard Solvent	100 [g]	NA	< 100 [g]	NA	< 100 [g]	NA
Diesel	2,000	2,000	< 2,000	< 2,000	< 2,000	< 2,000
Heavy Oil	2,000	2,000	< 2,000	< 2,000	< 2,000	< 2,000
Total TPH [i]	(j)	(j)	2,000	2,000	2,000	2,000

Notes:
NA - Not applicable because not detected or detected at a frequency of less than 5 percent of samples analyzed.
(a) Soil screening level concentrations were developed in Table 1-2 of the FSTM.
(b) Preliminary cleanup levels (PCULs) were developed by Ecology (Ecology 2010a and 2010b).
(c) PCULs for PCBs and cPAHs for a standard point of compliance (POC) were developed to be protective of surface water. PCULs for a standard POC are presented in Table B of the Draft Cleanup Standards document (Ecology 2010a). The TPH PCUL for saturated soil was later revised, and lead was determined not to be an indicator chemical for unsaturated soil (Ecology 2010b).
(d) If a conditional POC is necessary and granted at the point where groundwater discharges into surface water, soil concentrations must be protective of surface water at or near the vicinity of the point of discharge and protective of groundwater (per drinking water standards) elsewhere throughout the site (Ecology 2010a).
(e) Basis for near-surface soil AOC boundaries for chromium.
(f) Basis for deep vadose zone soil AOC boundaries for chromium.
(g) COCs present in only isolated areas of the Facility: lead in the ORB Man-Made Depressions, and gasoline in Oil House, ORB, Truck Shop, and G-1 Transfer Line areas.
(h) Actual MDLs may be subject to modification based on further discussions (Ecology 2010a).
(i) Total TPH concentration is defined as the sum of gasoline-, diesel-, and heavy oil-range TPH concentrations (Ecology 2010a and 2010b).
(j) Total TPH concentration not considered in development of screening levels (SLs).

Table 2-2 - Environmental Upgrades at the Remelt/Hot Line Area Casting Complexes

Activity	Casting Complexes							
	DC-1	DC-2	DC-3	DC-4	DC-5	DC-6	DC-7	DC-8
Replace Melter Furnace Door Jambs with Waterless Jambs	TBD	DC-2E Complete DC-2W TBD	TBD	Complete	Complete	Complete	Complete	TBD
Reroute Existing Door Jamb Drains to Pit	Complete	Complete	Complete	NA	NA	NA	NA	TBD
Verify Casting Pit Integrity	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
Eliminate Embedded Water Supply Piping	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
Contain Hydraulics/Lubrication	Complete	TBD	Complete	Complete	Complete	Complete	Complete	Complete
Route Overflow Lines to Sewer	Complete	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Seal DC-7/DC-8 Control House Sump	NA	NA	NA	NA	NA	NA	85% Complete	

Activity	Sewer Segments				
	MH 3B to MH 3	MH 2 to MH 3	MH 9 to MH 3	MH 7B to MH 9	MH 3 to MH 4
Slip Line Sewer Piping	Complete	TBD	TBD	Complete	TBD

Sewer Segment	Location Description
MH 2 to MH 3	Column Line Ux collector to DC-8/DC-7 Control Room.
MH 3B to MH 3	West of DC-8 to DC-8/DC-7 Control Room.
MH 7B to MH 9	East of DC-1 to DC-4.
MH 9 to MH 3	DC-4 to DC-8/DC-7 Control Room.
MH 3 to MH 4	DC-8/DC-7 to South of Casting.

Notes:
Table information provided by Kaiser, April 21, 2010, and May 23, 2011 Table information last updated May 23, 2011.
MH - Manhole.
NA - Not applicable.
TBD - Schedule to be determined.

Table 2-3 – Summary of Monitoring Requirements for Remedial Alternative A1: Institutional Controls, Monitoring, and MNA

Locations and Quantity (N) [a]	Medium	Frequency	Parameters (methods)	Comment	Evaluation Criteria
Compliance Monitoring Plan					
Protection monitoring wells N = 19	Groundwater	Semi-annual or quarterly	Field parameters [b] TPH (EPA Method 8015 modified) TPH-G, TPH-Dx (Ecology methods) VOCs (EPA Method 8260) PAHs (EPA Method 8270-SIM) Ultra-low-level PCBs (EPA Method 8082) TSS (EPA Method 160.2) Chloride, nitrate, nitrite (EPA Method 300.0) Antimony, arsenic, iron, manganese, chromium (filtered, EPA Method 200.8, iron by 200.7)	See Sampling and Analysis Plan (SAP) (Hart Crowser 2007a) for additional details. Frequency and parameters are location dependent.	See SAP.
Performance monitoring wells N = 95	Groundwater	Semi-annual or quarterly	Same as for protection monitoring.	See SAP for additional details. Frequency and parameters are location dependent.	See SAP.
Monitored Natural Attenuation Monitoring Plan					
Performance monitoring	Soil	Every 5 years	TPH-G, TPH-Dx (Ecology methods) PAHs (EPA Method 8270-SIM)		TBD
Institutional Controls Monitoring Plans					
Facility Final Outfall 001	Water	Weekly or continuous	Flow rate, pH, temperature Oil and grease Visible sheen TSS Total metals (aluminum, chromium, recoverable zinc) Total phosphorous Cyanide Hardness	Required by NPDES permit (Ecology 1997). Refer to permit for details.	See NPDES permit.

Table 2-3 – Summary of Monitoring Requirements for Remedial Alternative A1: Institutional Controls, Monitoring, and MNA

Locations and Quantity (N) [a]	Medium	Frequency	Parameters (methods)	Comment	Evaluation Criteria
Facility Final Outfall 001	Water	Quarterly for one year	Acute toxicity: (1) Fathead minnow (method per EPA/600/4-90/027F); and (2) Daphnid (method per EPA/600/4-90/027F). Chronic toxicity: (1) Fathead minnow (method per EPA/600/4-91/002); and (2) Water flea (method per EPA/600/4-91/002).	Required by NPDES permit. Refer to permit for details.	See NPDES permit.
Facility Final Outfall 001	Water	Biweekly	PCBs	Required by Agreed Order No. 02WQER-3487 (Ecology 2002).	See Agreed Order.
Facility Internal Outfall 002	Water	Weekly or continuous	Flow rate Oil and grease TSS Orthophosphate (filtered) Total phosphorous Total metals (aluminum, chromium, zinc) Hexavalent chromium Cyanide	Required by NPDES permit. Refer to permit for details.	See NPDES permit.
Facility Internal Outfall 003	Water	Weekly or continuous	Flow rate BOD_5 TSS Fecal coliform pH	Required by NPDES permit. Refer to permit for details.	See NPDES permit.
Facility Plant Intake	Water	Weekly	Oil and grease TSS Total aluminum Total recoverable zinc Total chromium	Required by NPDES permit. Refer to permit for details.	See NPDES permit.

Table 2-3 – Summary of Monitoring Requirements for Remedial Alternative A1: Institutional Controls, Monitoring, and MNA

Locations and Quantity (N) [a]	Medium	Frequency	Parameters (methods)	Comment	Evaluation Criteria
Facility Plant Lagoon Effluent (BWSF Influent)	Water	Biweekly	Low-level PCBs (EPA Method 8082)	Required by Amended Order No. 2868 (Ecology 2005).	Maximum 0.78 g/day PCB loading to BWSF system.
Facility Plant Lagoon Influent (Internal Outfalls 004 and 005)	Water	Biweekly	Low-level PCBs (EPA Method 8082)	Samples to be archived for a minimum of 30 days for potential later analysis in the event lagoon effluent PCB exceedance. Required by Amended Order No. 2868.	See Amended Order.
Facility Plant BWSF System	Water	Daily	Flow rate	Required by Amended Order No. 2868.	See Amended Order.
See Kaiser Stormwater Pollution Prevention Plan (SWPPP)	Stormwater discharges (see NPDES permit), Facility pollutant controls	Annual	Compliance with SWPPP and NPDES permit requirements.	Required by NPDES permit. Refer to SWPPP for details.	See SWPPP.
West Discharge Ravine (WDR)	Planted native trees, shrubs, live stakes, and invasive plants	Annual for 3 years	Plant survival Areal coverage of plants Invasive plant areal coverage	See WDR Restoration Monitoring Plan (Hart Crowser 2007b).	After 3 years: (1) Minimum plant survival = 80% (2) Minimum plant areal coverage = 80% (3) Invasive plant areal coverage < 10%
See Table 2-4	Facility pavement above AOCs	Annual	Visual signs of deterioration (e.g., abrasion, cracking, chemical deterioration, subsidence) to be recorded.	Pavement and cap integrity criteria (e.g., abrasion) will be defined.	TBD

Table 2-3 – Summary of Monitoring Requirements for Remedial Alternative A1: Institutional Controls, Monitoring, and MNA

Locations and Quantity (N) [a]	Medium	Frequency	Parameters (methods)	Comment	Evaluation Criteria
Throughout Facility	Physical measures	Ongoing	Visual signs of potential failure of control.	Includes Facility fences, gates, signs, access controls.	TBD
Throughout Facility	Storage tanks, loading/unloading areas, transfer piping, secondary containment, valve structures, pumping equipment, oil/water separation equipment	Quarterly	Visual signs of leaks, damage, deterioration, corrosion, or other evidence of potential failure.	See Spill Prevention Control and Countermeasure (SPCC) Plan (GeoEngineers 2008).	TBD

Notes:

This table presents an overview of monitoring requirements. Refer to the description of the remedial alternative for more details.

The components that will be implemented depend on the alternative selected.

(a) "N" does not include quality assurance/quality control (QA/QC) samples, which will also be analyzed.

(b) Field parameters include groundwater elevation, turbidity, pH, conductivity, dissolved oxygen (DO), oxidation-reduction (redox) potential, and temperature.

BWSF - Black walnut shell filter.

NA - Not applicable.

PAHs - Polycyclic aromatic hydrocarbons.

PCBs - Polychlorinated biphenyls.

TBD - To be determined.

TPH-Dx - Diesel- and oil-range petroleum hydrocarbons.

TPH-G - Gasoline-range petroleum hydrocarbons.

TSS - Total suspended solids.

VOCs - Volatile organic compounds.

Table 2-4 – Summary of Monitoring Requirements for Remedial Alternative A2: Institutional Controls, Monitoring, MNA, and Containment

Locations	Medium	Frequency	Parameters (methods)	Comment	Evaluation Criteria
Construction Quality Assurance Plan (CQAP)					
Asphalt and concrete caps	Cap construction materials	Variable, as needed upon material delivery and preparation	Material quality Asphalt or concrete mixing per specification Asphalt temperature Asphalt extraction and gradation	Check that parameters meet or exceed specified requirements.	NA
	Subgrade	Regularly during work day	Grading Slope Compaction	Check that parameters meet or exceed requirements for overlying cap.	NA
	Cap material placement and compaction	Regularly during work day	Lift thickness Compaction Post-compaction, in-place density and air voids Joint construction and sealing	Check that parameters meet or exceed specified requirements.	NA
	Completed asphalt or concrete surface	Once (after construction completion)	Permeability (ASTM Method D 5084)		NA
Multi-layer caps	Cap construction materials	Variable, as needed upon material delivery and preparation	Check topsoil, drainage layer sand, liner quality. Confirm that liner material is of correct thickness and is undamaged.	Check that parameters meet or exceed specified requirements.	NA
	Subgrade	Regularly during work day	Grading Slope Compaction Subgrade surface	Check grading and slope are per specification, and that subgrade compaction provides required hydraulic conductivity. Subgrade surface should be amenable to liner installation (no depressions or jagged surfaces that could puncture or tear liner during installation of overlying layers).	NA

Table 2-4 – Summary of Monitoring Requirements for Remedial Alternative A2: Institutional Controls, Monitoring, MNA, and Containment

Locations	Medium	Frequency	Parameters (methods)	Comment	Evaluation Criteria
	Cap material placement and compaction	Regularly during work day	Liner and seams	Check for liner damage during installation and that liner seams are properly sealed.	NA
Health and Safety Plan (HASP)					
Air Monitoring	Air	Daily	Benzene (Colorimetric Tubes)	Air monitoring takes place during ground-disturbing activities in VOC-impacted areas, as required by the HASP.	NA
Operation, Maintenance, and Monitoring Plans					
Cap integrity long-term monitoring	Asphalt, concrete, and multi-layer caps	Annual	Visual signs of deterioration (e.g., abrasion, cracking, chemical deterioration, settlement, and subsidence) to be recorded. Core samples of asphalt and concrete caps to be collected for analysis of permeability (ASTM Method D 5084).	Cap integrity criteria (e.g., abrasion) will be defined. Sampling and analysis protocol will be defined in the Sampling and Analysis Plan (SAP).	NA

Notes:

This table presents an overview of monitoring requirements. Refer to the description of the remedial alternative for more details.

The monitoring requirements for Alternative A2 include the monitoring elements for Alternative A1 (see Table 2-3).

The components that will be implemented depend on the alternative selected.

NA - Not applicable.

Table 2-5 – Summary of Monitoring Requirements for Remedial Alternative A3: SVE with Off-Gas Treatment for Near-Surface Soil [a]

Locations	Medium	Frequency	Parameters (methods)	Equipment	Comment	Evaluation Criteria
Installation						
Ambient air	Air	Daily	VOCs	Multirae	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD
Ambient air	Air	Daily	Dust generation from visual observation	NA	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD
Startup						
Air monitoring along treatment train	Air	Weekly	Benzene and/or toluene	Colorimetric tubes	As required by the SVE O&M Plan	Air quality permit limits
SVE wellhead	Air	Daily	Pressure	Pressure gage	As required by the SVE O&M Plan	TBD
SVE system manifold	Air	Daily	Air flow rate	Rotameter	As required by the SVE O&M Plan	TBD
Containment surfaces	Sealed asphalt surface.	Daily	Visual signs of deterioration (e.g., abrasion, cracking, chemical deterioration, subsidence) to be recorded.	NA	As required by the SVE O&M Plan	As required by Cap Integrity Plan as described in Alternative A2

Table 2-5 – Summary of Monitoring Requirements for Remedial Alternative A3: SVE with Off-Gas Treatment for Near-Surface Soil [a]

Locations	Medium	Frequency	Parameters (methods)	Equipment	Comment	Evaluation Criteria
Annual O&M						
Air monitoring of carbon effluent	Air	Quarterly	Benzene and/or toluene	Summa canister	Ensure discharge air meets permitting requirements	Air quality permit limits
Air monitoring along treatment train	Air	Monthly	Benzene and/or toluene	Colorimetric tubes	As required by the SVE O&M Plan	Air quality permit limits
SVE wellhead	Air	Monthly	PSI	Pressure gage	As required by the SVE O&M Plan	As required by O&M Plan
SVE system manifold	Air	Monthly	SCFM	Rotatmeter	As required by the SVE O&M Plan	As required by O&M Plan
Cap integrity	Sealed asphalt surface.	Annual	Visual signs of deterioration (e.g., abrasion, cracking, chemical deterioration, subsidence) to be recorded.	NA	As required by the SVE O&M Plan	As required by Cap Integrity Plan as described in Alternative A2
End of Treatment						
Blower suction	Air	Weekly	Benzene and/or Toluene	Summa canister	To confirm point of diminishing returns has been reached. Assume 3 samples collected.	NA
Soil sampling	Soil	At end of treatment	Gasoline or Stoddard solvent, SVOCs	Sampling jars	Ecology guidance document used to determine sampling schedule – 13 borings. Two samples collected from each boring.	100 mg/kg for Stoddard and gasoline

Table 2-5 – Summary of Monitoring Requirements for Remedial Alternative A3: SVE with Off-Gas Treatment for Near-Surface Soil [a]

Locations	Medium	Frequency	Parameters (methods)	Equipment	Comment	Evaluation Criteria
Long-Term Monitoring						
Containment surfaces	Sealed asphalt surface.	Annual	Visual signs of deterioration (e.g., abrasion, cracking, chemical deterioration, subsidence) to be recorded.	NA	Cap integrity criteria (e.g., abrasion) will be defined.	NA

Notes:

(a) This table presents an overview of monitoring requirements for the SVE portion of Alternative A3. Refer to Tables 2-3 and 2-4 for Alternatives A1 and A2.

NA - Not applicable.

TBD - To be determined.

Table 2-6 – Summary of Monitoring Requirements for Remedial Alternative A4: Excavation and Off-Site Disposal [a]

Locations	Medium	Frequency	Parameters	Comment	Evaluation Criteria
Protection Monitoring					
Dust monitoring	Air	Daily	Visual inspection of dust generation.	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD in HASP
Mechanical screening area	Soil	As needed	TPH, PAHs, PCBs, metals	Sample soil below liner if breach is observed to confirm that the contaminants did not migrate to the soil below the liner.	See Table 2-1
Performance Monitoring					
Mechanical screening area	NA	Daily	Visual inspection of particle sizes in screened stockpiles, visual inspections of liner.	Visual inspections to ensure that screening operations are performing correctly and that the liner remains intact.	TBD in Screening Plant O&M Plan
Confirmational Monitoring					
Excavation footprints	Soil	During remedial action	TPH, PAHs, PCBs, metals	Parameters will be chosen based on COCs present in specific AOCs.	See Table 2-1

Notes:

(a) Monitoring requirements for elements unique to A4 only; see Table 2-3 and 2-4 for monitoring requirements for Alternatives A1 and A2.

NA - Not applicable.

TBD - To be determined.

Table 2-7 – Summary of Monitoring Requirements for Remedial Alternative A5a: Excavation and On-Site Biotreatment [a]

Locations	Medium	Frequency	Parameters	Comment	Evaluation Criteria
Protection Monitoring					
Dust monitoring	Air	Daily	Visual inspection of dust generation.	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD in HASP
Mechanical screening area	Soil	As needed	TPH, PAHs	Sample soil below liner if breach is observed to confirm that the contaminants did not migrate to the soil below the liner.	See Table 2-1
Leachate collection	Water	Prior to discharging water from tanks	Phosphorus	The Spokane River has a TMDL for phosphorus. Phosphorus will be added to landfarm to promote biological activity and leachate will be tested prior to discharge.	Spokane River TMDL
Performance Monitoring					
Mechanical screening area	NA	Daily	Visual inspection of particle sizes in screened stockpiles, visual inspections of liner.	Visual inspections to ensure that screening operations are performed correctly and that the liner remains intact.	TBD in Screening Plant O&M Plan
Landfarm sampling	Soil	Quarterly	TPH, PAHs, water content, nutrients, pH, respiration test	Sample soil in landfarm to determine whether biodegradation is occurring (i.e., a decrease in TPH concentration) and whether adjustments needed to nutrients, pH, water content.	TBD in Landfarm O&M Plan
Confirmational Monitoring					
Excavation footprints	Soil	During remedial action	TPH, PAHs	Parameters will be chosen based on COCs present in specific AOCs.	See Table 2-1
Landfarm sampling	Soil	After remedial objectives achieved	TPH, PAHs	Parameters will be chosen based on COCs present in specific AOCs.	See Table 2-1

Notes:

(a) Monitoring requirements for elements unique to A5a only; see Table 2-3 and 2-4 for monitoring requirements for Alternative A1 and A2.

NA - Not applicable.

Table 2-8 – Summary of Monitoring Requirements for Remedial Alternative A5b: Excavation and On-Site Thermal Desorption [a]

Locations	Medium	Frequency	Parameters	Comment	Evaluation Criteria
Protection Monitoring					
Dust monitoring	Air	Daily	Visual inspection of dust generation.	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD in HASP
Mechanical screening area	Soil	As needed	TPH, PAHs	Sample soil below liner if breach is observed to confirm that the contaminants did not migrate to the soil below the liner.	See Table 2-1
Performance Monitoring					
Mechanical screening area	NA	Daily	Visual inspection of particle sizes in screened stockpiles, visual inspections of liner.	Visual inspections to ensure that screening operations are performed correctly and that the liner remains intact.	TBD in Screening Plant O&M Plan
Treated soil stockpile sampling	Soil	Every 2,000 cubic yards of treated soil	TPH, PAHs	Sample thermally treated soil to determine whether thermal treatment is working correctly.	See Table 2-1
Thermal treatment unit emissions	Air	Daily	TPH, PAHs, CO, particulates	Sample emissions from thermal unit to determine whether the afterburner is working properly.	TBD in Thermal Desorber O&M Plan
Confirmational Monitoring					
Excavation footprints	Soil	During remedial action	TPH, PAHs	Parameters will be chosen based on COCs present in specific AOCs.	See Table 2-1
Treated soil stockpile sampling	Soil	After remedial objectives achieved	TPH, PAHs	Parameters will be chosen based on COCs present in specific AOCs.	See Table 2-1

Notes:

(a) Monitoring requirements for elements unique to A5b only; see Table 2-3 and 2-4 for monitoring requirements for Alternative A1 and A2.

NA - Not applicable.

Table 2-9 – Summary of Monitoring Requirements for Remedial Alternative A6: Excavation and Off-Site Incineration [a]

Locations	Medium	Frequency	Parameters	Comment	Evaluation Criteria
Protection Monitoring					
Dust monitoring	Air	Daily	Visual inspection of dust generation.	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD in HASP
Mechanical screening area	Soil	As needed	TPH, PAHs, PCBs, metals	Sample soil below liner if breach is observed to confirm that the contaminants did not migrate to the soil below the liner.	See Table 2-1
Performance Monitoring					
Mechanical screening area	NA	Daily	Visual inspection of particle sizes in screened stockpiles, visual inspections of liner.	Visual inspections to ensure that screening operations are performed correctly and that the liner remains intact.	TBD in Screening Plant O&M Plan
Confirmational Monitoring					
Excavation footprints	Soil	During remedial action	TPH, PAHs, PCBs, metals	Parameters will be chosen based on COCs present in specific AOCs.	See Table 2-1

Notes:

(a) Monitoring requirements for elements unique to A6 only; see Table 2-3 and 2-4 for monitoring requirements for Alternative A1 and A2.

NA - Not applicable.

Table 2-10 - Summary of Detailed Analysis of Alternatives Applicable to VOCs in Near-Surface Soil at the Kaiser Facility

	Criteria	Alternative A1 Institutional Controls, Monitoring, and MNA	Alternative A2 Alternative A1 Plus Containment	Alternative A3 Alternative A2 Plus SVE
Threshold Requirements	Overall Protection of Human Health and the Environment	Does not directly reduce the concentration of VOCs in near-surface soil to below SLs. Some natural attenuation of VOCs may occur; however, this process will require a long time to reduce VOC concentrations to SLs. Does not address the human health direct contact and ingestion pathways at the Facility. Does not address the soil to groundwater pathway that could potentially transfer VOCs to human receptors in groundwater or the Spokane River. Provides less overall protection to the environment than Alternative A2 or A3.	Physical and administrative controls, BMPs, and containment are used to reduce the potential for worker exposure to VOCs and reduce the potential for VOCs in near-surface soil to migrate to groundwater and potentially to receptors in groundwater or the Spokane River. Removes the human health direct contact and ingestion pathways. Short-term risks are manageable. More protective than Alternative A1.	Alternative A3 eliminates the risk associated with the direct contact of Facility workers and the public to VOCs in near-surface soil in the VOC AOCs by removing VOCs and installing a containment surface. Alternative A3 removes and destroys approximately 410 pounds of VOCs in the AOCs that are treated. The VOCs will be removed in a relatively short time (about 4 years). Will reduce the future transport of VOCs from near-surface soil to groundwater and potentially to the receptors in groundwater or the Spokane River. The technologies employed by this alternative have been successfully implemented at other sites, but bench- and pilot-scale tests may be needed to prove their suitability at the Facility. Short-term risks are manageable. Alternative A3 is more permanent and provides a greater degree of protection than Alternative A2.
	Comply with Cleanup Standards	The concentration of VOCs will naturally attenuate; however, the attenuation process is slow and will require a long time to reach SLs. Does not address the human health direct contact and ingestion pathways at the Facility. Does not address the soil to groundwater pathway that could potentially transfer VOCs to human receptors in groundwater or the Spokane River. Does not meet existing MTCA threshold requirements.	Cuts the human health direct contact and ingestion pathways that were identified in the HHERA (Pioneer 2012), and eliminates the risk posed by the VOCs to Facility workers and visitors. The containment surfaces prevent rainwater from conveying VOCs from near-surface soil to groundwater and potentially to receptors in groundwater or the Spokane River. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. Judged to meet MTCA requirements for near-surface soil (alone) and for groundwater and surface water when combined with the alternatives selected in Sections 3 through 5.	SVE treatment is expected to reduce the concentration of VOCs in the four AOCs to concentrations below SLs. The containment surfaces prevent rainwater from conveying VOCs from near-surface soil to groundwater and potentially to receptors in groundwater or the Spokane River. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. Judged to meet MTCA requirements for near-surface soil (alone) and for groundwater and surface water when combined with the alternatives selected in Sections 3 through 5.
	Comply with Applicable State and Federal Laws	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No action- or location-specific ARARs have been identified for near-surface soil at the Facility that are judged to be applicable to Alternative A1 (see Appendix G).	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A2. The identified action-specific ARARs for Alternative A2 consist of requirements associated with implementation of the alternative (see Appendix G). These ARARS are judged to be attainable and do not affect the alternative selection process.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A3. The identified action-specific ARARs for Alternative A3 consist of requirements associated with implementation of the alternative (see Appendix G). These ARARS are judged to be attainable and do not affect the alternative selection process.
	Provide for Compliance Monitoring	Alternative A1 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative A2 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative A3 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.
Disproportionate Cost Analysis	Protectiveness	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.
	Permanence	BMPs will reduce the release of hazardous substances to the environment. Access controls reduce the opportunity for Facility visitors to contact VOCs in near-surface soil. Existing paved surfaces (floor slabs, roads) also prevent direct contact with VOCs in near-surface soil. Does not actively reduce the toxicity, mobility, or volume of VOCs present in near-surface soil; however, natural attenuation of VOCs will continue, but this process will require a long time to reduce VOC concentrations to SLs. Less permanent than Alternatives A2 and A3.	BMPs will reduce the release of hazardous substances to the environment. Access controls reduce the opportunity for Facility visitors to contact VOCs in near-surface soil. Existing paved surfaces also prevent direct contact with VOCs in near-surface soil. Does not actively treat the soil within the VOC AOCs; however, natural attenuation of VOCs will continue, but this process will require a long time to reduce VOC concentrations to SLs. Provides a lower degree of permanence than is provided by Alternative A3 since Alternative A3 removes and destroys VOCs.	The BMPs in place at the Facility will reduce the release of hazardous substances to the environment. Access controls will reduce the opportunity for visitors to the Facility to come in contact with the VOCs contained in near-surface soil. Alternative A3 will eliminate the risk to Facility workers and the public from the potential for direct contact or ingestion of contaminated near-surface soil. Expected to remove and destroy approximately 410 pounds of VOCs in the AOCs that are treated. The VOCs will be removed and destroyed in a relatively short time (about 4 years). Alternative A3 provides a higher degree of permanence than Alternative A2 since Alternative A3 removes and destroys VOCs. Alternative A3 is judged to be the most permanent treatment alternative for VOCs.

Table 2-10 - Summary of Detailed Analysis of Alternatives Applicable to VOCs in Near-Surface Soil at the Kaiser Facility

	Criteria	Alternative A1 Institutional Controls, Monitoring, and MNA	Alternative A2 Alternative A1 Plus Containment	Alternative A3 Alternative A2 Plus SVE
Disproportionate Cost Analysis	Effectiveness over the Long Term	The institutional controls, BMPs, monitoring, and MNA employed in this alternative are currently in use at the Kaiser Facility. Does not directly address the VOCs in near-surface soil. Natural attenuation processes at the Facility will continue, but VOC concentrations will not be reduced to below SLs within a reasonable time frame. Near-surface soil will continue to pose potential risks to human health and the environment. Much less effective over the long term than Alternatives A2 and A3.	The paving surfaces employed by this alternative have been successfully implemented at Kaiser and other locations. The existing pavement and floor slabs and new containment surfaces provided in Alternative A2 will protect Facility workers and visitors from direct contact with VOCs in these areas, and prevent rainwater from conveying VOCs to groundwater and potentially to the receptors in groundwater or the Spokane River. Does not generate treatment residues or waste materials. Surface water runoff from the containment surfaces will be collected and conveyed to uncontaminated areas to infiltrate or to the Kaiser WWT plant for treatment. Judged to be less effective over the long term than Alternative A3.	Will reduce the concentration of VOCs in near-surface soil in the four AOCs that would be treated to concentrations below SLs within a relatively short (about 4 years) time period. Protects Facility workers and visitors from direct contact with VOCs, and prevents rainwater from conveying COCs to groundwater and potentially to the receptors in groundwater or the Spokane River. Alternative A3 generates spent carbon that will be regenerated by experienced contractor. Surface water runoff from the containment surfaces will be collected and conveyed to uncontaminated areas to infiltrate or to the Kaiser WWT plant for treatment. The technologies employed by this alternative have been successfully implemented at other locations. Bench- and pilot-scale tests may be required to demonstrate their effectiveness at the Facility. Alternative A3 is expected to be more effective in the long term than Alternative A2.
Disproportionate Cost Analysis	Management of Short-Term Risks	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create any new or additional risk to human health and the environment.	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces will be mitigated by adherence to the health and safety plan (HASP). Alternative A2 has fewer short-term risks than Alternative A3.	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces will be mitigated by adherence to the HASP. Short-term risks to workers operating the SVE system will be mitigated by their adherence to the HASP. Only experienced contractors will handle, remove, and regenerate spent carbon. Alternative A3 is judged to have greater short-term risk than Alternative A2.
Disproportionate Cost Analysis	Technical and Administrative Implementability	The actions associated with Alternative A1 are already in place at the Kaiser Facility.	BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at Kaiser for many years. Alternative A2 is a less complex technical process and requires fewer environmental permits than Alternative A3.	BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at Kaiser for many years. SVE is a presumptive remedy for the removal of VOCs from soil and is considered to be an implementable conventional technology but requires technical expertise for design and execution. Management of spent carbon will require technical expertise and administrative support (profiling, coordinating with contractor). Alternative A3 is judged to have a greater level of technical complexity and more administrative requirements than Alternative A2.
Disproportionate Cost Analysis	Consideration of Public Concerns	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.
Disproportionate Cost Analysis	Conceptual-Level Cost (NPV -35/+50 percent)	$13.6 million	$15.8 million	$16.3 million
Disproportionate Cost Analysis	Total Cost per Pound of COC Treated or Contained	Not evaluated - baseline cost	$38,500/pound of VOC contained	$39,800/pound of VOC removed and destroyed
	Restoration Time Frame	Natural attenuation processes at the Facility will continue, but the time frame needed for recovery to occur will be long. The restoration time frame for Alternative A1 is judged to be unreasonable.	Does not directly reduce the toxicity, mobility, or volume of the VOCs contained in near-surface soil. Natural attenuation processes at the Facility will continue. The time frame needed for the concentration of VOCs in near-surface soil to fall below SLs will be long. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. Cap can be installed in a relatively short time frame (about 1 year). This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).	Natural attenuation processes at the Facility will continue. The risks to Facility workers and visitors from direct contact or ingestion of COCs will be eliminated once the containment surfaces have been installed. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. The containment surfaces can be installed in a relatively short time frame (about 1 year) which approximates the restoration time frame for this alternative. This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4). The concentration of VOCs in near-surface soil in the four AOCs that will be treated will be reduced to concentrations below SLs within a relatively short (about 4 years) time period.

Table 2-11 - Summary of Detailed Analysis of Alternatives Applicable to SVOCs in Near-Surface Soil at the Kaiser Facility

	Criteria	Alternative A1 Institutional Controls, Monitoring, and MNA	Alternative A2 Alternative A1 Plus Containment	Alternative A4 Alternative A1 or A2 Plus Excavation and Off-Site Disposal	Alternative A5 Alternative A1 or A2 Plus Excavation and On-Site Treatment	Alternative A6 Alternative A1 or A2 Plus Excavation and Off-Site Treatment (Incineration)
Threshold Requirements	Overall Protection of Human Health and the Environment	Does not directly reduce the concentration of SVOCs in near-surface soil to below SLs. Some natural attenuation of SVOCs may occur, although this process will require a long time to reduce SVOC concentrations to SLs. Does not address the soil to groundwater pathway. Provides less overall protection to the environment than other alternatives.	Eliminates the risk associated with the direct contact of Facility workers and visitors to SVOCs in AOCs that were identified in the Human Health and Ecological Risk Assessment (HHERA) (Pioneer 2012) as posing a direct contact or ingestion human health risk. Physical and administrative controls, BMPs, and containment are used to reduce the potential for worker exposure to SVOCs and reduce the potential for SVOCs in near-surface soil to migrate to groundwater. Short-term risks are manageable. More protective than Alternative A1.	Eliminates the risk associated with the direct contact of Facility workers and visitors to SVOCs in AOCs that were identified in the HHRA as posing a direct contact human health risk by disposing of the soil that can be excavated at a permitted and lined landfill. Will reduce the future transport of SVOCs from near-surface soil to the groundwater. Removes approximately 143,000 pounds of SVOCs in the AOCs. Does not directly destroy SVOCs, although natural attenuation processes will reduce remaining SVOC concentrations over a long time. The SVOCs will be removed via excavation in a relatively short time (about 1 year). The technologies employed by this alternative have been successfully implemented at other sites. Short-term risks are manageable. Is more permanent and provides a greater degree of protection than Alternative A2. Less protective than Alternatives A5 and A6.	Eliminates the risk associated with the direct contact of Facility workers and visitors to SVOCs in AOCs that were identified in the HHRA as posing a direct contact human health risk by excavating and treating the soil on site. Will reduce the future transport of SVOCs from near-surface soil to the groundwater. Removes approximately 143,000 pounds of SVOCs in the AOCs. Alternative A5 destroys approximately 135,000 pounds of SVOCs (assuming 95% destruction). The risk posed by SVOCs will be reduced in a relatively short time (about 1 to 2 years). The technologies employed by this alternative have been successfully demonstrated. Short-term risks are manageable. Is more permanent and provides a greater degree of protection than Alternatives A2 and A4. Less protective than Alternative A6.	Eliminates the risk associated with the direct contact of Facility workers and the public to SVOCs in AOCs that were identified in the HHRA as posing a direct contact human health risk, by excavating and treating the soil off site. Will reduce the future transport of SVOCs from near-surface soil to the groundwater. Removes and destroys approximately 143,000 pounds of SVOCs in the AOCs. The risk posed by SVOCs will be reduced in a relatively short time (about 1 year). The technologies employed by this alternative have been successfully demonstrated. Short-term risks are manageable. Alternative A6 is judged to be the most permanent alternative for SVOCs and provides more protection than Alternatives A1, A2, A4, and A5.
Threshold Requirements	Comply with Cleanup Standards	The concentration of VOCs will naturally attenuate; however, the attenuation process is slow and will require a long time to reach SLs. Does not address the human health direct contact and ingestion pathways at the Facility. Does not address the soil to groundwater pathway that could potentially transfer SVOCs to receptors in the Spokane River. Does not meet existing MTCA threshold requirements.	Cuts the human health direct contact and ingestion pathways that were identified in the HHERA, and eliminates the risk posed by the SVOCs to Facility workers and visitors. The containment surfaces prevent rainwater from conveying SVOCs from near-surface soil to groundwater. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. Judged to meet MTCA requirements for near-surface soil (alone) and for groundwater and surface water when combined with the alternatives selected in Sections 3 though 5.	Cuts the human health direct contact and ingestion pathways that were identified in the HHERA, and eliminates the risk posed by the SVOCs to Facility workers and visitors. Excavation and off-site disposal are expected to remove soil above SLs in the areas that are excavated. The containment surfaces added in Alternative A4b prevent rainwater from conveying SVOCs from deep vadose zone soil to groundwater. Judged to meet MTCA requirements for near-surface soil (alone) and for groundwater and surface water when combined with the alternatives selected in Sections 3 through 5.	Cuts the human health direct contact and ingestion pathways that were identified in the HHERA, and eliminates the risk posed by the SVOCs to Facility workers and visitors. Excavation and on-site treatment are expected to remove soil above SLs in the areas that are excavated. On-site treatment is expected to reduce the concentration of SVOCs in the excavated soil to concentrations below SLs. The containment surfaces added when Alternative A2 is included prevent rainwater from conveying SVOCs from vadose zone soil to groundwater. Judged to meet MTCA requirements for near-surface soil (alone) and for groundwater and surface water when combined with the alternatives selected in Sections 3 through 5.	Cuts the human health direct contact and ingestion pathways that were identified in the HHERA, and eliminates the risk posed by the SVOCs to Facility workers and visitors. Excavation and off-site disposal is expected to remove soil above SLs in the areas that are excavated. Off site incineration is expected to reduce the concentration of SVOCs in the excavated soil to concentrations below SLs. The containment surfaces added when Alternative A2 is included prevent rainwater from conveying SVOCs from vadose zone soil to groundwater. Judged to meet MTCA requirements for near-surface soil (alone) and for groundwater and surface water when combined with the alternatives selected in Sections 3 through 5.
Threshold Requirements	Comply with State and Federal Law	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. Location-specific ARARs were not identified for near-surface soil at the Facility, and action-specific ARARs were not identified for Alternative A1. Does not meet existing MTCA threshold requirements.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A2. The identified action-specific ARARs for Alternative A2 consist of requirements associated with implementation of the alternative (see Appendix G). These ARARS are judged to be attainable and do not affect the alternative selection process.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A4. The identified action-specific ARARs for Alternative A4 consist of requirements associated with implementation of the alternative (see Appendix G). These ARARS are judged to be attainable and do not affect the alternative selection process.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A5. The identified action-specific ARARs for Alternative A5 consist of requirements associated with implementation of the alternative (see Appendix G). These ARARS are judged to be attainable and do not affect the alternative selection process.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A6. The identified action-specific ARARs for Alternative A6 consist of requirements associated with implementation of the alternative (see Appendix G). These ARARS are judged to be attainable and do not affect the alternative selection process.
Threshold Requirements	Provide for Compliance Monitoring	Alternative A1 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative A2 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative A4 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative A5 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative A6 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.

Table 2-11 - Summary of Detailed Analysis of Alternatives Applicable to SVOCs in Near-Surface Soil at the Kaiser Facility

	Criteria	Alternative A1 Institutional Controls, Monitoring, and MNA	Alternative A2 Alternative A1 Plus Containment	Alternative A4 Alternative A1 or A2 Plus Excavation and Off-Site Disposal	Alternative A5 Alternative A1 or A2 Plus Excavation and On-Site Treatment	Alternative A6 Alternative A1 or A2 Plus Excavation and Off-Site Treatment (Incineration)
Disproportionate Cost Analysis	Protectiveness	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.
	Permanence	BMPs will reduce the release of hazardous substances to the environment. Access controls reduce the probability for Facility workers and visitors to contact SVOCs in near-surface soil. Existing paved surfaces also prevent direct contact with SVOCs in near-surface soil. Does not actively reduce the toxicity, mobility, or volume of SVOCs present in near-surface soil. Some natural attenuation of SVOCs may occur, although this process will require a long time to reduce SVOC concentrations to SLs. Less permanent than other alternatives.	BMPs will reduce the release of hazardous substances to the environment. Access controls reduce the probability for Facility visitors to contact SVOCs in near-surface soil. Existing paved surfaces also prevent direct contact with SVOCs in near-surface soil. Does not actively treat the soil within the SVOC AOCs. Provides a lower degree of permanence than is provided by Alternatives A4 through A6.	The BMPs in place at the Facility will reduce the release of hazardous substances to the environment. Access controls will reduce the probability for Facility workers and visitors to come in contact with the SVOCs contained in near-surface soil. Alternative A4 will eliminate the risk to Facility workers and visitors from direct contact or ingestion of contaminated near-surface soil. Removes and contains about 143,000 pounds of SVOCs in the AOCs that are excavated. The SVOCs will be removed in a relatively short time (approximately 1 year) period. Alternative A4 provides additional permanence over Alternative A2 but is less permanent than Alternatives A5 and A6.	The BMPs in place at the Facility will reduce the release of hazardous substances to the environment. Access controls will reduce the probability for Facility workers and visitors to come in contact with the SVOCs contained in near-surface soil. Alternative A5 will eliminate the risk to Facility workers and visitors from direct contact or ingestion of contaminated near-surface soil. Removes approximately 143,000 pounds and destroys approximately 135,000 pounds of SVOCs in the AOCs that are excavated. The SVOCs will be removed and treated in a relatively short time (about 1 to 2 year) period. More permanent than Alternatives A1, A2, and A4. Less permanent than Alternative A6.	The BMPs in place at the Facility will reduce the release of hazardous substances to the environment. Access controls will reduce the probability for Facility workers and visitors to come in contact with the SVOCs contained in near-surface soil. Alternative A6 will eliminate the risk to Facility workers and visitors from direct contact or ingestion of contaminated near-surface soil. Removes and destroys approximately 143,000 pounds of SVOCs in the AOCs that are excavated. The SVOCs will be removed and treated in a relatively short time (about 1 year) period. Alternative A6 is judged to be the most permanent alternative evaluated for SVOCs.
	Effectiveness over the Long Term	The institutional controls, BMPs, monitoring, and MNA employed by this alternative are currently in use at the Kaiser Facility. Does not directly address the SVOCs in near-surface soil. Natural attenuation processes at the Facility will continue, but will require a long time for SVOC concentrations to be reduced to below SLs. Near-surface soil will continue to pose potential risks to human health and the environment. Much less effective over the long term than other alternatives.	The paving surfaces employed by this alternative have been successfully implemented at Kaiser and at other locations. Does not actively treat the SVOCs in near-surface soil. Natural attenuation processes at the Facility will continue, but will require a long time for SVOC concentrations to be reduced to below SLs. Does not generate treatment residues or waste materials. Surface water runoff from the containment surfaces will be collected and directed to uncontaminated soil areas for infiltration or sent to the Kaiser WWT plant for treatment. Less effective over the long term than Alternatives A4 through A6.	Places soil in an engineered, lined, monitored landfill. Will remove SVOCs in AOCs that can be excavated. Protects Facility workers and visitors from direct contact with SVOCs, and prevents rainwater from conveying COCs in near-surface and vadose zone soils to groundwater. The technologies employed by this alternative have been successfully implemented at Kaiser and other locations. Greater long-term effectiveness than Alternative A2; less long-term effectiveness than Alternatives A5 and A6.	Destroys SVOCs in AOCs that can be excavated. Protects Facility workers and visitors from direct contact with SVOCs, and prevents rainwater from conveying COCs to groundwater. The technologies (biotreatment and thermal treatment) employed by this alternative are considered presumptive remedies for SVOCs and have been successfully demonstrated at other locations. Greater long-term effectiveness than Alternatives A2 and A4. Less long-term effectiveness than Alternative A6.	Destroys SVOCs in AOCs that can be excavated. Protects Facility workers and visitors from direct contact with SVOCs, and prevents rainwater from conveying COCs to groundwater. Permitted incineration facility located in Utah. Greater long-term effectiveness than Alternatives A2, A4, and A5.
	Management of Short-Term Risks	Uses existing procedures to implement institutional controls, BMPs and groundwater monitoring, and does not create any new or additional short-term risk to human health and the environment.	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces will be mitigated by their adherence to the health and safety plan (HASP). Fewer short-term risks than Alternatives A4, A5, and A6.	Short-term risks associated with excavation and mechanical screening will be mitigated by adherence to the HASP. Transport containers will be covered and take the appropriate measures to reduce risk to the communities that they travel through. Only properly licensed material haulers will be used. Fewer short-term risks than Alternatives A5 and A6.	Short-term risks associated with the excavation and screening will be mitigated by adherence to the HASP. Transport containers will be covered and take the appropriate measures to reduce risk to the communities that they travel through. Only properly licensed material haulers will be used. Short-term risks to workers operating the bio or thermal treatment systems will be mitigated by their adherence to the HASP. Greater short-term risks than Alternatives A2 and A4. Fewer short-term risks than Alternative A6.	Short-term risks associated with the excavation and screening will be mitigated by adherence to the HASP. Transport containers will be covered and take the appropriate measures to reduce risk to the communities that they travel through. Only properly licensed material haulers will be used. Short-term risks to workers operating the incinerator will be mitigated by their adherence to the HASP prepared by Clean Harbors. Greater short-term risks than Alternatives A2, A4, and A5.
	Technical and Administrative Implementability	The actions associated with Alternative A1 are already in place at the Kaiser Facility.	BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years.	Excavation and off-site disposal is a common technology and has been previously employed at Kaiser and is considered to be an implementable conventional technology. More implementable than Alternatives A5 and A6. Less implementable than Alternative A2.	Biotreatment and thermal treatment are presumptive remedies for the removal of SVOCs from soil and are considered to be implementable conventional technologies. More permitting and administrative requirements than Alternatives A2 and A4. Less implementable than Alternatives A2 and A4, more implementable than Alternative A6.	Excavation and incineration are generally technically and administratively implementable. An off-site permitted incineration facility is located in Utah. Alternative A6 has more permitting requirements and is judged to be less implementable than Alternatives A2, A4, and A5.
	Consideration of Public Concerns	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.
	Conceptual-Level Cost (NPV -35/+50 percent)	$13.6 million	$15.8 million	$18.7 million (Alternative A4a) $20.9 million (Alternative A4b)	$19.1 million (Alternative A5a with A1) $21.4 million (Alternative A5a with A2) $19.9 million (Alternative A5b with A1) $22.2 million (Alternative A5b with A2)	$39.0 million (with Alternative A1) $41.3 million (with Alternative A2)

Table 2-11 - Summary of Detailed Analysis of Alternatives Applicable to SVOCs in Near-Surface Soil at the Kaiser Facility

Criteria	Alternative A1 Institutional Controls, Monitoring, and MNA	Alternative A2 Alternative A1 Plus Containment	Alternative A4 Alternative A1 or A2 Plus Excavation and Off-Site Disposal	Alternative A5 Alternative A1 or A2 Plus Excavation and On-Site Treatment	Alternative A6 Alternative A1 or A2 Plus Excavation and Off-Site Treatment (Incineration)
Total Cost per Pound of COC Treated or Contained	NA - baseline cost	$110/pound of SVOC contained	$131/pound of SVOC removed and contained (Alternatives A4a) $146/pound of SVOC removed and contained (Alternatives A4b)	$141/pound of SVOC destroyed (Alternative A5a with A1) $159/pound of SVOC destroyed (Alternative A5a with A2) $147/pound of SVOC destroyed (Alternative A5b with A1) $164/pound of SVOC destroyed (Alternative A5b with A2)	$273/pound of SVOC destroyed (with Alternative A1) $289/pound of SVOC destroyed (with Alternative A2)
Restoration Time Frame	Natural attenuation processes at the Facility will continue, but the time frame needed for recovery to occur will be long. The restoration time frame for Alternative A1 is judged to be unreasonable.	Does not directly reduce the toxicity or volume of the SVOCs contained in near-surface soil. Natural attenuation processes at the Facility will continue. The time needed for the concentration of SVOCs in near-surface soil below the cap to fall below SLs will be long. However, cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. The cap can be installed in a relatively short (about 1 year) time period, which approximates the restoration time frame for this alternative. The risks to Facility workers and visitors from direct contact or ingestion of SVOCs will be eliminated once the containment surfaces have been installed. Reduces the potential for SVOCs in near-surface soil to migrate to groundwater. This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).	Natural attenuation processes at the Facility will continue for soil with concentrations of SVOCs above SLs that are present under building slabs or existing pavement; however, these processes will require a long time to reduce SVOC concentrations to SLs. The risks to Facility workers and visitors from direct contact or ingestion of COCs will be eliminated once the containment surfaces have been installed. The remedial objectives for Alternative A4 will be reached in a relatively short (about 1 year) time period. This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).	Natural attenuation processes at the Facility will continue for soil with concentrations of SVOCs above SLs that are present under building slabs or existing pavement, although these process will require a long time to reduce SVOC concentrations to SLs. The risks to Facility workers and visitors from direct contact or ingestion of COCs will be eliminated once the containment surfaces have been installed. The concentration of SVOCs in near-surface soil in the AOCs that will be treated will be reduced to concentrations below SLs within a relatively short (about 1 to 2 years) time period. This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).	Natural attenuation processes at the Facility will continue for soil with concentrations of SVOCs above SLs that are present under building slabs or existing pavement; however, these processes will require a long time to reduce SVOC concentrations to SLs. The risks to Facility workers and visitors from direct contact or ingestion of COCs will be eliminated once the containment surfaces have been installed. The remedial action objectives for Alternative A6 will be reached in a relatively short (about 1 year) time period. This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).

Table 2-12 - Summary of Detailed Analysis of Alternatives Applicable to PCBs in Near-Surface Soil at the Kaiser Facility

	Criteria	Alternative A1 Institutional Controls, Monitoring, and MNA	Alternative A2 Alternative A1 Plus Containment	Alternative A4 Alternative A2 Plus Excavation and Off-Site Disposal	Alternative A6 Alternative A2 Plus Excavation and Off-Site Incineration
Threshold Requirements	Overall Protection of Human Health and the Environment	Does not reduce the concentration of PCBs in near-surface soil to below SLs. Does not address the human health direct contact and ingestion pathways at the Facility. Does not address the soil to groundwater pathway that could potentially transfer PCBs to receptors in the Spokane River. Provides less overall protection to the environment than Alternatives A2, A4, and A6.	Physical and administrative controls, BMPs, and containment are used to reduce the potential for worker exposure to PCBs and reduce the potential for PCBs in near-surface soils to migrate to groundwater and potentially to receptors in the Spokane River. Removes the direct contact and ingestion pathways at the Facility. Provides the same degree of risk reduction to Facility workers and visitors and to receptors in the Spokane River as Alternatives A4 and A6. Short-term risks are manageable. More protective than Alternative A1 but less protective than Alternative A4 or A6.	Alternative A4 permanently reduces the toxicity, mobility, or volume of PCBs present in near-surface soils accessible to excavation at the Facility. Alternative A4 removes approximately 8 pounds of PCBs via excavation, which are disposed of at an off-site landfill facility. Removes the direct contact and ingestion pathways at the Facility. Short-term risks are manageable. Containment caps would be implemented where PCBs remain in deep vadose zone soils to reduce the potential for PCBs in vadose zone soils to migrate to groundwater and potentially to receptors in the Spokane River. Alternative A4 is more protective than either Alternatives A1 and A2, but less protective than Alternative A6.	Alternative A6 permanently reduces the toxicity, mobility, or volume of PCBs present in near-surface soils accessible to excavation at the Facility. Alternative A6 removes approximately 8 pounds of PCBs via excavation, which are destroyed at an off-site incineration facility. Containment is used to reduce the potential for PCBs remaining in deep vadose zone soils to migrate to groundwater and potentially to receptors in the Spokane River. Removes the direct contact and ingestion pathways at the Facility. Short-term risks are manageable. Since incineration destroys contaminant mass, rather than merely isolating it in a containment facility, Alternative A6 is considered more protective than Alternatives A1, A2, and A4.
	Comply with Cleanup Standards	The concentration of PCBs in the AOCs containing PCBs will remain above SLs. Does not address the human health direct contact and ingestion pathways at the Facility. Does not address the soil to groundwater pathway that could potentially transfer PCBs to receptors in groundwater or the Spokane River. Does not meet existing MTCA threshold requirements.	Cuts the direct contact and ingestion pathways that were identified in the HHERA and eliminates the risk posed by PCBs to Facility workers and visitors. The containment surfaces prevent rainwater from conveying PCBs from near-surface soil to groundwater and potentially to receptors in groundwater or the Spokane River. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. Judged to meet MTCA requirements for near-surface soils (alone) and for groundwater and surface water when combined with the alternatives selected in Sections 3 through 5.	Since Alternative A4 would remove PCBs and contain them in an off-site landfill, this alternative directly meets the SLs that have been established for PCBs at the Kaiser Facility. Cuts the direct contact and ingestion pathways that were identified in the HHERA and eliminates the risk posed by PCBs to Facility workers and visitors. The containment surfaces prevent rainwater from conveying PCBs remaining in deep vadose zone soil to groundwater and potentially to receptors in groundwater or the Spokane River.	Since Alternative A6 would remove PCBs and destroy them via incineration, this alternative directly meets the SLs that have been established for PCBs at the Kaiser Facility. Cuts the direct contact and ingestion pathways that were identified in the HHERA and eliminates the risk posed by PCBs to Facility workers and visitors. The containment surfaces prevent rainwater from conveying PCBs remaining in deep vadose zone soils to groundwater and potentially to receptors in groundwater or the Spokane River.
	Comply with Applicable State and Federal Law	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. Location-specific and action-specific ARARs were not identified for Alternative A1. Does not meet existing MTCA threshold requirements.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. The identified action-specific ARARs for Alternative A2 consist of requirements associated with implementation of the alternative (see Appendix G). Location-specific ARARs consist of potential restrictions related to construction near the shoreline of the Spokane River. These ARARS are judged to be attainable and do not affect the alternative selection process.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. The identified action-specific ARARs for Alternative A4 consist of requirements associated with implementation of the alternative (see Appendix G). Location-specific ARARs consist of potential restrictions related to construction near the shoreline of the Spokane River. These ARARS are judged to be attainable and do not affect the alternative selection process.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. The identified action-specific ARARs for Alternative A6 consist of requirements associated with implementation of the alternative (see Appendix G). Location-specific ARARs consist of potential restrictions related to construction near the shoreline of the Spokane River. These ARARS are judged to be attainable and do not affect the alternative selection process.
	Provide for Compliance Monitoring	Alternative A1 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative A2 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative A4 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative A6 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.

Table 2-12 - Summary of Detailed Analysis of Alternatives Applicable to PCBs in Near-Surface Soil at the Kaiser Facility

	Criteria	Alternative A1 Institutional Controls, Monitoring, and MNA	Alternative A2 Alternative A1 Plus Containment	Alternative A4 Alternative A2 Plus Excavation and Off-Site Disposal	Alternative A6 Alternative A2 Plus Excavation and Off-Site Incineration
Disproportionate Cost Analysis	Protectiveness	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.
	Permanence	BMPs will reduce the release of hazardous substances to the environment. Facility access controls reduce the probability for visitors to contact PCBs in near-surface soil. Existing paved surfaces also prevent direct contact with PCBs in near-surface soil. Does not reduce the toxicity, mobility, or volume of PCBs present in near-surface soils. Less permanent than Alternatives A2, A4, and A6.	BMPs will reduce the release of hazardous substances to the environment. Facility access controls reduce the probability for visitors to contact PCBs in near-surface soil. Existing paved surfaces also prevent direct contact with VOCs in near-surface soil. Does not directly treat the soils within the PCB AOCs. Provides a lower degree of permanence than is provided in Alternative A4, which removes and disposes of PCBs off site. Provides a lower degree of permanence than Alternative A6, which removes and destroys PCBs via off-site incineration.	Alternative A4 permanently reduces the mass of PCBs in near-surface soils present at the Facility. Alternative A4 removes and disposes approximately 8 pounds of PCBs at an off-site landfill. BMPs will reduce the release of hazardous substances to the environment. Provides a greater degree of permanence than Alternatives A1 and A2, but is less permanent than Alternative A6.	Alternative A6 permanently reduces the mass of PCBs in near-surface soils present at the Facility. Alternative A6 removes the same mass of PCBs as in Alternative A4, but destroys this mass of PCBs at an off-site incineration facility. BMPs will reduce the release of hazardous substances to the environment. Alternative A6 is judged to be the most permanent treatment alternative for PCBs, and is judged to be more permanent than Alternatives A1, A2, and A4 since it is the only alternative that destroys PCBs.
	Effectiveness over the Long Term	The institutional controls, monitoring, and MNA employed by this alternative are currently in use at the Kaiser Facility. Does not reduce the concentration of PCBs in near-surface soil to below SLs. These soils will continue to pose potential risks to human health and the environment. Much less effective over the long term than Alternatives A2, A4, and A6.	The paved surfaces employed by this alternative have been successfully implemented at Kaiser and other locations. Does not reduce the concentration of PCBs in near-surface soil to below SLs. The existing pavement and floor slabs and new containment surfaces provided in Alternative A2 will protect Facility workers and visitors from direct contact with PCBs in these areas, and prevent rainwater from conveying PCBs to groundwater and potentially to the receptors in the Spokane River. Does not generate treatment residues or waste materials. Surface water runoff from the containment surfaces will be collected and conveyed to the Kaiser WWT for treatment. Less effective over the long term than Alternative A4 or A6.	Alternative A4 removes PCB mass from accessible near-surface soil AOCs via excavation. The excavated soils would be disposed of in an off-site landfill. The containment surfaces provided by Alternative A2 would prevent rainwater from conveying PCBs remaining in deep vadose zone soils to groundwater and potentially to the receptors in groundwater or the Spokane River. Institutional controls would be implemented that would prohibit or limit activities that could interfere with the long-term integrity of the containment system. An inspection and maintenance plan that would assure the integrity of the containment surfaces would be prepared and implemented. The containment surfaces are expected to remain effective for an extended period of time (decades). Alternatives A4 is judged to have more long-term effectiveness than Alternatives A1 and A2, but less than Alternative A6.	Alternative A6 removes PCB mass from accessible near-surface soil AOCs via excavation. The excavated soils containing PCBs would be destroyed through incineration. The containment surfaces provided by Alternative A2 would prevent rainwater from conveying PCBs remaining in deep vadose zone soils to groundwater and potentially to the receptors in groundwater or the Spokane River. Institutional controls would be implemented that would prohibit or limit activities that could interfere with the long-term integrity of the containment system. An inspection and maintenance plan to assure the integrity of the containment surfaces would be prepared and implemented. The containment surfaces are expected to remain effective for an extended period of time (decades). Alternative A6 is judged to have greater long-term effectiveness than Alternatives A1, A2, and A4.
	Management of Short-Term Risks	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create any new or additional risk to human health and the environment.	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces will be mitigated by their adherence to the HASP. Short-term risks are judged to be more manageable for Alternative A2 than for Alternatives A4 and A6.	Short-term risks to construction workers during excavation and installation of the containment surfaces will be mitigated by adherence to the HASP. Alternative A4 results in additional short-term risks in the transportation of PCB-contaminated soil to an off-site landfill. Additional short-term risks are associated with handling the waste material at the landfill. These risks would be mitigated by adherence to the health and safety procedures that the transportation and landfill contractors would implement as part of their operations. Short-term risks are judged to be more manageable for Alternative A4 than for Alternative A6, but less manageable than those associated with Alternative A2.	Short-term risks to construction workers during excavation and installation of the containment surfaces will be mitigated by their adherence to the HASP. Alternative A6 results in additional short-term risks in the transportation of PCB-contaminated soil to the off-site incineration facility. Additional short-term risks are associated with handling the waste material at the incineration facility. Additionally, short-term risks are associated with the operation of the incinerator. These risks would be mitigated by adherence to the health and safety procedures that the transportation and incineration contractors would implement as part of their operations. Short-term risks are judged to be less manageable for Alternative A6 than for Alternatives A2 and A4.

Table 2-12 - Summary of Detailed Analysis of Alternatives Applicable to PCBs in Near-Surface Soil at the Kaiser Facility

	Criteria	Alternative A1 Institutional Controls, Monitoring, and MNA	Alternative A2 Alternative A1 Plus Containment	Alternative A4 Alternative A2 Plus Excavation and Off-Site Disposal	Alternative A6 Alternative A2 Plus Excavation and Off-Site Incineration
Disproportionate Cost Analysis	Technical and Administrative Implementability	The actions associated with Alternative A1 are already in place at the Kaiser Facility.	BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at Kaiser for many years. Alternative A2 is judged to be more easily implemented than Alternatives A4 and A6.	Excavation and disposal of soil at an off-site landfill is a common practice and is judged to be implementable at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. Excavation and off-site disposal is judged to be a more complex technical operation that will require more regulatory permits than the installation of a cap. Alternative A4 is judged to be more difficult to implement than Alternative A2 but less difficult to implement than Alternative A6.	Incineration is judged to be a more complex technical operation that will require more regulatory permits than excavation and disposal. Thus Alternative A6 is judged to be more difficult to implement than Alternatives A2 and A4.
	Consideration of Public Concerns	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.
	Conceptual-Level Cost (NPV -35/+50 percent)	$13.6 million	$15.8 million	$18.7 million (Alternative A4a) $20.9 million (Alternative A4b)	$39.0 million (Alternative A6 with A1) $41.3 million (Alternative A6 with A2)
	Total Cost per Pound of COC Treated or Contained	NA	$2.0 million/pound of PCB contained	$2.3 million/pound of PCB removed and contained (Alternative A4a) $2.6 million/pound of PCB removed and contained (Alternative A4b)	$4.9 million/pound of PCB destroyed (Alternative A6 with A1) $5.2 million/pound of PCB destroyed (Alternative A6 with A2)
	Restoration Time Frame	Does not reduce the concentration of PCBs in near-surface soil to below SLs. The restoration time frame for Alternative A1 is judged to not be reasonable	Does not reduce the concentration of PCBs in near-surface soil to below SLs. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. Containment surfaces can be installed within a reasonable restoration time frame (about 1 year), which approximates the restoration time frame for this alternative. This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).	The excavation and transportation aspects of Alternative A4 is expected be completed in a short time frame (about 1 year). This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4). However, containment of PCB-impacted soil in a regulated landfill would require long-term monitoring at the landfill.	The restoration time frame associated with excavation and incineration under Alternative A6 is expected to be short (about 1 to 2 years). This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).

Table 2-13 - Summary of Detailed Analysis of Alternatives Applicable to Metals in Near-Surface Soil at the Kaiser Facility

	Criteria	Alternative A1 Institutional Controls, Monitoring, and MNA	Alternative A2 Alternative A1 Plus Containment	Alternative A4 Alternative A1 or A2 Plus Excavation and Off-Site Disposal
Threshold Requirements	Overall Protection of Human Health and the Environment	Does not reduce the concentration of metals in near-surface soil to below SLs. Concentrations of metals will not decrease over time by natural attenuation processes. Does not address the human health direct contact and ingestion pathways at the Facility. Does not address the soil to groundwater pathway that could potentially transfer metals to human receptors through groundwater or the Spokane River. Provides less overall protection to the environment than Alternatives A2 and A4.	Physical and administrative controls, BMPs, and containment are used to reduce the potential for worker exposure to metals and reduce the potential for metals in near-surface soil to migrate to groundwater and potentially to receptors in groundwater or the Spokane River. Removes the currently open human health direct contact and ingestion pathways at the Facility. Provides the same amount of risk reduction for human and ecological receptors as Alterntive A4. More protective than Alternative A1.	Eliminates the risk associated with the direct contact of Facility workers and visitors to metals in near-surface soil in the metal AOCs and will reduce the future transport of metals from near-surface soil to groundwater by excavating and disposing of the soil in a permitted lined landfill. Removes approximately 3,400 pounds of metals. Approximately 30 pounds of metals will remain in place under buildings, under existing pavement, or within 20 feet of buildings. Existing pavement will prevent direct human contact and rainwater from conveying COCs to groundwater via infiltration. Alternative A4b adds containment to the AOCs where COCs at concentrations above SLs are expected to remain in vadose zone soil (refer to Section 2.1.4). However, accessible metal-impacted soil is not located above impacted deep vadose zone soil. Since impacted soil will be removed from the Facility and contained in a permitted landfill, Alternative A4 is judged to be more protective than Alternative A2.
	Comply with Cleanup Standards	The concentration of metals will remain above SLs. Does not address the human health direct contact and ingestion pathways at the Facility. Does not address the soil to groundwater pathway that could potentially transfer metals to human receptors through groundwater or the Spokane River. Does not meet existing MTCA requirements.	Cuts the human health direct contact and ingestion pathways that were identified in the HHERA, and eliminates the risk posed by metals to Facility workers and visitors. The containment surfaces prevent rainwater from conveying metals from near-surface soil to receptors through groundwater or the Spokane River. Alternative A2 meets SLs since it meets the requirements of WAC 173-340-740(6)(f). Judged to meet MTCA requirements for near-surface soil (alone) and for groundwater and surface water when combined with the alternatives selected in Sections 3 through 5.	Excavation and off-site disposal is expected to remove soil above SLs in the areas that are excavated. Off-site disposal cuts the human health direct contact and ingestion pathways that were identified in the HHERA, and eliminates the risk posed by metals to Facility workers and visitors. The removal of impacted soil from the Facility prevents rainwater from conveying metals from near-surface soil to groundwater receptors and potentially to receptors through groundwater or the Spokane River. Judged to meet MTCA requirements for near-surface soil (alone) and for groundwater and surface water when combined with the alternatives selected in Sections 3 through 5.
	Comply with Applicable State and Federal Law	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. Location-specific ARARs were not identified for near-surface soil at the Facility, and action-specific ARARs were not identified for Alternative A1. Does not meet existing MTCA threshold requirements.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A2. The identified action-specific ARARs for Alternative A2 consist of requirements associated with implementation of the alternative (see Appendix G). These ARARS are judged to be attainable and do not affect the alternative selection process.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for near-surface soil at the Facility applicable to Alternative A4. The identified action-specific ARARs for Alternative A4 consist of requirements associated with implementation of the alternative (see Appendix G). These ARARS are judged to be attainable and do not affect the alternative selection process.
	Provide for Compliance Monitoring	Alternative A1 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative A2 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative A4 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.
Disproportionate Cost Analysis	Protectiveness	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.
	Permanence	BMPs will reduce the release of hazardous substances to the environment. Access controls reduce the opportunity for Facility visitors to contact metals in near-surface soil. Existing paved surfaces also prevent direct contact with metals in near-surface soil. Does not reduce the toxicity, mobility, or volume of metals present in near-surface soil. Less protective than Alternatives A2 and A4.	BMPs will reduce the release of hazardous substances to the environment. Access controls reduce the opportunity for Facility visitors to contact metals in near-surface soil. Existing paved surfaces also prevent direct contact with metals in near-surface soil. Alternative A2 provides a lower degree of permanence than Alternative A4 since Alternative A4 removes metals from the Facility (metals are then contained in a permitted landfill).	The BMPs in place at the Facility will reduce the release of hazardous substances to the environment. Access controls will reduce the opportunity for workers and visitors at the Facility to come in contact with the metals contained in near-surface soil. Alternative A4 will eliminate the risk to Facility workers and visitors from direct contact or ingestion of contaminated near-surface soil. Removes and contains 3,400 pounds of metals in the AOCs that are excavated. The metals will be removed in a relatively short time (about 1 year) period. Alternative A4 provides a higher degree of permanence than Alternative A2, since Alternative A4 removes metals from the Facility (metals are then contained in a permitted landfill).

Table 2-13 - Summary of Detailed Analysis of Alternatives Applicable to Metals in Near-Surface Soil at the Kaiser Facility

	Criteria	Alternative A1 Institutional Controls, Monitoring, and MNA	Alternative A2 Alternative A1 Plus Containment	Alternative A4 Alternative A1 or A2 Plus Excavation and Off-Site Disposal
Disproportionate Cost Analysis	Effectiveness over the Long Term	The institutional controls, monitoring, and MNA employed by this alternative are currently in use at the Kaiser Facility. Does not reduce the metal concentrations in near-surface soil. Metals in near-surface soil will continue to pose potential risks to human health and the environment. Less effective over the long term than Alternatives A2 and A4.	Concentrations of metals will not decrease over time. The paving surfaces employed by the alternative have been successfully implemented at Kaiser and other locations. Pavement will prevent direct human contact and ingestion of metals and prevent rainwater from conveying COCs to groundwater via infiltration. Does not generate significant treatment residues or waste materials. Surface water runoff from the containment surfaces will be collected and conveyed to uncontaminated areas for infiltration or Kaiser WWT plant for treatment. Less effective over the long term than Alternative A4.	Removes metal-impacted soil from the Facility and places it in an engineered, lined, and monitored landfill. Will remove metals in AOCs from the Facility in a short time frame (about 1 year). Protects Facility workers and visitors from direct contact with metals and prevents rainwater from conveying COCs to groundwater. The technologies employed by this alternative have been successfully demonstrated at Kaiser and other locations. More effective over the long term than Alternative A2.
Disproportionate Cost Analysis	Management of Short-Term Risks	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create new or additional risk to human health and the environment.	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces will be mitigated by their adherence to the HASP. Alternative A2 creates fewer short-term risks than Alternative A4.	Short-term risks associated with the excavation and screening will be mitigated by adherence to the HASP. Transport containers will be covered and take the appropriate measures to reduce risk to the communities that they travel through on their way to the landfill. Only properly licensed material haulers will be used. Alternative A4 has a greater level of short-term risks than Alternative A2 based on the higher level of technical complexity of this alternative.
Disproportionate Cost Analysis	Technical and Administrative Implementability	The actions associated with Alternative A1 are already in place at the Kaiser Facility.	BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. Alternative A2 is more technically and administratively implementable than Alternative A4 since capping is judged to be less technically complex and to require fewer environmental permits than Alternative A4 excavation and disposal in a permitted landfill.	Technical expertise will be required to coordinate, execute, and engineer the excavation and off-site disposal of Alternative A4. Management of soil at landfill facility will require administrative support for items such as permitting, profiling, and monitoring. Alternative A4 is less technically and administratively implementable than Alternative A2 based on the complexity of this alternative.
Disproportionate Cost Analysis	Consideration of Public Concerns	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.
Disproportionate Cost Analysis	Conceptual-Level Cost (NPV -35/+50 percent)	$13.6 million	$15.8 million	$18.7 million (Alternative A4a) $20.9 million (Alternative A4b)
Disproportionate Cost Analysis	Total Cost per Pound of COC Treated or Contained	Not evaluated - baseline cost	$4,600/pound of metals contained	$5,500/pound of metals excavated (Alternative A4a) $6,100/pound of metals excavated and contained (Alternative A4b)
	Restoration Time Frame	Concentrations of metals will not decrease over time and will remain in soil in perpetuity. The restoration time frame for Alternative A1 is judged to not be reasonable.	Concentrations of metals will not decrease over time and will remain in soil in perpetuity. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. The containment cap can be installed in a relatively short time frame (about 1 year), which approximates the restoration time frame for this alternative. This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).	Alternative A4 can be implemented in a relatively short time frame at the Facility. Metal-impacted soil can be removed from the Facility to a permitted landfill within approximately one year. This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).

Site Plan and Near-Surface Soil (< 20 Feet) Areas of Interest

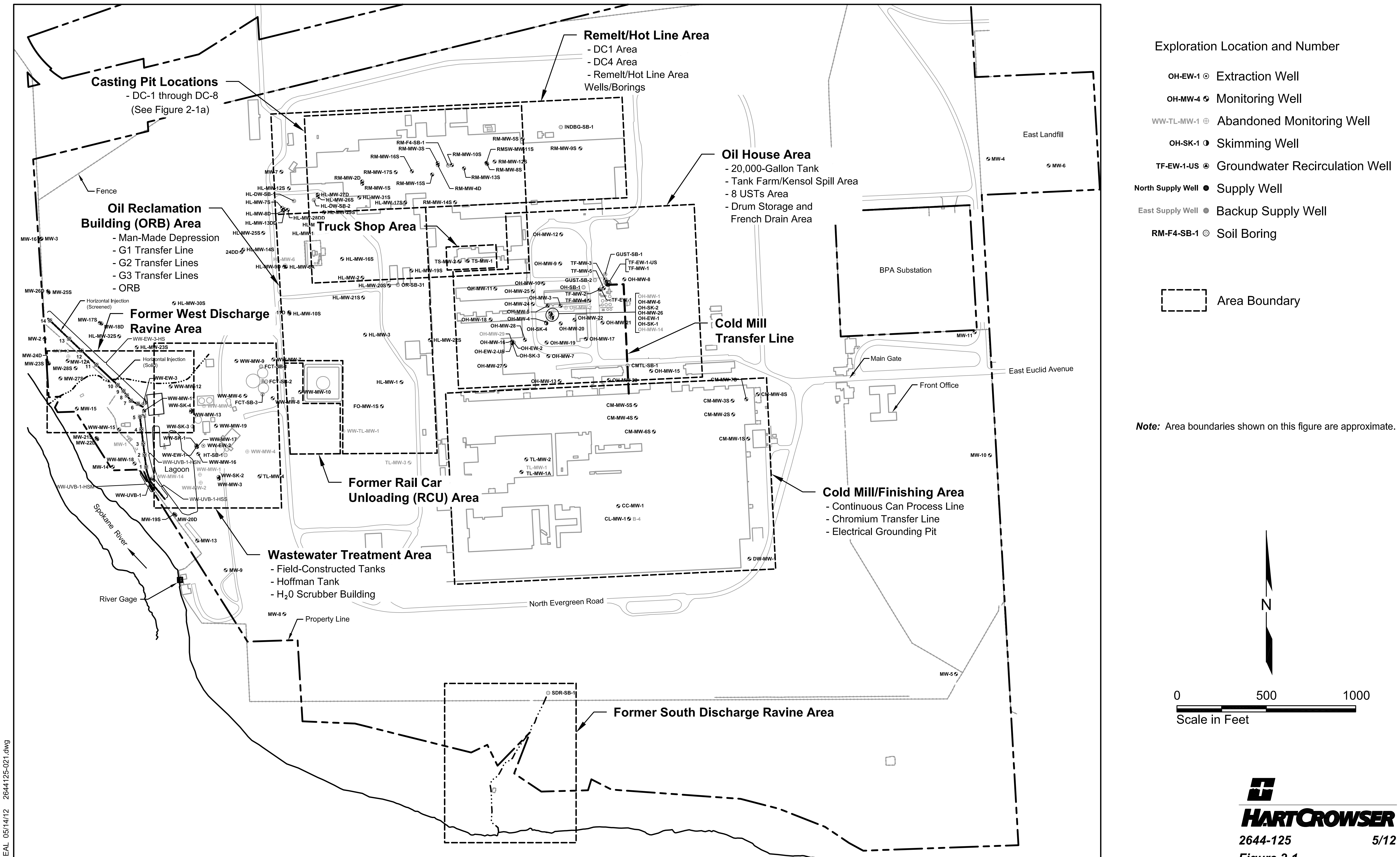

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Figure 2-1

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DC-1 through DC-8 Casting Pit Location Plan

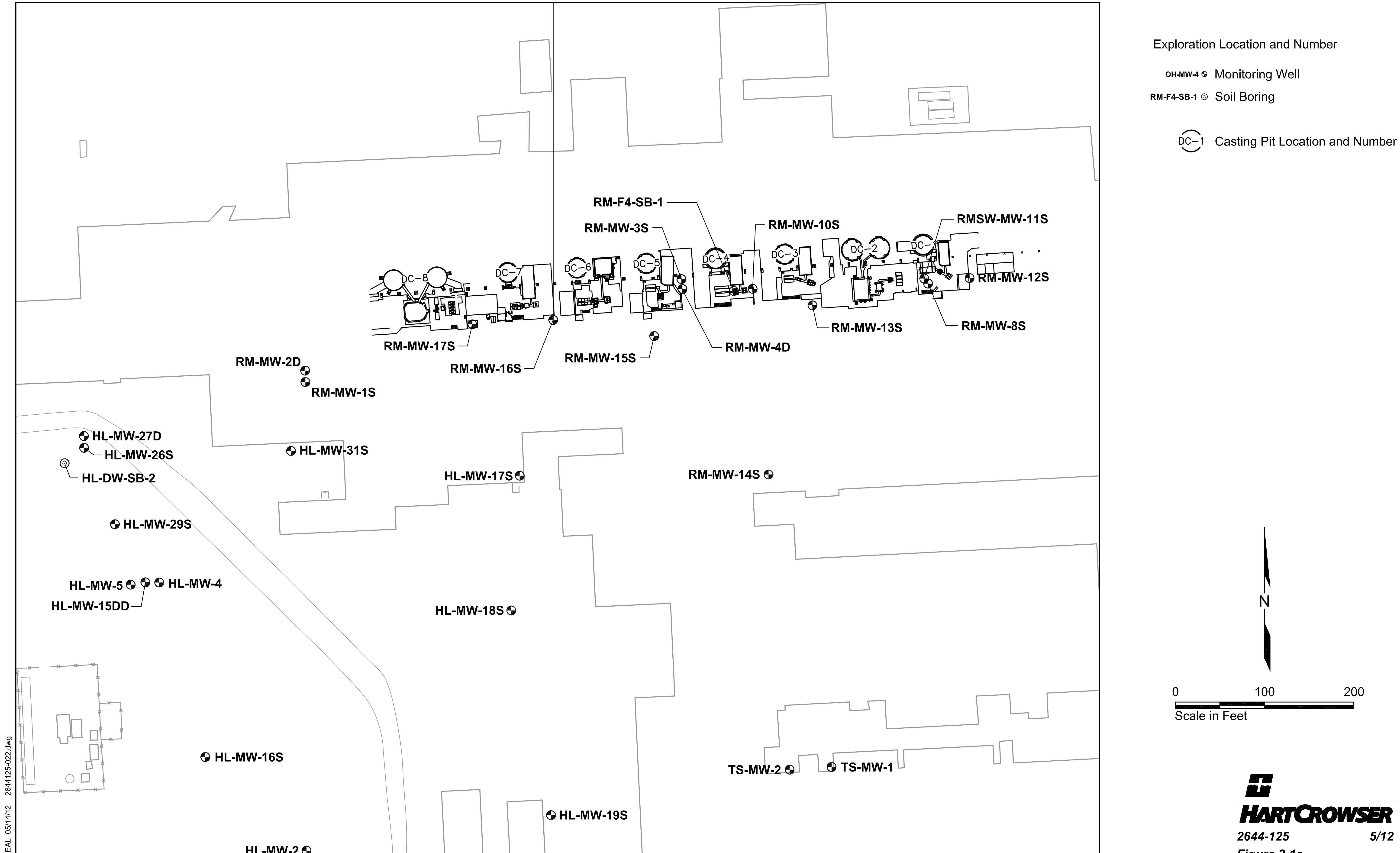

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Figure 2-1a

Protection and Performance Monitoring Well Location Plan

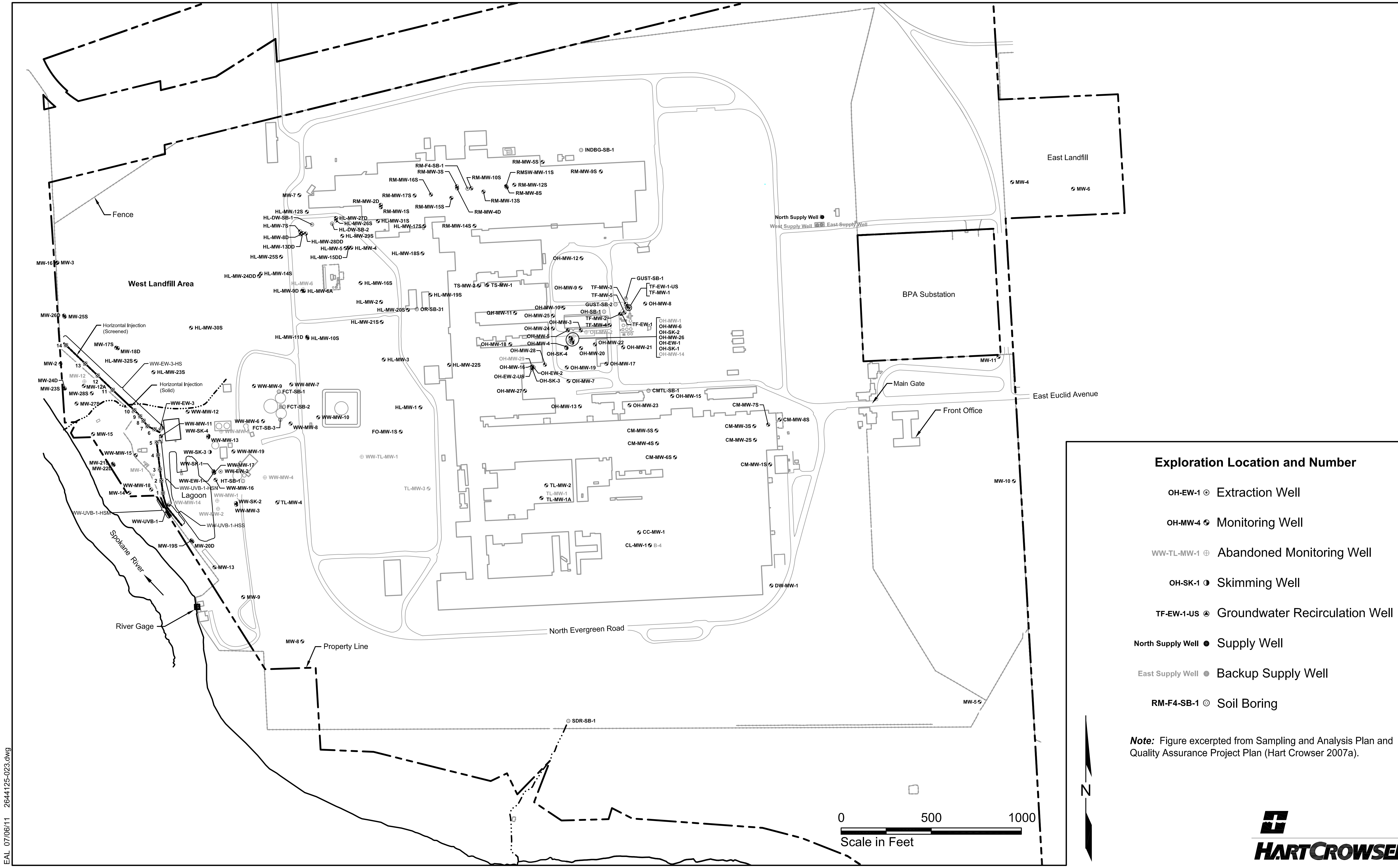

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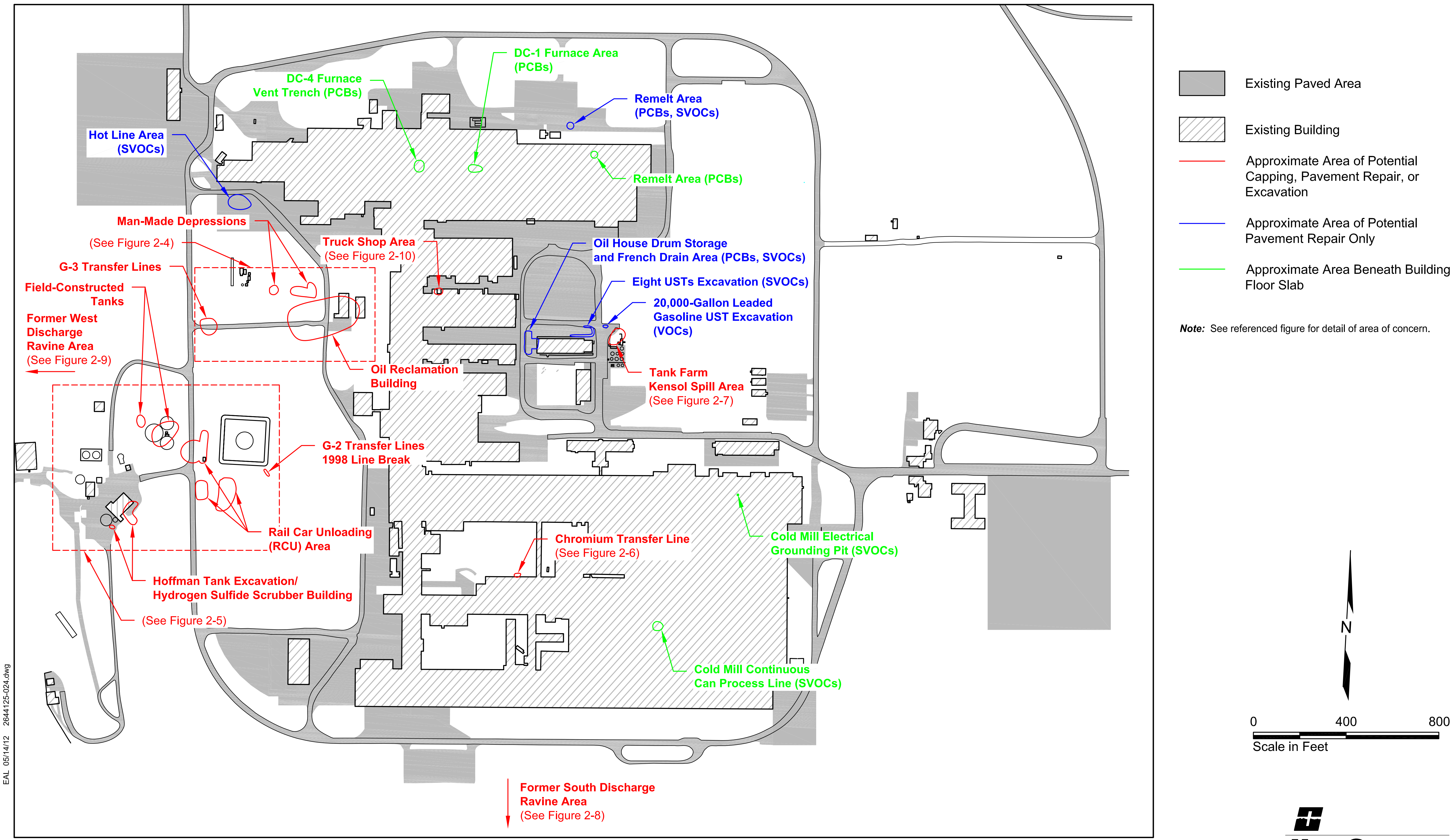
Figure 2-2

Near-Surface Soil AOCs - Potential Capping, Excavation, or Pavement Repair Areas



Note: See referenced figure for detail of area of concern.

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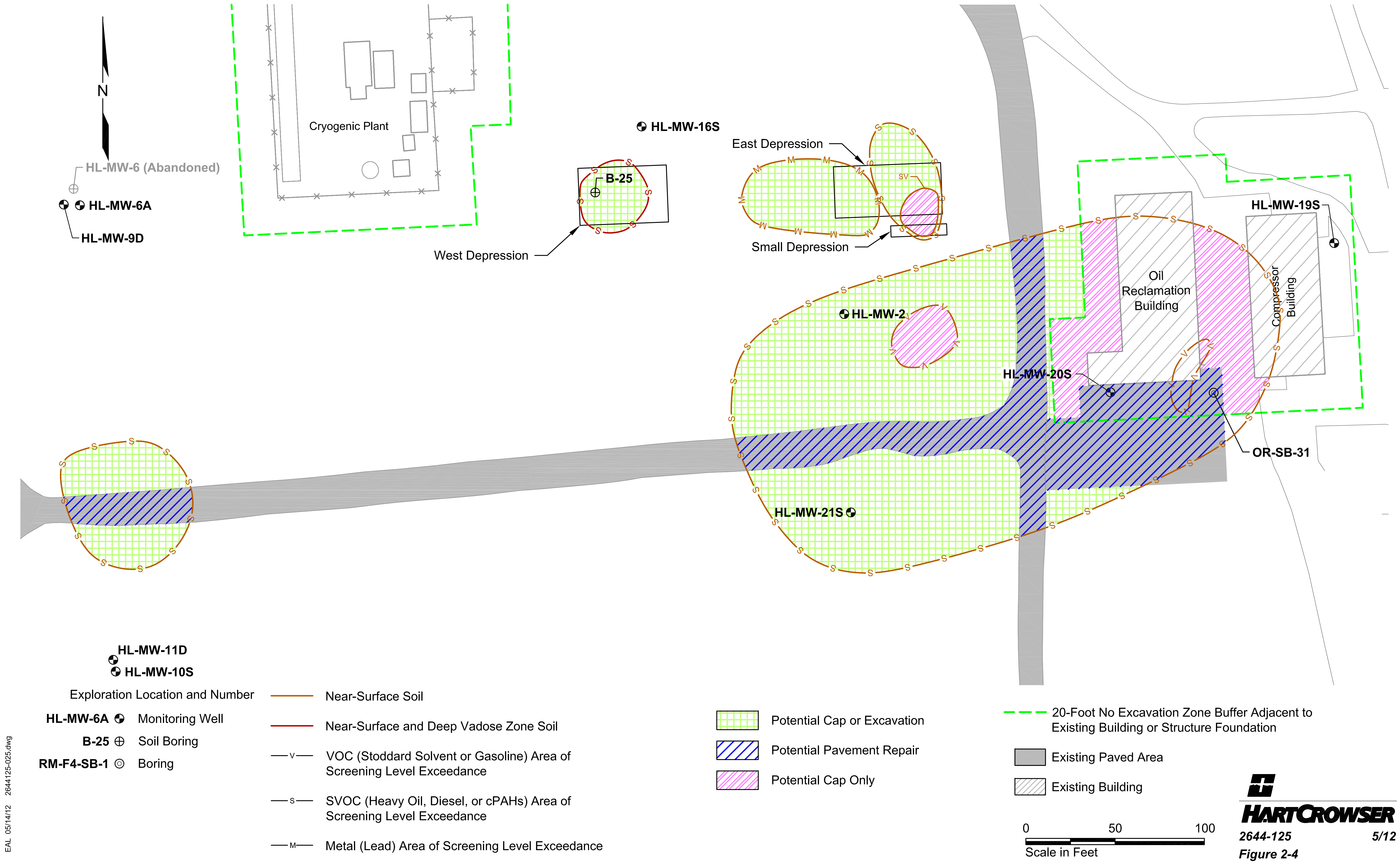
Figure 2-3

Near-Surface Soil AOCs - Potential Capping, Excavation, or Pavement Repair Areas
Oil Reclamation Building and Surrounding Areas



Near-Surface Soil AOCs - Potential Capping, Excavation, or Pavement Repair Areas

Wastewater Treatment/Rail Car Unloading (RCU) Areas

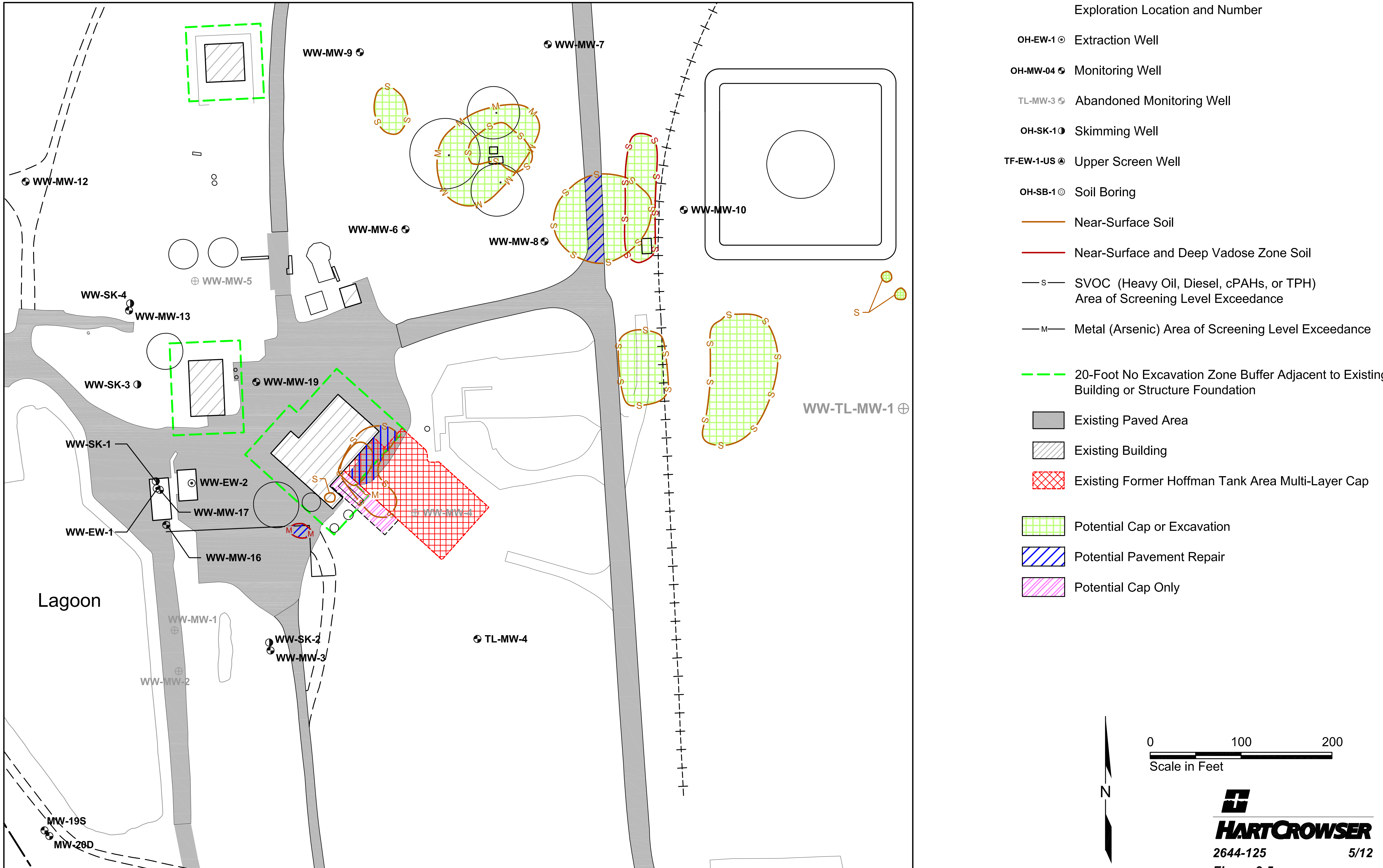


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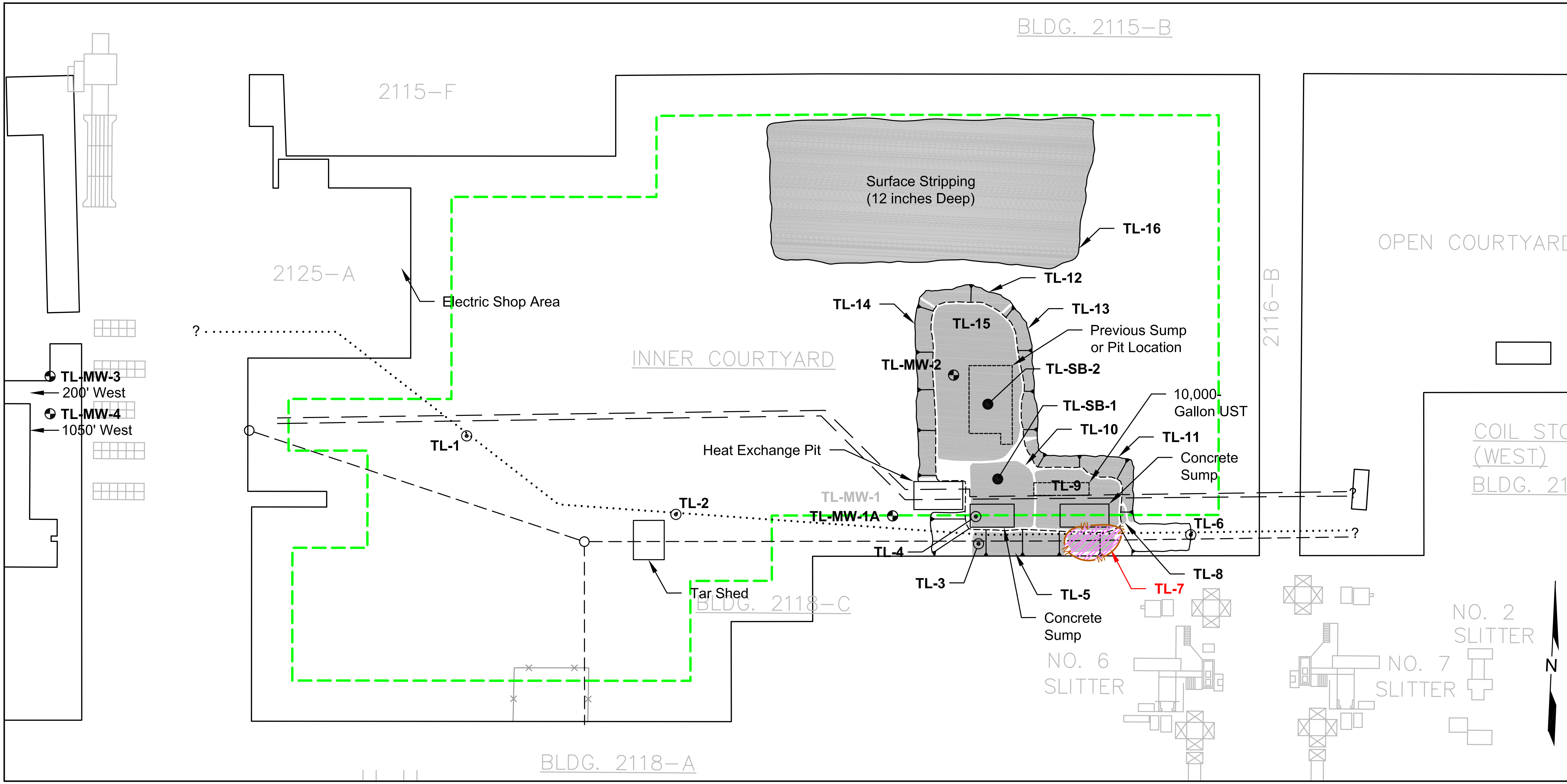
Figure 2-5

Near-Surface Soil AOCs - Potential Capping Areas
Chromium Transfer Line



EAL 05/14/12 2644125-027.dwg

Exploration Location and Number

TL-7 Soil Sampling Location with Screening Level Exceedance

TL-MW-2 Monitoring Well (October 16, 1980)

TL-SB-2 Soil Boring (October 16, 1980)

TL-6 Discrete Soil Sample

TL-15 Composite Soil Sample

Manhole

Chromium Transfer Line

Existing Gravity Lines for Phosphate-Bearing Waste

Storm Sewer Line

Near-Surface Soil

Metal (Chromium) Area of Screening Level Exceedance

20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation

Potential Cap Only

Note: Gray shading denotes area of historical excavation.

0 50 100
Scale in Feet

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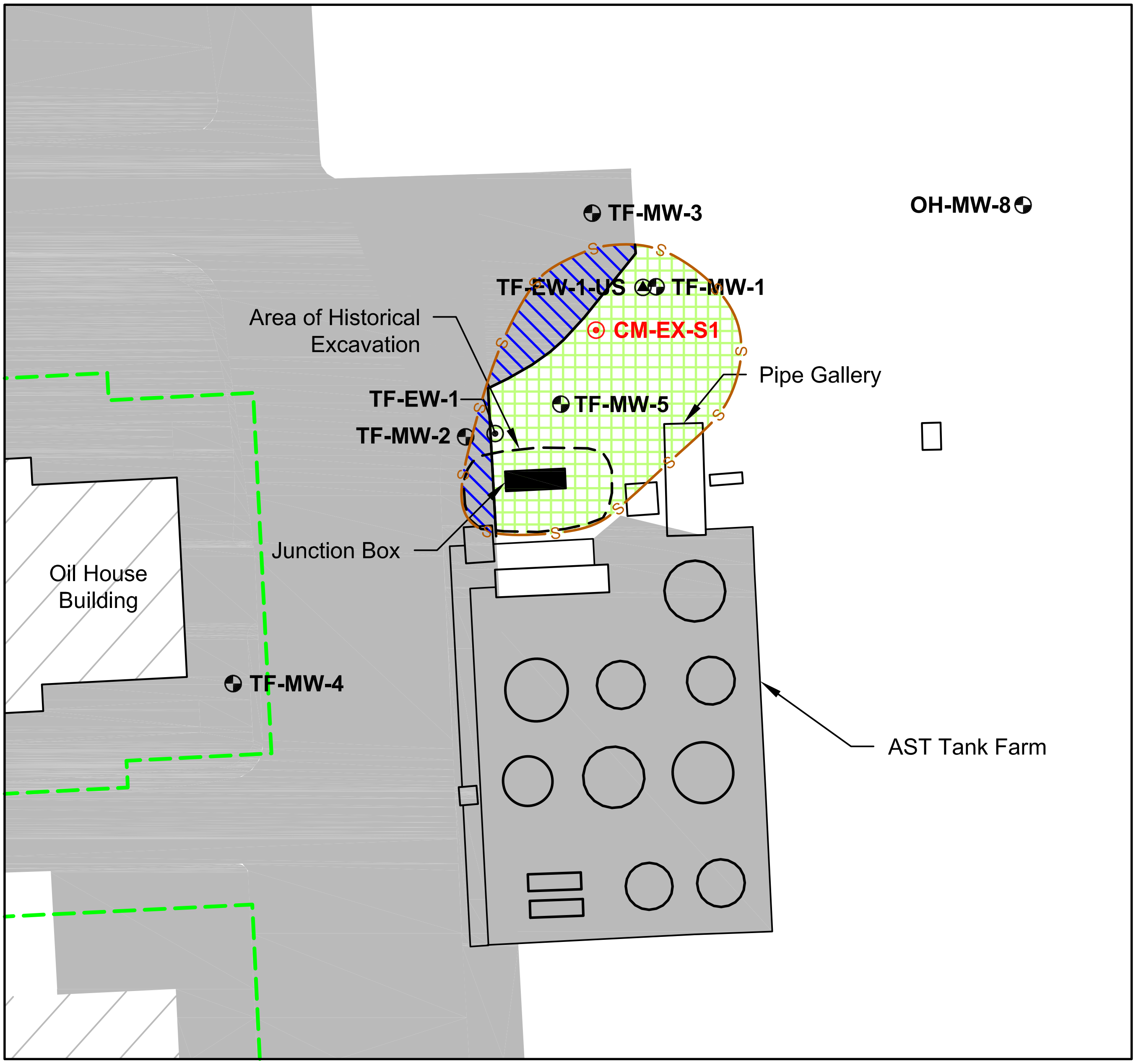
Figure 2-6

Near Surface Soil AOCs - Potential Capping, Excavation, or Pavement Repair Areas

Tank Farm Kensol Spill Area



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Exploration Location and Number

TF-EW-1 ⦿ Extraction Well

TF-MW-4 Monitoring Well

TF-EW-1-US Groundwater Recirculation Well

CM-EX-S1 ⦿ Sample with Screening Level Exceedance

Near-Surface Soil

—s— SVOC (TPH) Area of Screeing Level Exceedance

Potential Cap or Excavation

Potential Pavement Repair

Aboveground Storage Tank

20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation

N

0 40 80

Scale in Feet

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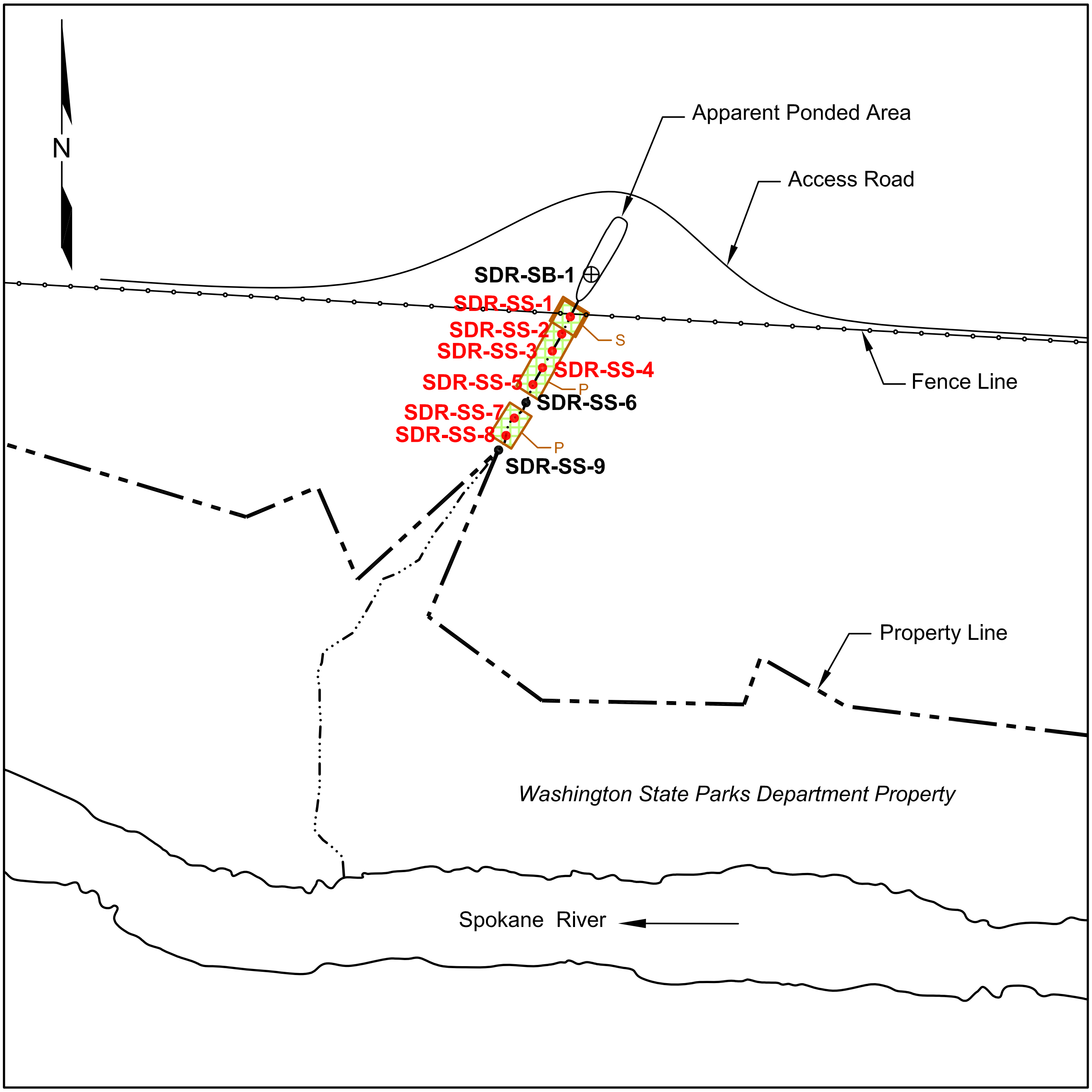
Figure 2-7

Near-Surface Soil AOCs - Potential Capping or Excavation Areas
Former South Discharge Ravine



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Exploration Location and Number

SDR-SB-1 ⊕ Boring

SDR-SS-6 • Surface Soil Sample

SDR-SS-1 • Sample Location with Screening Level Exceedance

—S— SVC (Heavy Oil) Area of Screening Level Exceedance

—P— PCB Area of Screening Level Level Exceedance

Near-Surface Soil

Potential Cap or Excavation

0 200 400

Scale in Feet

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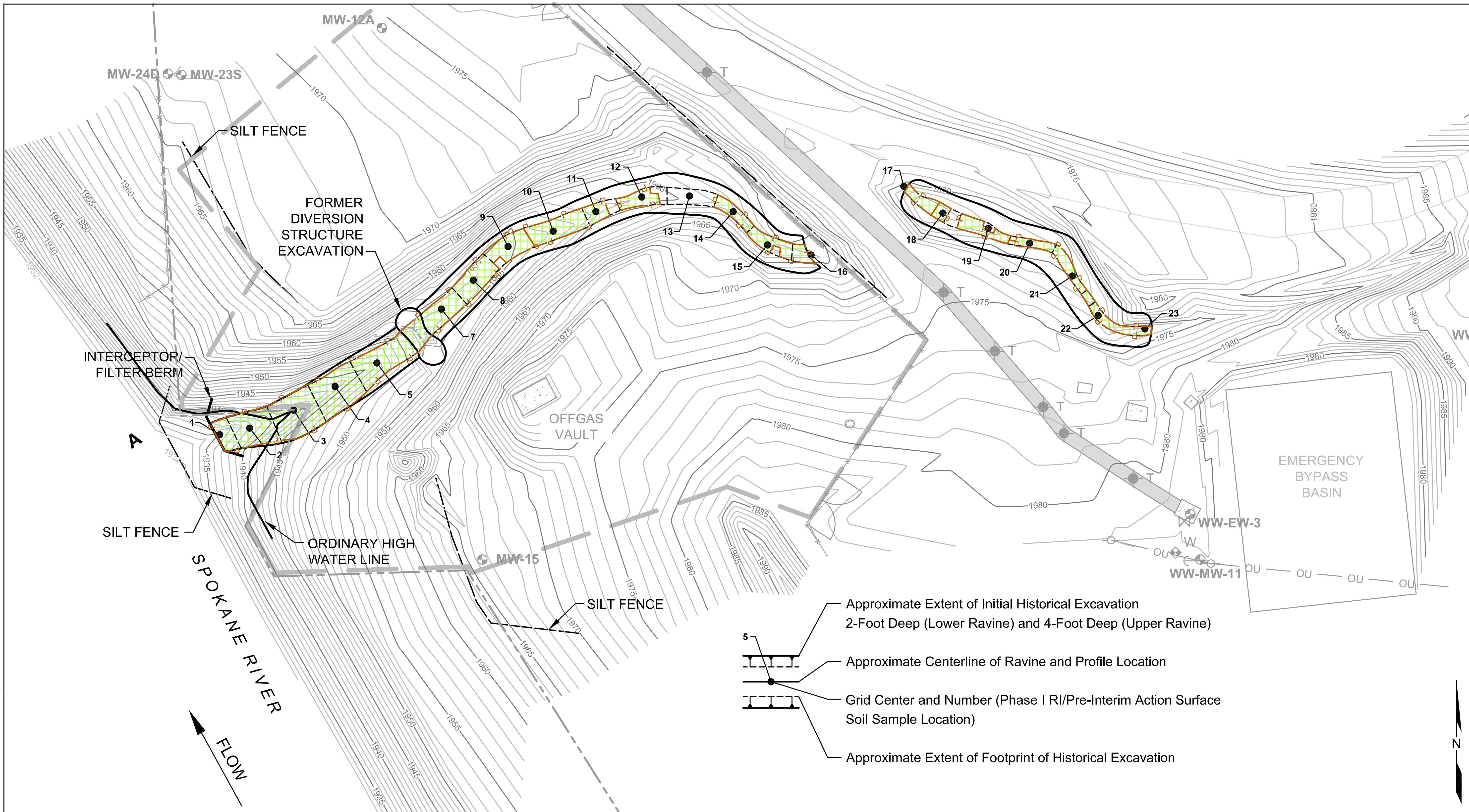
Figure 2-8

Near-Surface Soil AOCs - Potential Capping or Excavation Areas

Former West Discharge Ravine



PCB Area of Screening Level Exceedance

Near-Surface Soil

Potential Cap or Excavation

0 50 100
Scale in Feet

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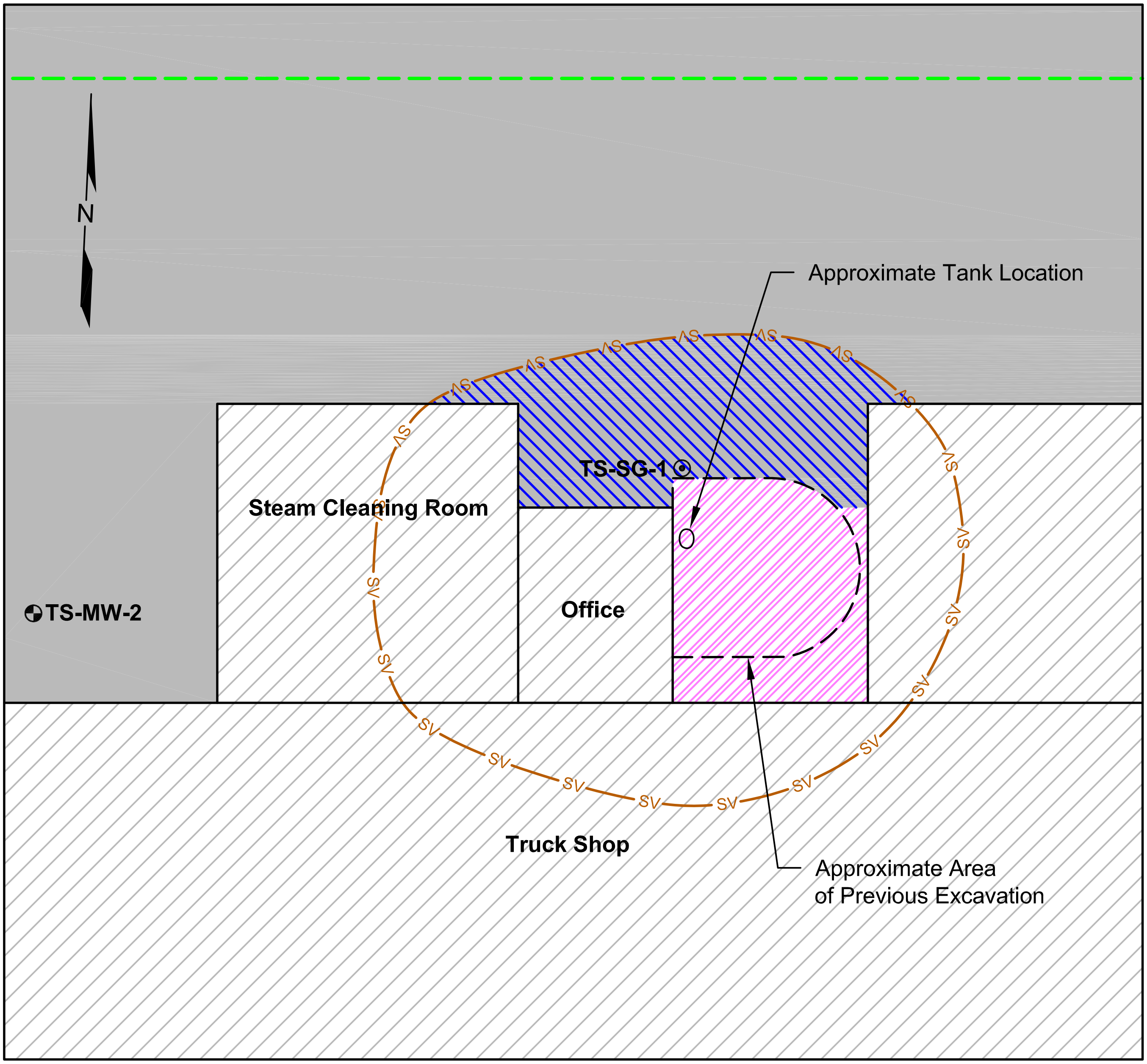
Figure 2-9

Near-Surface Soil AOCs - Potential Capping or Pavement Repair Areas
Truck Shop Area



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Potential Cap Only

Potential Pavement Repair

Near-Surface and Deep Vadose Zone Soil

VOC (Stoddard Solvent) Area of Screening Level Exceedance

SVOC (Heavy Oil) Area of Screening Level Exceedance

20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation

Existing Paved Area

Existing Building

Exploration Location and Number

TS-MW-2 Monitoring Well

TS-SG-1 Soil Gas Probe

0 10 20

Scale in Feet

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Figure 2-10

Alternative A3 - Site Plan for SVE Treatment of VOC-Impacted Near-Surface Soil

ORB and Surrounding Areas

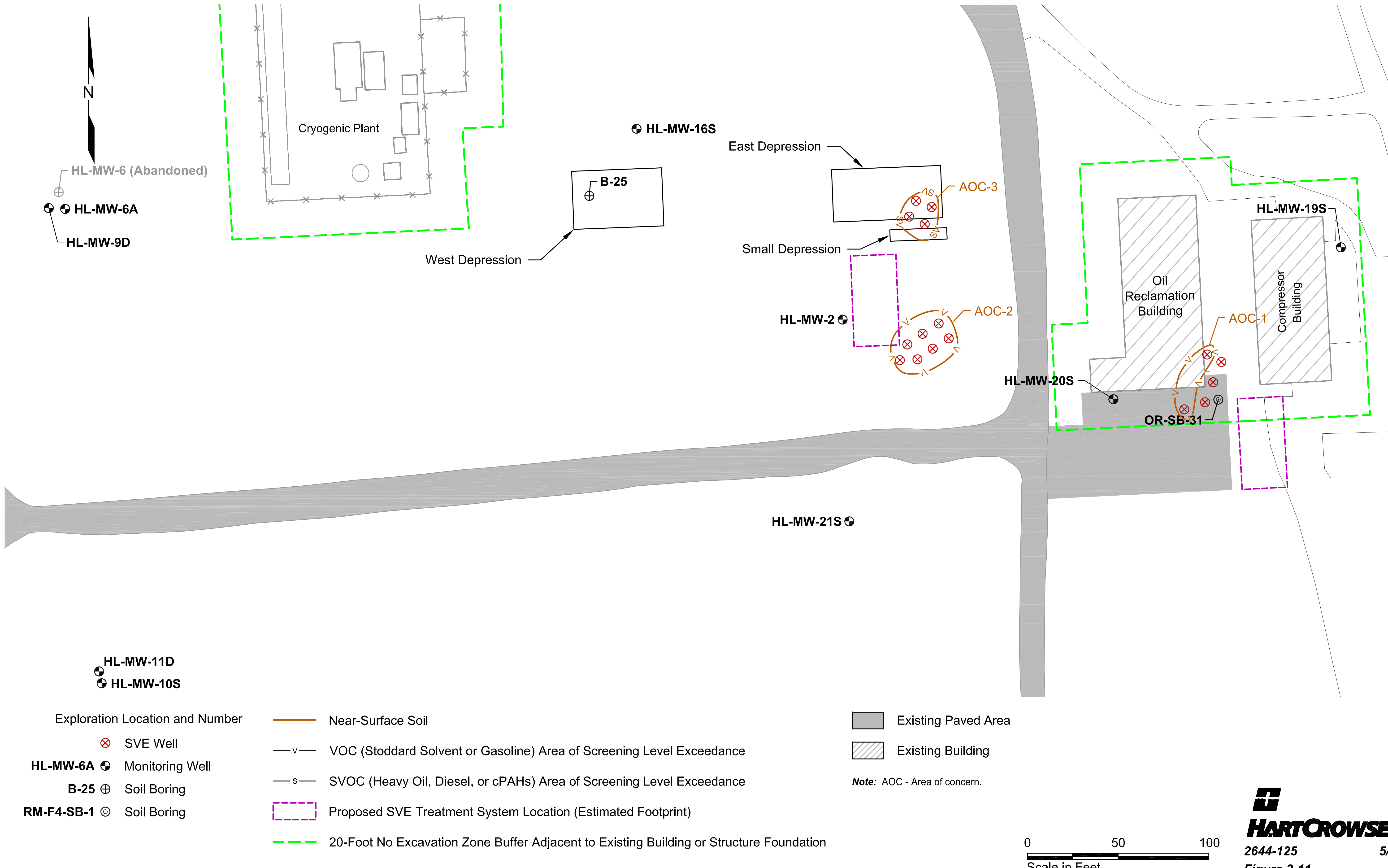

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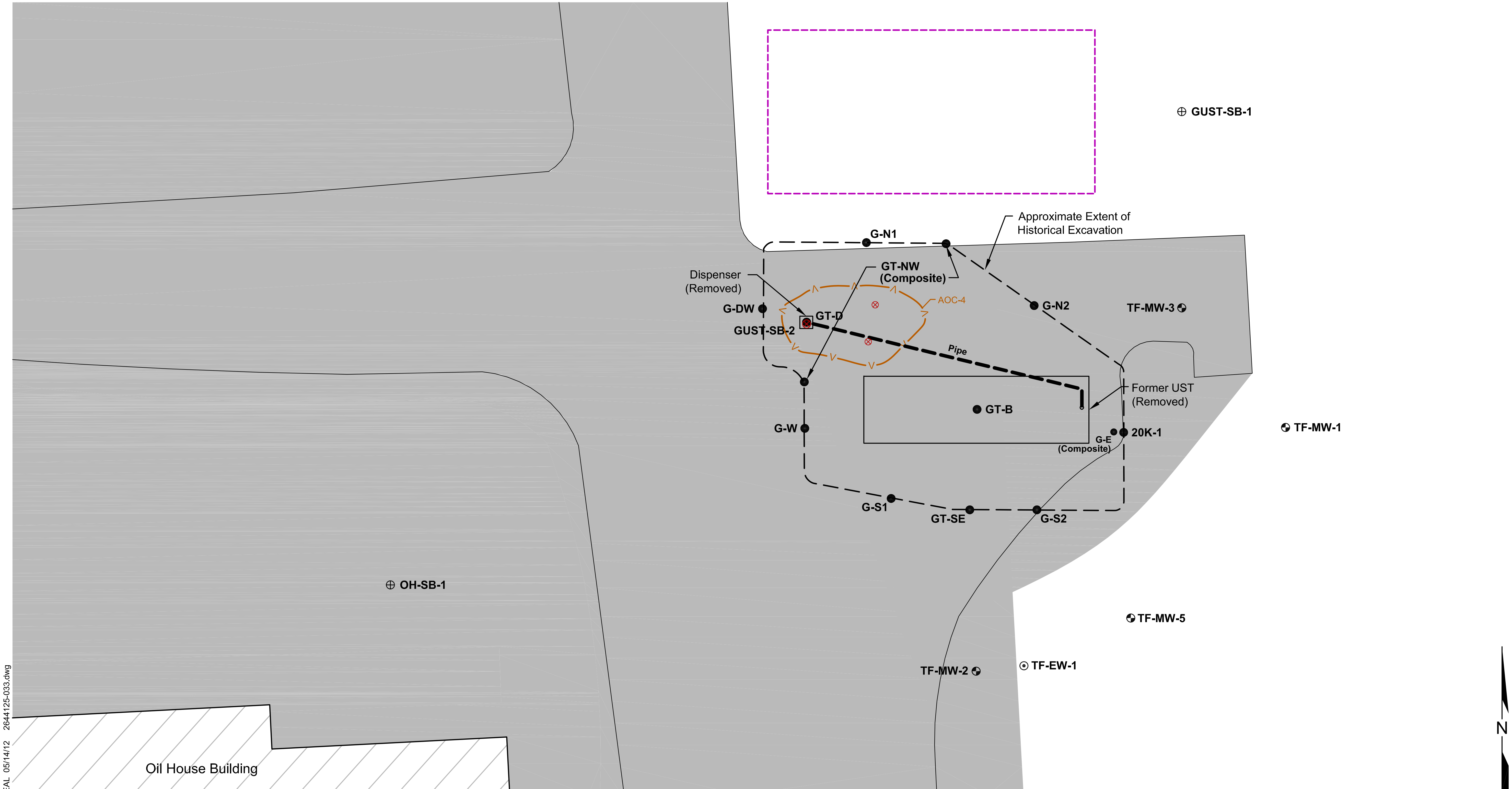
Figure 2-11

Alternative A3 - Site Plan for SVE Treatment of VOC-Impacted Near-Surface Soil

20,000-Gallon Leaded Gasoline UST Excavation



Exploration Location and Number

- SVE Well
- G-S1 Soil Verification Sample
- TF-MW-3 Existing Well
- GUST-SB-1 Soil Boring
- Near-Surface Soil
- VOC (Gasoline) Area of Screening Level Exceedance
- Proposed SVE Treatment System Location (Estimated Footprint)
- Existing Paved Area
- Existing Building

Note: AOC - Area of concern.

0 15 30
Scale in Feet

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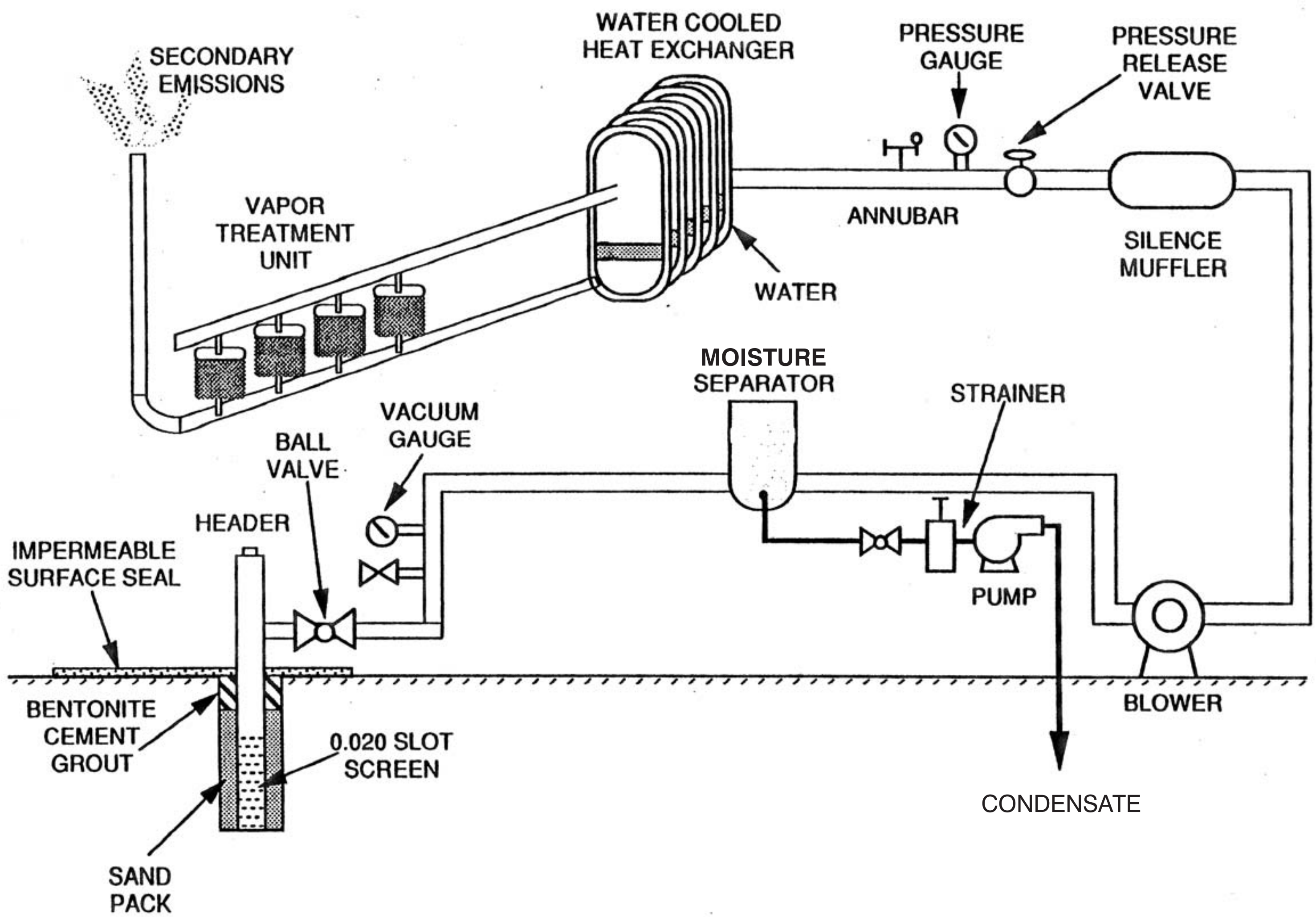
Figure 2-12

Alternative A3 - Typical Soil Vapor Extraction Process Flow Diagram



Adapted from Soil Vapor Extraction Technology Handbook (EPA 1991).

NOT TO SCALE

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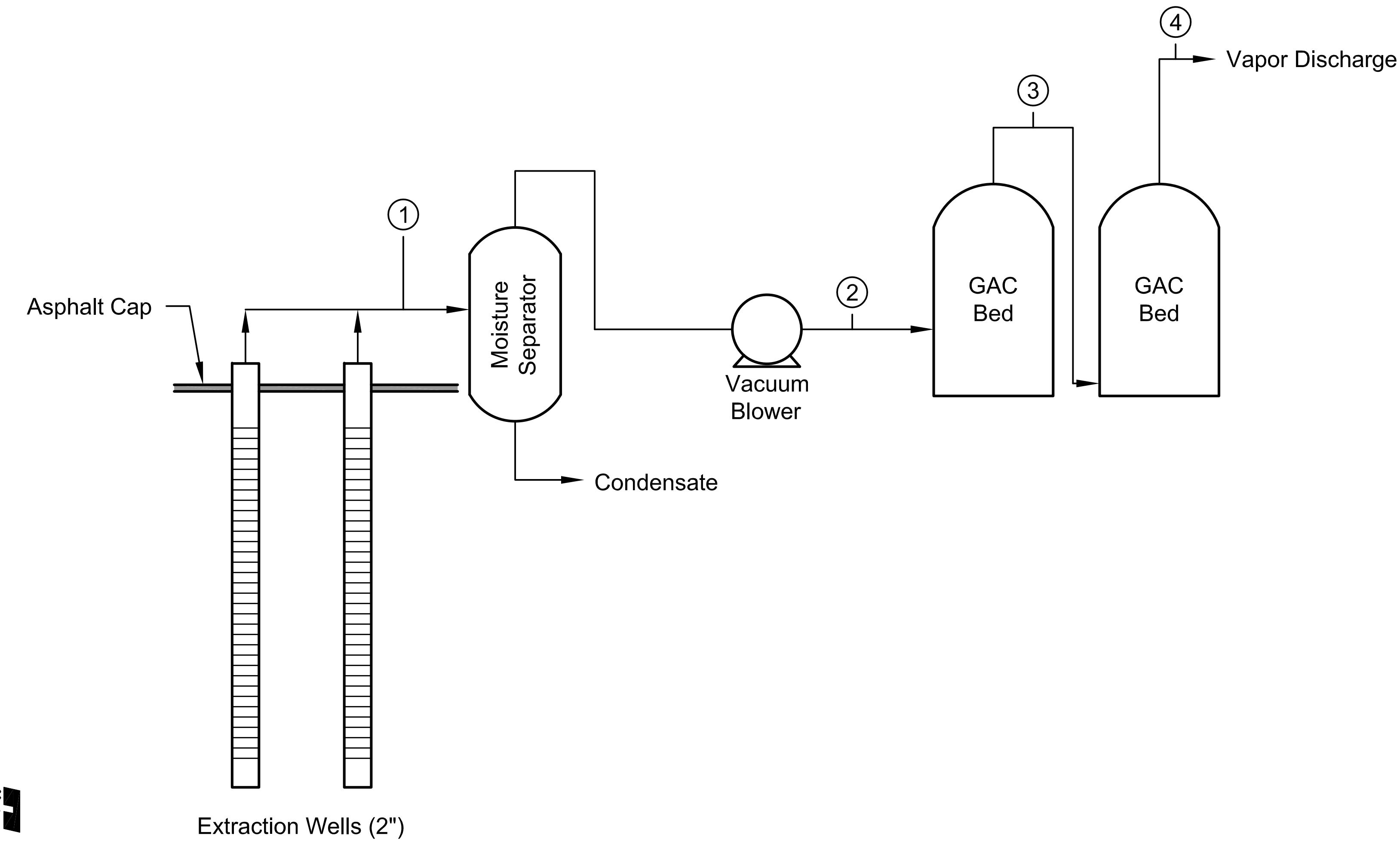
Figure 2-13

Alternative A3 - SVE Treatment Train Sampling Locations



1 Sampling Location and Number

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Figure 2-14

Alternative A5a - On-Site Biotreatment Layout

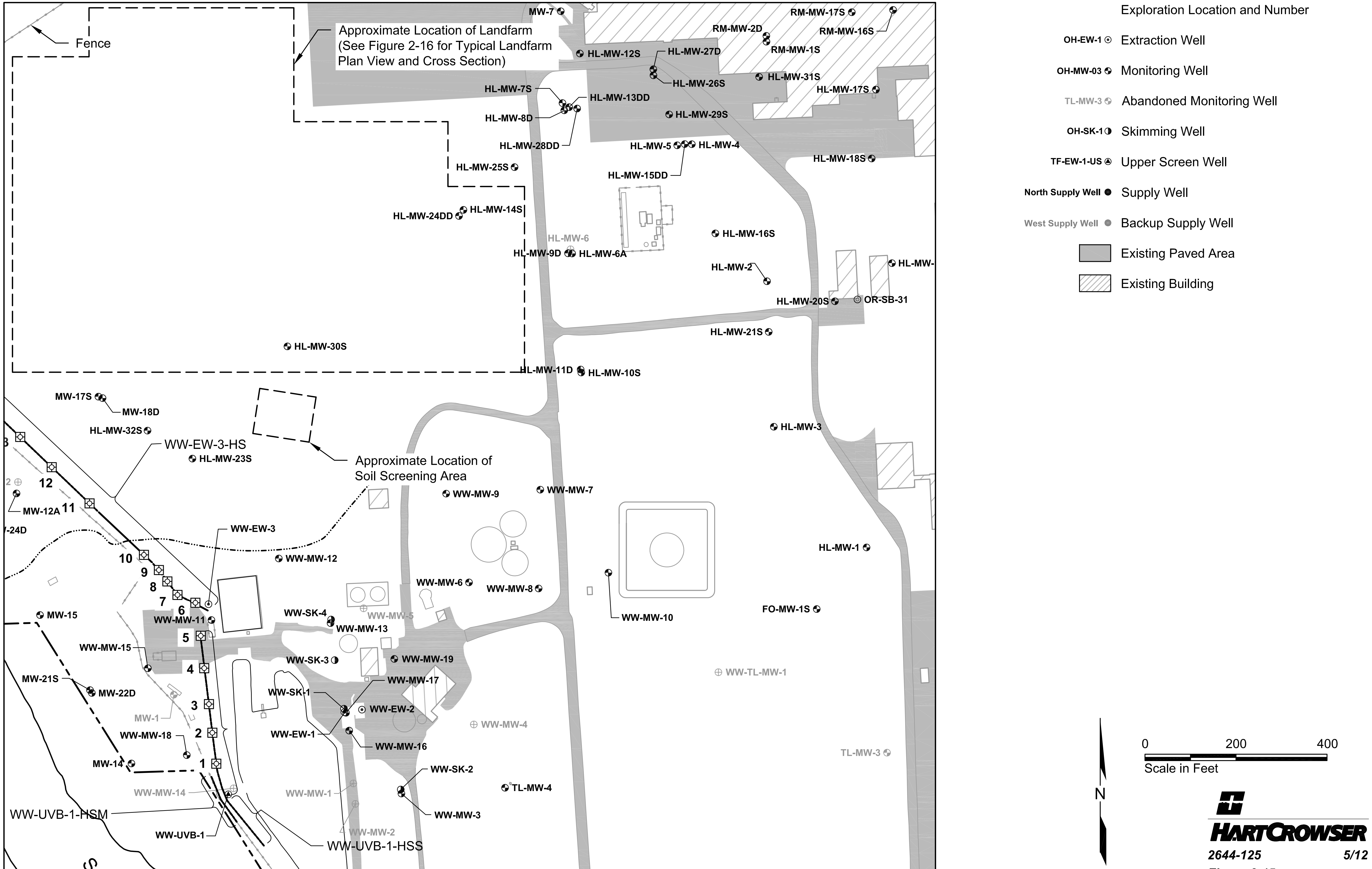

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Figure 2-15

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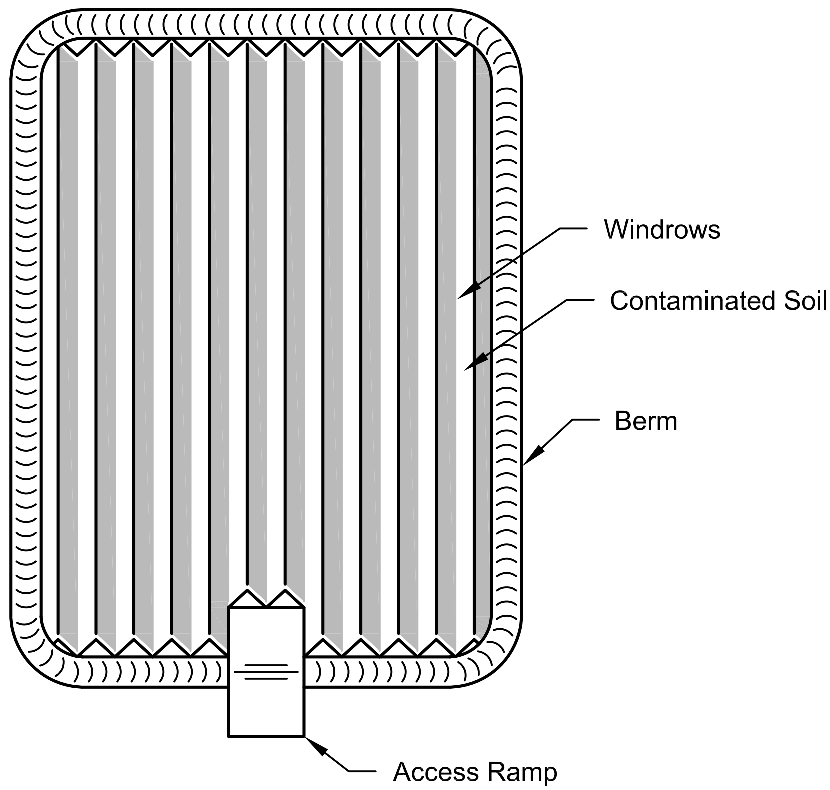
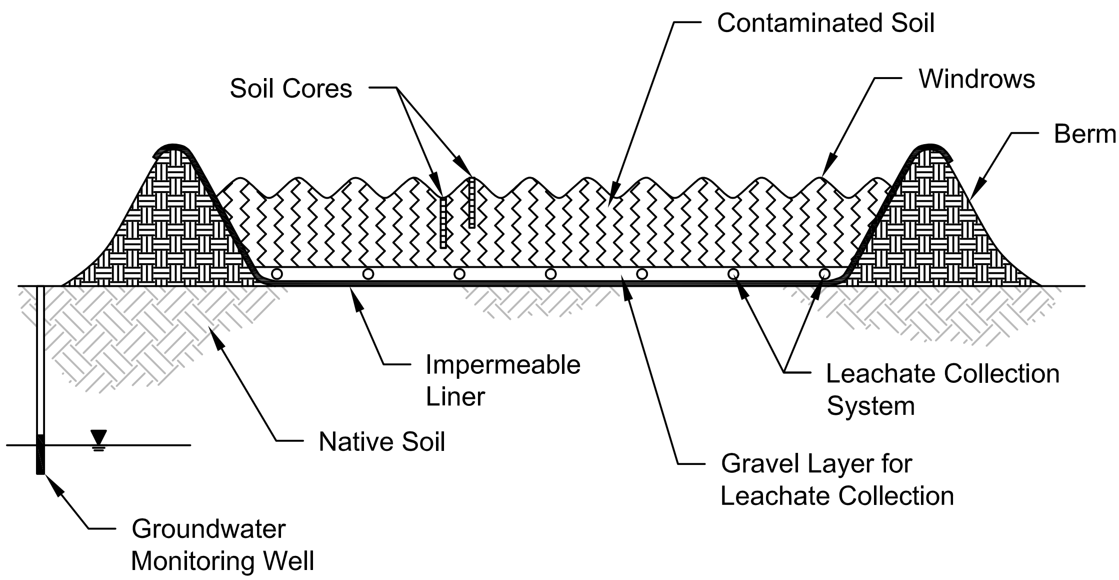
Alternative A5a - Typical Landfarm Design



PLAN VIEW
NOT TO SCALE



CROSS SECTION
NOT TO SCALE

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Adapted from How to Evaluate Cleanup Technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviers (EPA 1994)

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Figure 2-16

Alternative A5b - On-Site Thermal Treatment Layout

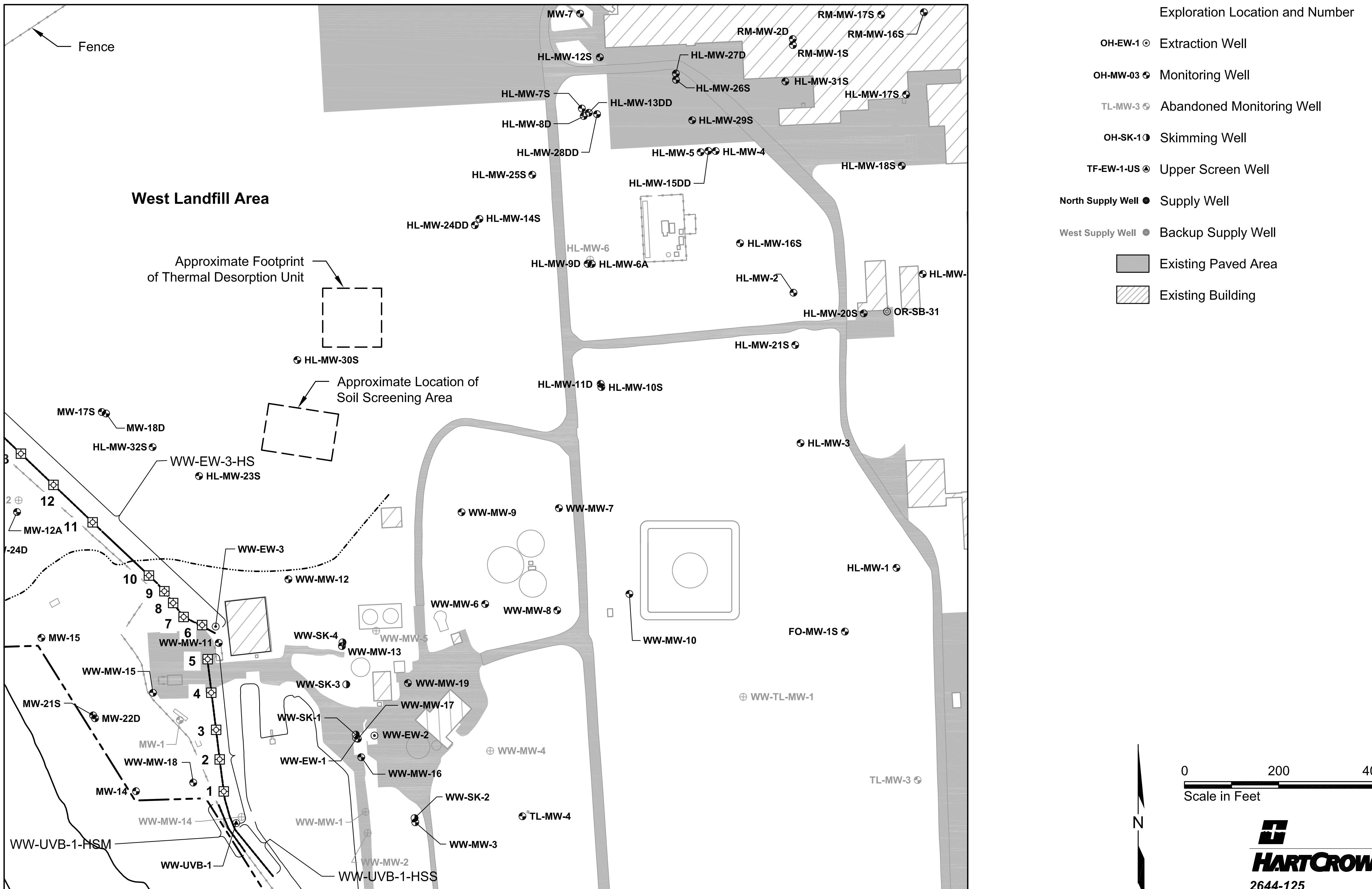

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Figure 2-17

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Alternative A5b - Process Flow Diagram for Thermal Desorption

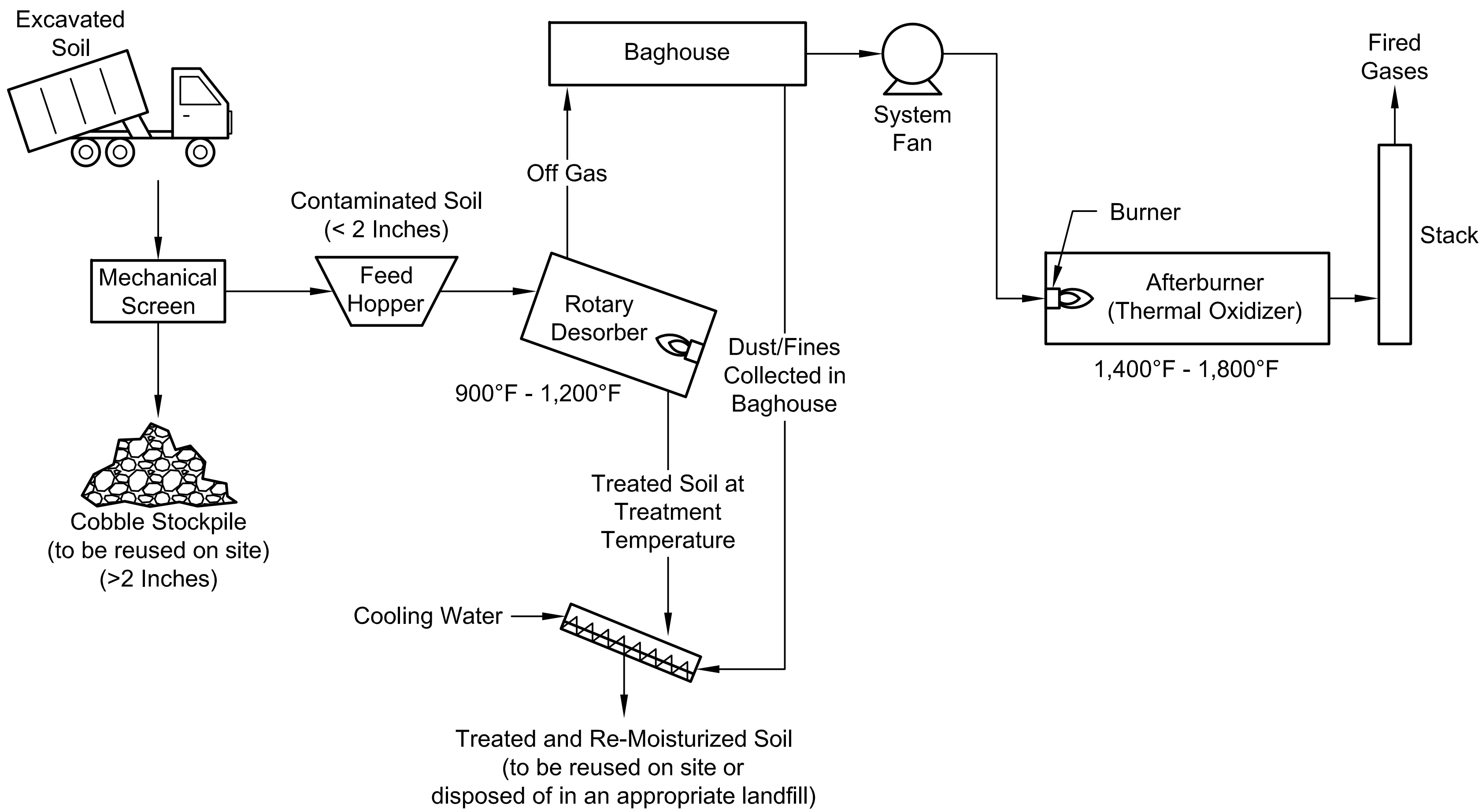

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Figure 2-18

Alternative A6 - Process Flow Diagram for Incineration

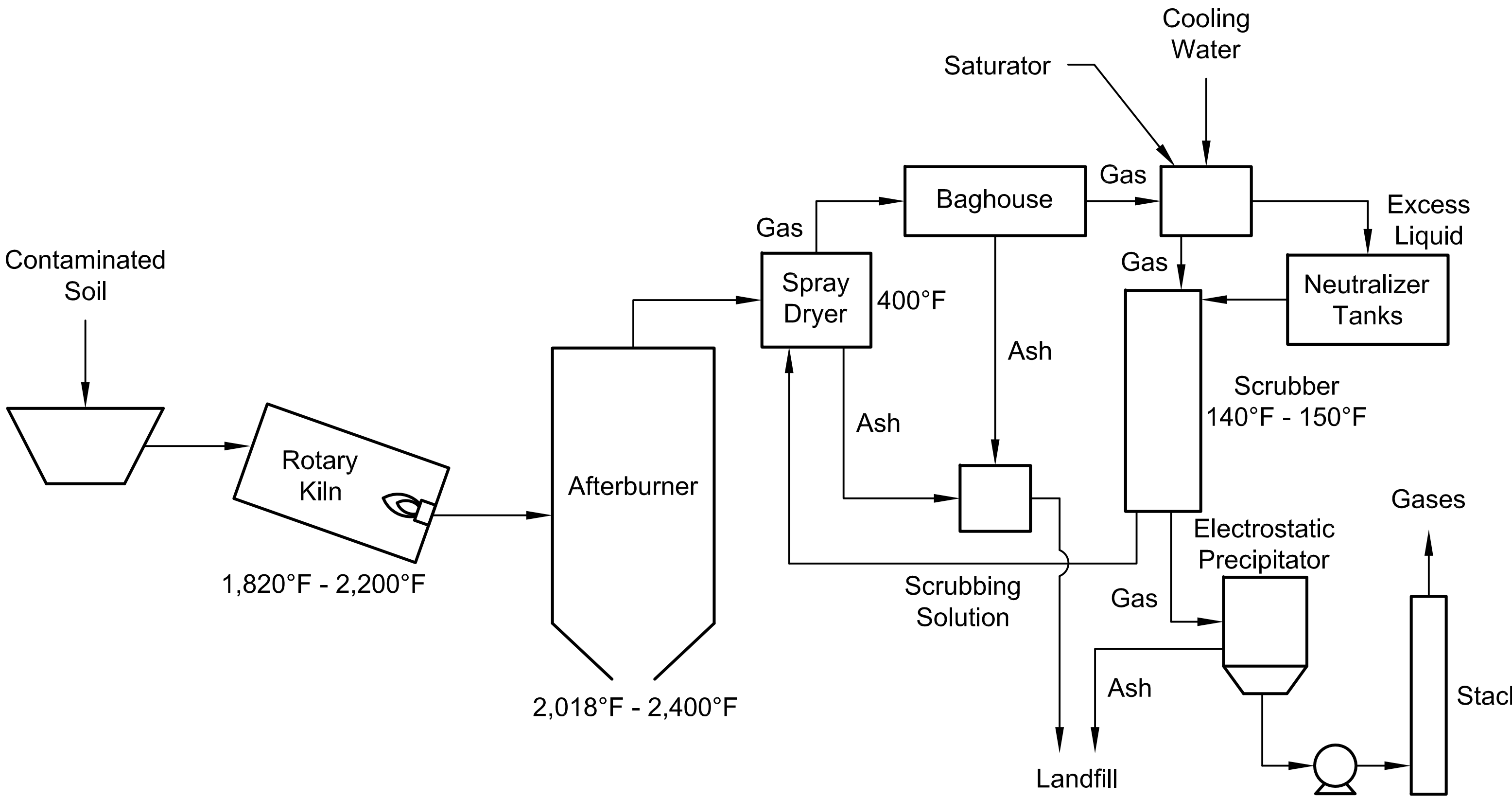

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Figure 2-19

CONTENTS <u>Page</u>

CONTENTS (Continued)

TABLES

FIGURES

3.0 REMEDIATION ALTERNATIVES FOR DEEP VADOSE ZONE SOIL

Section 3 of this feasibility study (FS) evaluates the technology-based remedial alternatives identified in the Feasibility Study Technical Memorandum (FSTM) (Hart Crowser 2012c) for deep vadose zone soil, based on the criteria in WAC 173-340-360, to identify the most appropriate technology-based alternatives for each individual constituent of concern (COC) or mixture of COCs in deep vadose zone soil throughout the Facility.

Section 3 of this FS focuses on remedial alternatives that will effectively treat volatile organic compounds (VOCs, e.g., Stoddard solvent), semivolatile organic compounds (SVOCs, e.g., diesel, heavy oil, and Kensol), polychlorinated biphenyls (PCBs), and metals (chromium and arsenic in isolated locations) in deep vadose zone soil. As defined in FSTM Section 3, deep vadose zone soil is located from 20 feet below ground surface (bgs) to the top of the water table, which ranges in depth from approximately 33 feet (near the river) to 68 feet in the mill area.

The areas of concern (AOCs) for each COC for deep vadose zone soil were defined in Section 3 of the FSTM. The AOCs were developed using screening levels (SLs) identified in the FSTM. These COC-specific AOCs are consolidated on Figure 3-1 of this FS, which depicts the COC-specific AOCs for deep vadose zone soil that are present in each of the operating areas of the Kaiser Facility.

The development and evaluation of remedial alternatives incorporate the estimated masses of COCs in the various AOCs at the Facility. Because the soil matrix at the Facility consists mostly of gravel and cobbles (Hart Crowser 2012b), the estimated COC masses were adjusted to account for the presence of these soil types. The mass estimate assumes that the COCs in collected soil samples were associated with the silt (when present), sand, and organic material (if any) that were present in the sample. The gravel and cobble portion of the sample was either not sent to or not analyzed by the laboratory, since cobbles would not fit in the sample jar and gravel would have to be pulverized in the laboratory prior to analysis. As a result, the concentration of COCs reported by the laboratory is an overestimate of the actual *in situ* concentration of COCs in soil at the Facility.

Nonetheless, the laboratory values were reported in the Final Soil Remedial Investigation (RI) (Hart Crowser 2012b) without accounting for the gravel and cobbles, since they represent a conservative estimate of the actual concentration of COCs present at the Facility, and contribute to a conservative approach to estimating risks to human health and the environment posed by COCs. Data indicate that at least 30 percent of Facility soil is greater than 2 inches in diameter (i.e., cobble size). Grain size distribution data from the Facility indicate that an average of 54 percent of the material is retained on a No. 4 sieve (0.187 inch). This fraction is considered gravel and cobbles (Hart Crowser 2012b).

The mass of COCs in each soil AOC (i.e., near-surface, deep vadose zone, and smear zone soil) presented in this FS were reduced by 54 percent from the values presented in the Final Soil RI and the FSTM to develop a more accurate estimate of COC mass.

As discussed in Section 2.0.1, Ecology developed preliminary cleanup levels (PCULs) for both a standard point of compliance (POC) and a conditional POC (Ecology 2010a and 2010b). The SLs and PCULs for soil at the Facility are compared in Table 2-1. Although the soil and groundwater PCULs were provided during the writing of this FS report, Ecology has allowed the continued use of the SLs in developing and evaluating the remediation alternatives for vadose zone soil presented herein (Ecology 2010b). Continuing to use the SLs in this regard ultimately does not significantly affect the evaluation of individual soil remediation alternatives, the evaluation of differences among alternatives, or the identification of a preferred alternative.

The SLs and PCULs for the COCs in the deep vadose zone are in general agreement, except for total PCBs (refer to Table 2-1). The difference between SLs and PCULs affects the delineation of AOC boundaries, which in turn influences other estimated parameters, such as impacted soil volumes and total mass of COCs. For instance, the total AOC area for PCBs in deep vadose zone soil would likely increase in size if the PCULs for the standard POC were used to delineate the boundaries rather than the SL. Conversely, if a conditional POC is granted, then the total AOC area would likely decrease in size.

The SLs for gasoline, diesel, heavy oil, and Kensol are the same as the PCULs for both standard and conditional POCs, so there would be no change in total AOC size for these COCs. Both the SL and the PCUL for arsenic are based on its natural background concentration in the Spokane area and are not dependent on the POC. The PCUL for arsenic is slightly lower than the SL, and a slightly larger AOC may result in the use of this PCUL.

The change in AOC size would not affect the outcome of the evaluation of the alternatives for deep vadose zone soil. Ultimately, the AOCs will be determined based on final CULs identified by Ecology and presented in the Cleanup Action Plan (CAP).

The most appropriate technology-based alternatives for deep vadose zone soil identified in Section 3 will be assembled to identify the appropriate area-based remedial alternative(s) for each operating area of the Facility (e.g., Oil House area, Wastewater Treatment area) and for the petroleum hydrocarbon and the Remelt/Hot Line groundwater plumes in Section 6 of this FS.

This section evaluates remedial technologies that were judged to be the most applicable to COCs in deep vadose zone soil by the FSTM. Section 3 is organized as follows:

- Section 3.1 – Description of Remedial Alternatives for Deep Vadose Zone Soil;

- Section 3.2 – Evaluation of Remedial Alternatives for Deep Vadose Zone Soil; and

- Section 3.3 – Comparative Analysis of Remedial Alternatives for Deep Vadose Zone Soil.

Estimated costs have been prepared for the deep vadose zone soil remedial alternatives. These costs are summarized for each alternative in their respective descriptions in Section 3.1. Cost estimate summary tables and backup calculations for each alternative are provided in Appendix B. Table B-1 in this appendix compares the net present value costs for the deep vadose zone soil remedial alternatives. These estimated costs are used in Sections 3.2 and 3.3 as part of the process for evaluating each technology-based remedial alternative, and selecting the most appropriate alternative for each COC group present in deep vadose zone soil. The same cost estimation resources as described in Section 2.2.1 were used to prepare estimated costs for the deep vadose zone soil remedial alternatives. The cost tables in Appendix B are annotated to reflect the resources used to develop an estimated cost (-35 to +50 percent) for each line item.

3.1 DESCRIPTION OF REMEDIAL ALTERNATIVES FOR DEEP VADOSE ZONE SOIL

The technology-based remedial alternatives developed by the FSTM are discussed in this section as follows:

- Section 3.1.1 – Alternative B1: Institutional Controls, Monitoring, and Monitored Natural Attenuation;

- Section 3.1.2 – Alternative B2: Institutional Controls, Monitoring, Monitored Natural Attenuation, and Containment;

- Section 3.1.3 – Alternative B3: Alternative B2 Plus Soil Vapor Extraction with Off-Gas Treatment;

- Section 3.1.4 – Alternative B4: Alternative B2 Plus *In Situ* Treatment; and

- Section 3.1.5 – Alternative B5: Containment of Non-Comingled PCB AOCs.

3.1.1 Alternative B1: Institutional Controls, Monitoring, and Monitored Natural Attenuation

Alternative B1, which consists of institutional controls, monitoring, and monitored natural attenuation (MNA), is common for each of the alternatives that are evaluated for the remediation of deep vadose zone soil at the Kaiser Facility. Deep vadose zone areas of interest at the Facility are shown on Figure 3-1. The elements of Alternative B1 are evaluated in Sections 3.2 and 3.3.

The institutional control and monitoring elements of Alternative B1 are the same as the elements contained in Alternative A1 for near-surface soil. These elements are described in Sections 2.1.1.1 and 2.1.1.2, respectively, and in Table 2-3, and will not be described further in Section 3. Additional institutional controls (if any) that are associated with each remedial alternative proposed for deep vadose zone soil are included in the description of that alternative provided in this section of the FS (i.e., Sections 3.1.1 through 3.1.5). Similarly, any additional monitoring requirements for each alternative are discussed in the section of the FS devoted to that alternative.

The MNA element, however, differs for Alternatives A1 and B1, in that the two alternatives involve different AOC locations and different exploration depths where natural attenuation will be monitored. The MNA plan for Alternative B1 is described below.

3.1.1.1 Monitored Natural Attenuation

A simplified and straightforward MNA approach is proposed for deep vadose zone soil at the Kaiser Facility, similar to the approach described for near-surface soil in Section 2.1.1.3. MNA will be implemented for the deep vadose zone soil for COCs that are judged to be most amenable to this remedial process (essentially COCs that fall under VOC, SVOC, and other petroleum hydrocarbon categories). MNA monitoring locations will be based on the AOCs where MNA-amenable COCs remain in place, with a spatial sampling frequency sufficient to monitor AOCs that meet this criterion. It is assumed that monitoring will occur every 5 years. The quantity of monitoring locations and samples to be collected per location are based on the following criteria:

- Monitoring locations will be determined based on a density of one location per 10,000 square feet (sq ft) of AOC (excluding AOCs that are currently beneath existing pavement and floor slabs).

- Soil explorations will be advanced at these locations to a maximum depth of 68 feet.

- Samples for laboratory analysis will be collected every 10 feet of impacted soil depth at each location.

Soil samples will be submitted for laboratory analysis of gasoline- and/or diesel-, and oil-range petroleum hydrocarbons, depending on the prevalent COC at the monitoring location.

3.1.1.2 Alternative B1 Estimated Cost

Assuming an operating period of 30 years and a discount rate of 7 percent, the total net present value (NPV) cost of Alternative B1, which includes institutional controls, monitoring, and MNA, is approximately $13.6 million (Appendix B, Table B-2). Backup for the summary in Table B-2 is presented in Tables B-7 through B-9. The estimated costs for Alternative B1 assume baseline institutional control and monitoring costs that are similar to those for Alternative A1 (see Table A-2 in Appendix A).

3.1.2 Alternative B2: Institutional Controls, Monitoring, Monitored Natural Attenuation, and Containment

Alternative B2 adds the additional protection of containment to Alternative B1. The same containment technologies that are judged appropriate for near-surface soil at the Kaiser Facility, which include asphalt, concrete, and multi-layer caps, also apply to deep vadose zone soil.

Multi-layer capping technology will be used to extend the footprint of the existing multi-layer cap in the Hoffman Tank area. As can be seen on Figure 3-2, the PCB AOC boundary in the Hoffman Tank area appears to abut or extend slightly beyond the edge of the existing multi-layer cap in this area. Since the estimated boundary of the AOC is approximate, the edge of the AOC boundary may actually reside entirely beneath the existing cap, or it may extend beyond the edge of the cap. It is conservatively assumed that the existing multi-layer cap in the Hoffman Tank area will be extended as a contingency in the event that the PCB AOC in this area does extend beyond the existing cap. The necessity of this measure will be further assessed during the remedial design phase of the preferred alternative identified in Section 6 of this FS.

These containment technologies and their selection criteria are described in Section 2.1.2.2, and the performance and confirmational monitoring associated with the installation and long-term maintenance of asphalt and concrete caps are described in Section 2.1.2.3. Section 3.1.2.1 discusses the development of the containment footprint for deep vadose zone soil AOCs.

3.1.2.1 Footprint of the Containment Cap for Deep Vadose Zone Soil

The AOCs for each COC for deep vadose zone soil were defined in Section 3 of the FSTM. These COC-specific AOCs are consolidated on Figure 3-1 of this FS, which depicts the COC-specific AOCs for deep vadose zone soil that are present in each of the operating areas of the Facility. The boundaries of the COC-specific AOCs were determined by comparing measured COC concentrations with the SL for that COC. Figure 3-1 and detail Figures 3-2 through 3-5 indicate areas where capping may potentially be implemented. Figure 3-1 also shows deep vadose zone soil AOCs that are entirely beneath existing paved areas or beneath building floor slabs. The lateral area of deep vadose zone soil that could be contained for the purposes of Section 3 of the FS is estimated as follows, using the same methodology employed for near-surface soil in Section 2.1.2.1: (1) Start with the overall areal footprint of the consolidated deep vadose zone soil AOCs shown on Figure 3-1; then (2) subtract the area of existing floor slab and pavement to estimate the area of potential new cap. For the purpose of this FS, it is assumed that existing floor slabs, roads, and other paved surfaces at the Facility are acceptable as containment caps in their current condition. It is likely that some of the existing paved surfaces at the Facility will need to be upgraded to act as an effective containment, however. This issue will be addressed during the remedial design phase of the preferred alternative identified in Section 6 of this FS.

The consolidated area of deep vadose zone soil AOCs totals approximately 44,000 sq ft, of which approximately 62 percent (27,400 sq ft) is located below existing floor slabs, pavement, or caps (i.e., existing Hoffman Tank area multi-layer cap) within the operating areas. Based on the areal estimation approach described above, the total area of AOC-based potential new cap is approximately 16,600 sq ft. The multi-layer cap extension in the Hoffman Tank area will add approximately 3,200 sq ft to the estimated 500 sq ft AOC-based area at this location, which results in a total potential new cap area of approximately 19,800 sq ft. The types of cap construction considered for deep vadose zone soil include asphalt, concrete, and multi-layer cap construction, which are assumed to have areas of approximately 13,700, 2,400, and 3,700 sq ft, respectively.

Some of the deep vadose zone soil AOCs overlap or coincide with existing near-surface soil AOCs. When considering the deep vadose zone and near-surface soil AOCs together, the overlap between these areas results in a total cap footprint that is smaller than when considering these soil AOCs separately. Thus, the footprint of the containment cap for deep vadose zone soil described in this section is not indicative of the final containment footprint that may be recommended for the Facility. This final footprint will depend upon the remedies selected for the other segments of the Facility (e.g., near-surface soil, petroleum groundwater plume) as described in Sections 2 and 4 through 6 of this FS and the final CULs selected by Ecology in the CAP. The potential new cap area for deep vadose zone soil of approximately 19,800 sq ft and respective areas of the different types of cap (asphalt, concrete, and multi-layer) are used to estimate the cost of this capping alternative, and the potential cap overlap between the deep vadose zone and near-surface soil AOC is not considered further in this section.

Capping materials will be selected for the deep vadose zone soil AOCs based on the criteria listed in Section 2.1.2.2. For the purpose of estimating costs for Alternative B2, it is assumed that, excluding the area of the multi-layer cap extension in the Hoffman Tank area, 85 percent of the remainder of deep vadose zone soil AOC area will be capped with asphalt and 15 percent with concrete. Some AOCs that are covered by existing pavement may require repair or replacement to implement a cap. Areas of potential pavement repair, essentially existing paved areas that overlie a deep vadose zone soil AOC, are shown on Figures 3-1 through 3-5. For estimating costs in this section, it is assumed that pavement repair will not be required for these areas.

3.1.2.2 Monitoring Requirements for Alternative B2

Monitoring will be required during installation of the containment caps in addition to subsequent monitoring during the operation and maintenance (O&M) period of the caps. These monitoring requirements are analogous to the requirements discussed for Alternative A2 for near-surface soil, and are discussed in Section 2.1.2.3 and summarized in Table 2-4.

After installation of the cap, initial permeability typically is measured by collecting asphalt and/or concrete cores at a sampling density specified in the engineering plans and specifications. To estimate costs for cap installation for

Alternative B2, it is assumed that, initially, permeability samples will be collected from asphalt or concrete caps at a frequency of one sample per 10,000 sq ft of cap area. The cost estimates further assume that cap integrity will be visually monitored on an annual basis. If visual inspection indicates a breach of asphalt or concrete cap integrity, the damaged pavement will be further assessed and subsequently removed and replaced or repaired at that location, if warranted. It is estimated that the life span of asphalt and concrete caps is approximately 20 years. For the purpose of cost estimation, it is assumed that the caps will require repair of 5 percent of their area per year.

3.1.2.3 Alternative B2 Estimated Cost

Assuming an operating period of 30 years and a discount rate of 7 percent, the total NPV cost of the unique elements of Alternative B2 (which excludes the elements of Alternative B1 that are included in this alternative) is approximately $1.1 million (Appendix B, Table B-3). Backup cost information for the summary in Table B-3 is also provided in Appendix B, as referenced in the notes in Table B-3. The total estimated NPV cost of Alternative B2 is $14.7 million.

3.1.3 Alternative B3: Alternative B2 Plus Soil Vapor Extraction with Off-Gas Treatment

Alternative B3 adds soil vapor extraction (SVE) to Alternative B2 for those areas of the Facility where VOCs are present in deep vadose zone soil at concentrations above SLs.

3.1.3.1 Deep Vadose Zone Soil Areas Where SVE Will Be Implemented

There are three AOCs with VOC concentrations above the SLs in the deep vadose zone soil horizon at the Facility. The AOC boundaries and the concentration of VOCs present in the AOCs were estimated in Section 3.5 of the FSTM. The method used to estimate the concentration of VOCs present in each AOC provided a very conservative overestimate of the concentration of VOCs that are present in each AOC (refer to Section 2.6 of the FSTM).

For the purposes of this discussion, these three AOCs will be identified as AOC-6, AOC-7, and AOC-8 (VOC AOC-1 through AOC-5 are referenced in Section 2.1.3.1 for near-surface soil). These three AOCs are in the Oil House area and are impacted by Stoddard solvent (CAS No. 8052-41-3) that is comingled with SVOCs and/or PCBs. Additional information on Stoddard solvent is presented in the Agency for Toxic Substances and Disease Registry's (ASTDR) Toxicological Profile for Stoddard solvent (ASTDR 1995).

AOC-6 and AOC-7 are located in the Tank Farm Kensol Spill area (see Figure 3-6). AOC-6 is located north of the AST Tank Farm and is approximately centered on well TF-EW-1-US (Figure 3-6). The average concentration of Stoddard solvent in this area is approximately 260 milligrams per kilogram (mg/kg). AOC-6 is approximately 890 sq ft, and the total mass of Stoddard solvent in this area is approximately 300 pounds. AOC-7 is located west of the AST Tank Farm (Figure 3-6). The average concentration of Stoddard solvent in AOC-7 is 150 mg/kg. The footprint of AOC-7 is approximately 1,900 sq ft, and the mass of Stoddard solvent in this area is approximately 370 pounds. The depth of contamination extends from 41 to 68 feet bgs in both AOC-6 and AOC-7, and overlaps the Kensol AOC in the Tank Farm Kensol Spill area. The average concentration of Kensol in this area is approximately 15,000 mg/kg.

AOC-8 is located west of the Oil House building near two former French drains (see Figure 3-7). The average concentration of Stoddard solvent in this AOC is approximately 230 mg/kg, and the size of the AOC is approximately 700 sq ft. The depth of contamination extends from 62.5 to 68 feet bgs in this area. The mass of Stoddard solvent present in AOC-8 is approximately 40 pounds. This area is also impacted by PCBs, Kensol, and heavy oil with average concentrations of approximately 80, 7,400, and 2,800 mg/kg, respectively.

The areas described above are near Facility operating areas, so it is assumed that utilities (such as electricity, natural gas) needed to implement an SVE system will be readily available. Mobilization costs include connection to these existing utilities for SVE treatment system operation.

An estimated 700 pounds of Stoddard solvent is present in AOC-6, AOC-7, and AOC-8. These AOCs also contain an estimated 107,000 pounds of comingled SVOCs. The selection of a remedial alternative for the deep vadose zone soil in these AOCs is likely to depend more on the potential risk reduction associated with the treatment of SVOCs, than the potential risk reduction associated with the treatment of the VOCs. Remedial alternatives potentially appropriate for the treatment of SVOCs in deep vadose zone soil are evaluated in Section 3.1.4.

Stoddard solvent may sorb to the soil matrix that is impacted with SVOCs. If this sorption occurs, it will reduce the removal and treatment effectiveness of the SVE system. For the purposes of this section, it is assumed that an SVE system can be operated effectively in this SVOC (Kensol)-rich environment. Pilot-scale tests would be required to define the operating parameters and treatment efficiency of the SVE system.

3.1.3.2 SVE System Description

As described in Section 2.1.3.2, SVE is a process that extracts volatile contaminants from the soil matrix by applying a vacuum across the targeted treatment area through a network of extraction wells. The application of a vacuum enhances contaminant volatilization and draws contaminant vapor to the surface via the extraction wells. Prior to discharge to the atmosphere, the extracted vapor stream typically is treated to remove contaminants. SVE is considered to be one of the most cost-effective remediation processes for soil contaminated with gasoline, solvents, or other VOCs (Johnson et al. 1990). SVE is a presumptive remedy for sites with VOCs present in soil where treatment is necessary (EPA 1993b and 1996e).

SVE Process Principles

In the SVE process, VOCs are volatilized and moved into the ambient air that is introduced into the subsurface by the application of a vacuum. Mass transfer occurs because of the VOC concentration gradient between the soil matrix and vapor stream; the greater the gradient, the greater the rate of transfer between matrices. Eventually, the soil VOC concentration becomes too low for mass transfer to be an effective means of contaminant removal. At this point, no significant change in VOC concentration would occur by continued SVE system operation (Wong et al. 1997).

Efficiency of treatment by SVE depends on the characteristics of the contaminant, soil properties, and site conditions (Wong et al. 1997). It is assumed that SVE could be a relatively effective treatment method at the Facility since Stoddard solvent is composed of volatile compounds, concentrations are not too low, and the soil matrix is porous, which will help movement of air in the subsurface. However, as discussed in Section 2.1.3, there are attractive forces between SVOC and VOC compounds that may make extraction of VOCs more difficult. Pilot-scale studies will be needed to define design and operating parameters such as well spacing, required vacuum, and the removal efficiency that can be expected. For the purpose of this discussion, assumptions have been made for conceptual design and operating parameters, which are stated below.

SVE System Well Placement

SVE wells are typically placed in the area of contamination, and the number of wells depends on the air permeability of the soil matrix. In general, deep vadose zone soil at the Facility is poorly sorted sand and gravel (Hart Crowser 2012c). To assist with air circulation, passive venting wells can be added to the periphery of the AOC where SVE is being implemented. For near-surface soil (Section 2.1.3.2), it is assumed that SVE wells will be placed 10 feet apart; however, the radius of influence of SVE wells in porous soil has been shown to increase with increasing treatment zone depths (EPA 1991). Thus, for deep vadose zone soil it is assumed that the SVE wells will be placed approximately 20 feet apart down the centerline of the AOC, and passive venting wells will be placed along the periphery of the AOC.

As described in Section 2.1.3.2, field testing can be performed prior to installation to determine the actual radius of influence and well spacing. Based on the well spacing described above, it is assumed that AOC-6 will contain three extraction wells and two passive wells to assist with air circulation. AOC-7 is assumed to require four extraction wells and three venting wells, and AOC-8 is assumed to require two extraction wells and two venting wells. In the Tank Farm area, the depth of contamination extends from 41 to 68 feet bgs for both AOC-6 and AOC-7. Potential well locations are shown on Figures 3-6 and 3-7.

The SVE well screen interval will extend between 41 to 68 feet bgs to target the contaminated soil horizon in these AOCs. In the Oil House Drum Storage and French Drain area, contamination extends from 62.5 to 68 feet bgs. For this area, wells will extend to 68 feet bgs, and the final 5.5 feet will be screened. Similar to the near-surface soil SVE wells, 2-inch-diameter wells will be installed in the three AOCs. The top 5 feet of the well boring will be sealed with bentonite and concrete.

To summarize, a total of nine extraction wells and seven passive venting wells will be installed in AOC-6 through AOC-8, with a diameter of 2 inches and depth of 68 feet. The screen interval for wells installed in the Tank Farm area will extend from 41 to 68 feet bgs, and for wells in the Oil House Drum Storage and French Drain Area the screen interval will be 62.5 to 68 feet bgs.

SVE System Equipment and Location

As described in Section 2.1.3.2, the SVE system consists of conveyance and treatment appurtenances. Figure 2-13 presents a process flow diagram of a typical SVE system that uses carbon adsorption to remove VOCs from the effluent stream. As shown on that figure, extracted soil vapor is conveyed using a blower, which first passes through a moisture separator, which separates water droplets from the vapor stream to protect the internal workings of the blower. As described above, the VOC AOCs for vadose zone soil are rich with SVOCs (see Section 3.1.3.1), which may be drawn into the extracted vapor stream and may condense in the moisture separator. From the blower, the vapor stream is directed to an off-gas treatment system that uses catalytic oxidation or carbon adsorption to destroy or remove VOCs from the off-gas stream. Similarly to the near-surface soil SVE treatment system (Section 2.1.3), it is assumed that activated carbon beds will be used for off-gas treatment in the deep vadose zone soil SVE system. SVE treatment systems are available as trailer-mounted units.

An impermeable surface seal is used to improve SVE treatment efficiency (see Section 2.1.3.2). For the purpose of the cost estimate for this alternative, an asphalt cap will be used for those portions of the deep vadose zone soil VOC AOCs that are not currently under pavement. Section 2.1.2 describes the asphalt capping that may be applied in these areas, which is assumed to be the same as the asphalt capping used under Alternatives A2 and B2.

For treatment of deep vadose zone soil, it is assumed that one rented trailer-mounted SVE system, with one blower (150 to 200 mmHg vacuum and 200 scfm flow rate) and two 2,000-pound granular activated carbon (GAC) beds, will be brought to the Facility and used to treat the three VOC-impacted deep vadose zone soil AOCs. The trailer-mounted unit will also be equipped with an appropriately sized moisture separator and system control panel. The system control panel will consist of pressure gauges, flow meters, and system sensors linked to an autodialer, which automatically notifies system operators (typically by telephone) in the event of a disruption in system operation (Zvibleman, B., Onion Equipment, personal communication, 2010, and Sumrack, C., Schrader Environmental Services, personal communication, 2010).

In the Tank Farm area, because of the close proximity of AOC-6 and AOC-7, piping will be installed so that both areas can be treated without moving the trailer-mounted unit. AOC-6 will be treated first, followed by AOC-7. Then the SVE treatment unit will be moved to AOC-8 (Oil House Drum Storage and French Drain area) for treatment. The proposed SVE treatment unit locations are shown on Figures 3-6 and 3-7. Note that conveyance piping for these areas will have to be underground to prevent interference with Facility operations.

SVE Treatment Time Frame and Effectiveness

It is assumed that treatment will last approximately 12 months for each of AOC-6, AOC-7, and AOC-8 and that the SVE treatment system will run continuously. Areas will be treated consecutively for a total treatment time of approximately 3 years. Based on a carbon usage rate of 0.25 pound of COC per 1 pound of GAC, it is estimated that carbon will need to be replaced once while AOC-6 is being treated, and twice while AOC-7 is being treated. At the end of treatment for AOC-8, the carbon vessels will need to be emptied, and spent carbon will have to be sent to a regeneration facility. The VOC COCs adsorbed on the GAC will be destroyed during the carbon regeneration process.

The goal of SVE treatment is to decrease the concentrations of VOCs in deep vadose zone soil to concentrations that are below SLs (100 mg/kg for Stoddard solvent and gasoline). However, as mentioned above, this technology depends on the VOC mass transport mechanism between the soil and vapor matrices, and a point of diminishing returns will eventually be reached. It is assumed that for the three VOC-impacted AOCs that are treated, final VOC concentrations will be below SLs, since site conditions (such as high soil permeability) and the volatile nature of the contaminants should enable effective SVE treatment. It is conservatively assumed that post-treatment concentrations will be slightly below SLs; therefore, the total quantity of VOCs removed from AOC-6 through AOC-8 is estimated to total approximately 330 pounds.

3.1.3.3 Monitoring Requirements for Alternative B3

Per WAC 173-340-410, compliance monitoring includes protection, performance, and confirmational monitoring during system installation and operation, and at the end of cleanup efforts. Table 2-5 summarizes elements of the performance and confirmational monitoring judged appropriate for the SVE portion of Alternative A3. These elements are the same for Alternative B3, except as described below.

As described in Section 2.1.3.3, dust and VOC concentrations will be monitored on a daily basis during piping and well installation. Protection and performance monitoring will be performed during SVE system operation, which includes recording air pressures and flow rates in addition to cap integrity inspections. It is assumed that SVE system startup will last approximately two weeks, and the frequency of system monitoring will be higher during this period than during normal operation. Protection monitoring will be dictated by air permitting limits as described below.

SVE System Air Emission Monitoring

The Spokane Regional Clean Air Agency (SRCAA) is the lead regulatory agency for air quality in the Spokane area. The air emissions threshold for soil and groundwater remediation operations is greater than 0.5 ton (1,000 pounds) per year of combined toxic air pollutants (TAPs) and VOC emissions (based on SRCAA Regulation I, Article IV, Exhibit R, Item 9). At the Kaiser Facility, the total mass of VOCs in each vadose zone AOC is less than this threshold. Since it is assumed that these AOCs will not be treated simultaneously, it is likely that air quality permitting will not be triggered. However, for costing purposes, it is conservatively assumed that air quality will be monitored.

Benzene will also be monitored using colorimetric tubes at various points within the SVE system to determine carbon bed breakthrough and to determine when the point of diminishing returns has been reached.

SVE System Performance and Confirmational Monitoring

For the purpose of estimating costs, it is assumed that concentrations of benzene will be monitored at four locations within the SVE system. Monitoring locations will be at location (1) vapor inlet of the moisture separator; location (2) vapor inlet of the first GAC bed; location (3) the outlet of the first GAC bed; and location (4) the outlet of the second GAC bed. These locations are shown on the process flow diagram of the system (Figure 2-14). During the first two weeks of startup, it is assumed that colorimetric tubes will be used to monitor at these four locations within the system on a weekly basis. During normal operation, colorimetric tubes will be used for monthly monitoring at these four locations. On a quarterly basis, Summa canister samples will be collected at location (4) for laboratory analysis to monitor emissions for regulatory compliance. Summa canister sample analysis will provide results with greater accuracy for this assessment. Laboratory analysis will be provided by a third party.

Eventually, SVE treatment may reach a point of diminishing returns, where concentrations in the soil would be too low to maintain sufficient mass transfer and treatment no longer would be cost-effective. For this discussion, it is assumed that this point will be reached during treatment of deep vadose zone soil. At the point of diminishing returns, colorimetric tube measurements for benzene at location (1) should be relatively low and constant. To verify the end of treatment, it is assumed that one sample will be collected per week for three weeks using Summa canisters. Samples will be collected at location (1) and sent to a laboratory for analysis.

At the end of treatment, confirmational soil samples will be collected from the deep vadose zone VOC AOCs. Ecology's Guidance for Site Checks and Site Assessments for Underground Storage Tanks (Ecology 2003) was used to estimate the number of soil samples that should be collected for confirmational sampling. Table 5-3 in this Ecology guidance document defines the minimum number of soil characterization samples that should be collected from an excavated stockpile volume. Since soil treated by SVE will not be excavated, the number of confirmational samples is based on the initial volume of impacted soil. Based on this guidance, it is assumed that 12 soil borings will be drilled, and two soil samples will be collected from each boring for analysis.

As mentioned above, because of the relatively low initial concentrations of VOCs in the deep vadose zone soil AOCs and the permeable soil matrix, it is assumed that, after treatment, concentrations of VOCs will be below SLs.

3.1.3.4 Alternative B3 Estimated Costs

Estimated costs for Alternative B3 are provided in Appendix B, in Table B-4 and Tables B-11 through B-15. As mentioned above, it is assumed that one trailer-mounted SVE treatment unit, with a blower capacity of 200 scfm and two 2,000-pound carbon beds will be rented to implement this alternative. Because of the time it will take to treat these three areas (up to 36 months), it is assumed that the trailer-mounted unit will be enclosed for protection from ambient weather conditions.

Capital costs associated with the SVE treatment system include contractor mobilization and demobilization; mobilization of the trailer-mounted treatment unit; installation of asphalt caps, wells, and piping conveyance system; connection to utilities (such as electricity) for system operation; and off-site disposal of drilling cuttings from well installation. Capital costs also include monitoring during construction and system startup (see details in Section 3.1.3.3). Other capital costs include submittals, plans, site preparation items (such as permits and utility location), and professional and technical services costs (such as project management).

Annual costs include operation and maintenance, monitoring, and professional and technical services. Periodic costs include assumed costs for equipment replacement, moving the trailer-mounted treatment unit to different AOCs, GAC replacement, confirmational soil monitoring, and confirmational air monitoring at sampling location (1) within the SVE system (see Section 3.1.3.3 for more detail on monitoring).

Periodic costs for the first year of operation (AOC-6 receiving treatment) is assumed to include one GAC change-out (based on a carbon usage rate of 0.25 pound COC per 1 pound GAC), costs for mobilizing the trailer-mounted treatment unit, and sampling and analysis associated with system startup and at the end of the treatment period. During the second year, when AOC-7 is being treated, it is assumed that periodic costs incurred include two GAC change-outs and moving the trailer-mounted unit. Because of the lower mass loading expected from AOC-8 (approximately 40 pounds of Stoddard solvent), no GAC change-out will be required during the third year of treatment. Since treatment will last a total of approximately 36 months, periodic costs for Year 4 include final demobilization costs (e.g., removal of the rented treatment unit), confirmational soil sampling and analysis, and final carbon removal and regeneration.

The NPV of implementing Alternative B3 over a 30-year time period assuming a discount rate of 7 percent is estimated to total approximately $15.3 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 3.1.3 and listed in the cost tables contained in Appendix B. The portion of this estimated cost that is directly applicable to the operation of the SVE system in the three AOCs that will be treated is estimated to total approximately $600,000 (refer to Table B-4). Supporting cost backup are presented in Appendix B and citations to the appropriate backup tables are presented in summary Table B-4.

3.1.4 Alternative B4: Alternative B2 Plus In Situ Treatment

Alternative B4 adds *in situ* treatment to Alternative B2 for AOCs where SVOCs are present in deep vadose zone soil at concentrations above SLs and for those AOCs where SVOCs are co-located with PCBs. Alternative B4a adds *in situ* enhanced bioremediation to Alternative B2 while Alternative B4b adds *in situ* chemical oxidation. Enhanced bioremediation (addition of nutrients and other amendments to the subsurface) was the only *in situ* bioremediation technology retained for SVOCs in the vadose zone soil. These alternatives were developed in Section 3.6 of the FSTM.

As discussed below, a further evaluation of the implementability and reliability of *in situ* enhanced bioremediation for vadose zone soil at the Kaiser Facility was conducted. The result of this evaluation was that *in situ* enhanced bioremediation was rejected as a potential remedial alternative for deep vadose soil at the Facility. The remainder of this FS refers to *in situ* chemical oxidation as Alternative B4.

3.1.4.1 Areas of *In Situ* Treatment

The AOCs for each COC for deep vadose zone soil are defined in Section 3.5 of the FSTM. The AOC boundaries and the concentration of COCs present in the deep vadose zone soil AOCs were estimated in Section 3.5 of the FSTM. The method used to estimate the concentration of COCs present in each AOC provided a very conservative overestimate of the concentration of COCs that are present in each AOC (refer to Section 2.6 of the FSTM).

These COC-specific AOCs are consolidated on Figure 3-1 of this FS, which depicts the COC-specific AOCs for deep vadose zone soil that are present in each of the operating areas of the Kaiser Facility. Figure 3-8 depicts the SVOC

AOCs that are judged to be amenable to *in situ* treatment. Some of the AOCs are located below floor slabs within the operating areas. For the purposes of this section of the FS, it is assumed that AOCs that exist under a floor slab will not be treated *in situ* because of potential interruptions to Facility operations and since the floor slabs prevent rainwater and other liquids from reaching the vadose zone.

These AOCs are located in the eastern Cold Mill/Finishing area and the Truck Shop area. The AOC located near the Truck Shop area is relatively small, and the portion not under building foundations is adjacent to high power lines, which limits accessibility to this AOC. The *in situ* treatment area will also exclude the footprint of the existing multi-layer cap in the Hoffman Tank area to prevent damage to the existing cap. The total treatment footprint of the vadose zone SVOC AOCs that will be treated *in situ* for the purposes of this section of the FS is approximately 22,000 sq ft, which is 83 percent of the total SVOC deep vadose zone AOCs (refer to Figure 3-8).

The depth interval for each AOC is discussed in the FSTM (Appendix C) and presented in Table 3-15 of the FSTM. The depth intervals range from a 5-foot interval to almost the entire depth of the deep (greater than 20 feet bgs) vadose zone.

3.1.4.2 Evaluation of *In Situ* Enhanced Bioremediation

Microorganisms need moisture, electron acceptors, nutrients, and favorable environmental conditions (e.g., absence of toxic conditions) to grow and to degrade contaminants. Bioremediation in the vadose zone can be limited by the lack of soil moisture; moisture content of 50 percent or more is considered ideal for bioremediation (Wong et al. 1997). Subsurface conditions at the Facility (i.e., sandy gravelly soil) provide a limited holding capacity for soil moisture. The stormwater infiltration rate is estimated to be 200 in/hr based on subsurface conditions, this means the water would travel through the subsurface at a rate of at least 200 in/hr (because the flow would be restricted to the pore space). One pore volume for the deep vadose zone AOCs is approximately 2 million gallons. The addition of at least 4 million gallons of water per day would be need to sustain a 50 percent moisture content in the deep vadose zone.

For *in situ* enhanced bioremediation to be successful, the microbes would need to be in direct contact with the SVOCs, moisture (and the oxygen it contains), and nutrients. Because of the highly porous soil in the SVOC AOCs, it may be difficult to achieve adequate lateral coverage of the added water and nutrients. In addition, the nutrient-amended water will likely pass through the SVOC zone without sufficient residence time for the biological conversion of SVOCs to benign end products to occur. Most bacteria degrade contaminants that are present in the dissolved phase. Over time, diffusion would cause additional SVOC mass in the light non-aqueous phase liquid (LNAPL) and sorbed phases to move into the dissolved phase, although this may take a long time. A surfactant would be required to remove the heavy-end petroleum from the LNAPL and sorbed state into solution to make the SVOCs more bioavailable.

There is the added risk that the addition of water, nutrients, and surfactant would cause the desorbed COCs (SVOCs and any co-mingled PCBs) to migrate to the smear zone and groundwater table prior to treatment. It is also likely that a substantial amount of the added water, nutrients, and surfactant would reach the groundwater. While the existing Interim Remedial Measure (IRM), would likely keep these additives and any COCs that are released from entering the Spokane River, this potential additional risk to human health and the environment would have to be assessed.

As a result of the cumulative impact of these technical concerns and the potential for added environmental risk, *in situ* enhanced bioremediation of vadose zone soil was judged not to be an implementable or reliable alternative for the treatment of vadose zone soil at the Kaiser Facility.

3.1.4.3 Description of *In Situ* Chemical Oxidation

The purpose of Alternative B4 is to chemically oxidize contaminants *in situ*. During *in situ* chemical oxidation, chemical oxidants that destroy the SVOCs are introduced to the soil column. Hydrogen peroxide (H_20_2), potassium permanganate ($KMn0_4$), ozone (O_3), and persulfate ($S_2 O_8{}^{2-}$) are the four most commonly used oxidants in this treatment process (EPA 2006b). Another common field application, Fenton's Reagent, uses hydrogen peroxide and an iron catalyst to create hydroxyl free radicals. Hydroxyl free radicals are able to oxidize complex organic compounds (EPA 1998).

Oxidant Selection

In situ ozonation is judged to have several advantages over other oxidants for the Kaiser Facility. The most significant advantage is that the gaseous nature of ozone promotes the controlled delivery of the oxidant through the vadose zone more readily than that of aqueous oxidants. The other commonly used oxidants (hydrogen peroxide/Fenton's reagent, potassium permanganate and persulfate) would be delivered in the aqueous phase. The addition of aqueous phase oxidants present risks similar to those discussed above for *in situ* enhanced bioremediation, in that SVOCs, PCBs, and oxidants could migrate to the smear zone and to groundwater.

Successful *in situ* chemical oxidation requires the intimate contact of the oxidant and the SVOC mass. An excess of oxidant (beyond what is stoichiometrically required) would need to be added to the subsurface to compensate for the inefficiencies in oxidant/contaminant contact. Ozone would be generated on site in a closed system, reducing health and safety risks associated with oxidant storage and handling. It is conservatively assumed that the off-gas removed by SVE from the treated soil matrix would have to be passed over a nickel catalyst bed to decompose any residual ozone. Pilot-scale studies would have to be completed to determine whether the nickel catalyst bed would be required based on the ozone concentration in the effluent.

Chemical Oxidation System Description

The key components of an ozone addition and SVE system for Alternative B4 include the generation and injection of ozonated air into subsurface wells, creating a pressure differential between the injection and extraction wells to move the ozonated air through the subsurface, and the treatment of any residuals in the extracted air stream. A process flow diagram of a typical ozonation system for vadose zone soil is presented on Figure 3-9.

To generate ozone, an air compressor first draws in ambient air, which is passed through an air dryer and then an oxygen concentrator. The oxygen concentrator removes nitrogen from the air stream and delivers air with 90 percent oxygen to the ozone generator. The ozone generator uses high-voltage electrical current to convert the oxygen to ozone, up to about 6 percent ozone by weight. The ozone is blended with ambient air, which allows the ozone to be injected into the subsurface at flow rates up to 10 cfm. Extraction wells would be placed parallel to injection wells, on a 15-foot spacing, to maintain control of the pressure gradient and minimize ozone loss to the surrounding area (Plummer et al. no date).

Ozone injection and extraction wells would be installed in a grid pattern throughout each SVOC AOC that is treated. Alternative B4 conservatively assumes an approximate radius of influence of 15 feet per well. The half-life of ozone is 3 days in air and 20 minutes in water at 20°C (EPA 2006b). The injection flow rate will be adjusted to optimize ozone distribution to account for the half-life and consumption rate of ozone to ensure both adequate ozone within the AOC and to minimize ozone losses to the surrounding area. An on-site pilot-scale test would be conducted as part of the remedial design to determine the site-specific radius of influence per well (well spacing), to assess treatment design parameters such as sparging flow rate, vapor extraction flow rate, ozone dosing, and whether off-gas treatment to remove ozone is required.

Ozone would flow through the AOC toward the extraction wells placed parallel to the injection wells.

Each line of wells could be used as either injection or extraction wells for greater control of air flow through the subsurface. About 115 wells would be installed in the AOCs treated by Alternative B4. The wells would be installed to the depth of contamination in each AOC (as described in Table 3-15 of the FSTM). The well screen length would correspond to the vertical extent of impacted soil. Conceptual well locations for the SVOC AOCs are shown on Figures 3-10 through 3-17.

System process equipment would be housed in an on-site, aboveground enclosure. As a rule of thumb, approximately 4 pounds of ozone are required to oxidize 1 pound of petroleum hydrocarbons in the diesel- to heavy oil-range (Plummer et al. no date). There are approximately 221,000 pounds of SVOCs present in the deep vadose zone SVOC AOCs that are being treated by Alternative B4. Additionally, there are approximately 700 pounds of VOCs comingled with the SVOCs in the AOCs that are treated. Because of the large quantities of SVOCs in the deep vadose zone and ozone generation rate limitations, four ozonation units would be used concurrently to treat the SVOC AOCs. Each system would initially operate on a continuous basis. However, cycling of system operation could be employed as SVOC concentrations decrease. Once an equilibrium (final) concentration of SVOCs is reached in an AOC, the treatment unit would be moved to another AOC.

With four systems, each supplying 25 pounds of ozone per day, under ideal conditions, it would take an estimated 26 years for complete oxidation of the 221,000 pounds of SVOCs. Ideal conditions include: 1) direct oxidation is the only treatment mechanism occurring in the AOC; 2) all the ozone added is used (no short circuiting); and 3) all the ozone added is able to contact all of the SVOCs that are present in the soil matrix. Ideal conditions are never present. It is assumed that 25 percent of the ozone would not make contact with the COCs because of short-circuiting caused by the highly porous soil in the vadose zone. It is also assumed that only 75 percent of the ozone/COC reactions would reach completion because of factors such as competition for consumption of the oxidant among natural organic matter, oxidant/contaminant contact inefficiencies, and incomplete reactions. Thus, this evaluation assumes that 56 percent of the mass of SVOCs in the AOCs that are treated would be oxidized in a 26-year period (124,000 pounds of SVOCs and 390 pounds of VOCs).

This removal efficiency would not be sufficient to meet SLs. Actual mass reduction rates would be determined during pilot-scale testing.

This evaluation assumes that ozone would not contribute significantly to the degradation or mobilization of PCBs that are comingled with SVOCs in the deep vadose zone soil. PCBs have been shown to be somewhat reactive under certain types of oxidation (ITRC 2005 and EPA 2006b). PCBs are generally considered recalcitrant to oxidation by ozone, although one study showed that PCBs were amenable to ozone oxidation (EPA 2006b). Considering that approximately 130 pounds of PCBs are comingled with 265,000 pounds of SVOCs in deep vadose zone soil, the oxidation of PCBs is judged incidental to the oxidation of SVOCs (i.e., SVOCs are the targeted compound for the ozone oxidation process but because ozone is not selective PCBs may be oxidized). The biological degradation of PCBs that are comingled with SVOCs is discussed further in Appendix F.

Soil vapor extraction flow, prior to release to the atmosphere, would be treated using GAC to remove contaminants in the extracted off-gas via chemical adsorption. The GAC captures and treats potential byproducts that may result from incomplete oxidation.

Once the adsorption capacity of the GAC is reached, it would be replaced with fresh carbon. Spent carbon is typically regenerated for reuse in other applications. The carbon regeneration process, which would be performed at an off-site facility, involves thermal treatment, in which contaminants are desorbed from the carbon and destroyed (see Section 2.1.3.2 for a discussion of why carbon is the preferred off-gas treatment alternative). It is assumed the off-gas system would also include a nickel catalyst bed to decompose any ozone that may be present in the off-gas. Spent catalyst would be returned to its supplier for reprocessing.

3.1.4.4 Monitoring Requirements for Alternative B4

Long-term performance and protection groundwater monitoring will be conducted and will have the objectives and scope described above for Alternative B1 (Section 3.1.1). Cap integrity monitoring for the areas of the Facility that are currently paved or under a floor slab will have the same objectives and scope described above for Alternative B2 (Section 3.1.2.2).

Protection monitoring for Alternative B4 will contain the monitoring elements prescribed by the Health and Safety Plan (HASP) and includes dust monitoring during well installation and ozone monitoring during work in the system enclosure.

Additional performance monitoring required as part of Alternative B4 include ozone and SVE system monitoring and quarterly soil sampling and analysis.

System monitoring will be conducted on a monthly basis and will include effluent monitoring of ozone, oxygen, VOC, and SVOC concentrations. Monthly monitoring will also include system parameter checks of injection and extraction flow rates and pressures. Monitoring requirements will be detailed in an O&M Plan.

Performance monitoring will also include annual soil sampling from borings within the footprint of the AOCs being treated to determine the extent that SVOC concentrations are being reduced. Ozone may react with metals in the subsurface and will oxidize them to their highest oxidative state. This may increase the toxicity and mobility of the metals (arsenic, iron, manganese) in the deep vadose zone. Annual soil sampling will include metals analysis to monitor for changes in oxidative states.

See Table 3-1 for a summary of monitoring requirements unique to Alternative B4.

3.1.4.5 Alternative B4 Estimated Costs

The NPV of implementing Alternatives B4 over a 30-year time period assuming a discount rate of 7 percent is estimated to be $23.2 million (-35 to +50 percent). The incremental cost of the *in situ* chemical oxidation elements for Alternative B4 is estimated to total approximately $8.5 million. A summary of the cost estimate is presented in Appendix B, Table B-5. Backup to this summary table is presented in other Appendix B tables as noted in Table B-5.

3.1.5 Alternative B5: Containment of Non-Comingled PCB AOCs

Alternative B5 adds the additional protection of containment to Alternative B1 for AOCs where PCBs at concentrations above SLs are not comingled with SVOCs in deep vadose zone soil. These deep vadose zone soil AOCs are located in the Remelt and the Oil House French Drain areas of the Facility.

The deep vadose zone AOCs where PCBs are not comingled with SVOCs are located below the concrete floor slab of the existing building in the Remelt area and below the existing pavement in the Oil House French Drain area. These AOCs were defined in Section 3 of the FSTM and are shown on Figure 3-1 of this FS. The area of these PCB AOCs totals approximately 6,900 sq ft. The floor slab above these AOCs is assumed to be suitable as a containment cap in its current condition for the purposes of this section. Thus, Alternative B5 will not require the installation of new containment caps; however, monitoring during the O&M period of using the existing floor slab as a containment technology will be necessary to ensure floor slab integrity and containment of the deep vadose zone PCB AOCs. The floor slab O&M and monitoring plans will be prepared as part of the institutional controls element of this alternative, as described in Sections 2.1.1.1 and 3.1.1 for Alternatives A1 and B1, respectively.

Monitoring will be required during the O&M period of the caps implemented at the Facility for deep vadose zone soil AOCs, which includes the existing floor slab over the PCB AOCs in the Remelt/Hot Line area. It is assumed that floor slab integrity will be visually monitored on an annual basis as part of implementation of the institutional controls element of this alternative. If visual inspection indicates a breach of cap integrity, the damaged pavement will be further assessed and subsequently sealed or removed and replaced at that location, if warranted. The institutional controls element of this alternative includes the maintenance of these areas of the floor slab.

3.1.5.1 Alternative B5 Estimated Cost

Alternative B5 does not include unique cost elements that are not already considered in Alternative B1. The institutional controls element of Alternative B1 includes annual and periodic costs related to floor slab O&M and monitoring. Capital costs associated with the containment element of Alternative B5 are also included in the institutional controls element of Alternative B1 (for example, preparation of floor slab O&M and monitoring plans). Alternative B5 will not require installation of new containment caps; thus, such costs are not included in the estimated cost for this alternative. As a result, the estimated cost for Alternative B5 equates to the estimated cost for Alternative B1. Assuming an operating period of 30 years and a discount rate of 7 percent, the total NPV cost of Alternative B5 totals approximately $13.6 million (Appendix B, Table B-6).

3.2 EVALUATION OF REMEDIAL ALTERNATIVES FOR DEEP VADOSE ZONE SOIL

Ecology has identified criteria that are used to evaluate remedial technologies and alternatives (WAC 173-340-360). These evaluation criteria are described in Section 2.2.1. The criteria are applied to Alternatives B1 through B5 in Sections 3.2.2 through 3.2.6. A comparative analysis is used to identify the most appropriate technology-based remedial alternative for each COC group in Section 3.3.

3.2.1 Remedial Action Objectives for Deep Vadose Zone Soil

Remedial action objectives (RAOs) are broad, administrative goals for a cleanup action that address the overall MTCA cleanup process, as summarized in Section 2.2.2. The RAOs for deep vadose zone soil at the Kaiser Facility must address the COCs identified for deep vadose zone soil, and the pathways by which these COCs can reach receptors on and off the Facility. The following COCs were identified for deep vadose zone soil:

- VOCs (Stoddard solvent);
- SVOCs (diesel, heavy oil, and Kensol);
- PCBs (total); and
- Metals causing potential human health risk (arsenic and chromium).

The pathway by which COCs in deep vadose zone soil can potentially reach receptors is the soil to groundwater pathway. This potential pathway assumes that rainwater could mobilize COCs in soil and carry them to the groundwater at concentrations that cause an exceedance of groundwater SLs. Soil SLs for this pathway were derived using the Fixed Parameter 3-Phase Partitioning Model (WAC 173-340-747[4] and MTCA Method B CULs, or MCLs established by the CWA or the SDWA, whichever is lower for groundwater). This pathway was determined to have the most impact on the SLs established for soil at the Kaiser Facility. Ultimately, final CULs for deep vadose zone soil will be established by Ecology and presented in the CAP.

The RAOs for deep vadose zone soil AOCs at the Facility are guided by MTCA requirements defined in WAC 173-340-740. Specifically, soil that is contained as a part of the remedy will be deemed to meet CULs if certain requirements set out in WAC 173-340-740(6)(f) are met, which are defined in Section 2.2.2.

The following RAOs are judged to apply to deep vadose zone soil AOCs at the Kaiser Facility:

- Meet the overall MTCA threshold requirements under WAC 173-340-360(2)(a), as defined by WAC 173-340-740(6)(f) for containment remedies;

- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]); and

- Protect groundwater and surface water quality.

The ways in which each remedial alternative will meet these RAOs for deep vadose zone soil are discussed in Section 3.2.2 through 3.2.6.

3.2.2 Evaluation of Remedial Alternative B1: Institutional Controls, Monitoring, and MNA

Alternative B1 uses the institutional control, monitoring, and MNA actions described in Section 3.1.1. The institutional controls include physical measures (e.g., fences and controlled access to the Facility), best management practices (BMPs), e.g., operating practices designed to prevent spills and leaks of chemicals and lubricants) and administrative measures (e.g., a restrictive covenant). An extensive groundwater monitoring program at the Facility has been in place for many years. This program contains a wide range of protection and performance monitoring for groundwater at the Facility, and is included as an element of Alternatives B2 through B5 to allow for evaluation of whether soil concentrations are protective of the soil to groundwater and groundwater to surface water pathways.

Alternative B1 does not employ any active remedial measures to reduce the toxicity, mobility, or volume of the COCs that are present in deep vadose zone soil at the Facility. However, it is assumed that some COCs (such as VOCs and SVOCs) are naturally attenuating in deep vadose zone soil, similarly to what has been observed in near-surface soil at the Facility. The capability of Alternative B1 to meet the cleanup requirements established by MTCA is summarized below.

3.2.2.1 Threshold Requirements

Protect Human Health and the Environment

Physical and administrative controls and BMPs are used to reduce the potential for worker exposure to COCs. The deep vadose zone soil AOCs, by definition, are located at depths greater than 20 feet. The depth of these AOCs prevents Facility workers and visitors from direct contact with COCs in these areas. Some deep vadose zone soil AOCs are located below existing pavement or building floor slabs, which prevents rainwater infiltration from conveying COCs from deep vadose zone soil to groundwater in these areas.

While some natural attenuation of SVOCs and VOCs in deep vadose zone soil may be occurring, this process would not result in SVOC or VOC concentrations reaching SLs for a long time.

Comply with MTCA Cleanup Standards

The implementation of Alternative B1 will not result in compliance with MTCA cleanup requirements. The SLs developed for the Facility were based on a conservative interpretation of the requirements of MTCA and contaminant-specific applicable or relevant and appropriate requirements (ARARs) promulgated by state and federal laws. These SLs are currently exceeded in the deep vadose zone soil AOCs identified on Figure 3-1. Natural attenuation may reduce the concentrations of SVOCs and VOCs to below SLs, but it would take a long time.

The human direct contact or ingestion exposure pathway for Facility workers and visitors does not exist because of the depth (greater than 20 feet) of the deep vadose zone AOCs. The exposure pathway for COCs to potentially reach groundwater and the Spokane River does exist for those AOCs that are not located under existing pavement or floor slabs at the Facility.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. No action- or location-specific ARARs have been identified for the deep vadose zone soil at the Facility applicable to Alternative B1 (see Appendix G, Tables G-3 and G-4).

Alternative B1 will not comply with MTCA cleanup requirements since concentrations of COCs in deep vadose zone soil will exceed SLs for a long time, and thus Alternative B1 does not meet the minimum requirements for cleanup actions established by WAC 173-340-360(2).

3.2.2.2 Other Requirements

Other requirements that remedial alternatives must fulfill once they meet threshold requirements are defined by WAC 173-340-360(2)(b) to include the use of permanent solutions to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]).

Use of Permanent Solutions to the Maximum Extent Practicable

The use of permanent solutions to the maximum extent practicable is a primary evaluation criterion for the remedial alternatives being considered for deep vadose zone soil. The specific criteria that must be addressed are specified in WAC 173-340-360(3)(f) and are discussed below.

Protectiveness. Alternative B1 does not actively reduce (beyond natural attenuation) the concentration of the COCs in deep vadose zone soil AOCs at the Facility. While it is assumed that some natural attenuation of SVOCs in deep vadose zone soil is occurring, this process will not result in a significant reduction in risk to human health and the environment or a reduction of COC concentrations to below SLs for a long time. Alternative B1 will not meet existing MTCA cleanup standards.

Alternative B1 will not break the soil to groundwater exposure pathway for AOC not located under existing pavement or floor slabs. By nature of the depth of the deep vadose zone AOCs, the direct contact or ingestion exposure pathway to Facility workers and visitors does not exist.

Permanence. The BMPs in place at the Facility will reduce the release of hazardous substances to the environment. The deep vadose zone soil AOCs are located at depths greater than 20 feet. The depth of these AOCs prevents Facility workers and visitors from direct contact with COCs in these areas. Some deep vadose zone soil AOCs are located below existing pavement or building floor slabs, which prevents rainwater from conveying COCs from deep vadose zone soil to groundwater in these areas.

While the natural attenuation processes that are assumed to be active in deep vadose zone soil will reduce SVOC concentrations over time, Alternative B1 will not actively reduce the toxicity, mobility, or volume of COCs present in deep vadose zone soil.

Cost. The NPV of implementing Alternative B1 over a 30-year time period is estimated to total approximately $13.6 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 3.1.1 and in the cost tables contained in Appendix B. Because the institutional controls, monitoring, and MNA described in Section 3.1.1 will be a part of Alternatives B2 through B5, the estimated NPV of Alternative B1 will be a component of the estimated cost of implementing these other alternatives.

Effectiveness over the Long Term. This alternative will not reduce the concentration of COCs currently present in deep vadose zone soil to concentrations below SLs for a long time. The existing pavement and floor slabs will prevent rainwater from conveying COCs to groundwater in the areas covered. The depth (greater than 20 feet) of the deep vadose zone soil AOCs will protect Facility workers and visitors from direct contact with COCs in these areas. However, this alternative does not break the soil to groundwater pathway or significantly reduce overall risk to human health and the environment posed by deep vadose zone soil.

Management of Short-Term Risks. This alternative uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create any new or additional risk to human health and the environment.

The short-term risks that are associated with implementation of existing and future institutional controls include:

- Potential exposure of Facility workers and visitors to hazardous materials (e.g., handling items containing hazardous waste as part of executing BMPs); and

- Hazards to workers associated with the industrial activities taking place at various locations within the Facility.

Technical and Administrative Implementability. The actions associated with the implementation of Alternative B1 are already in place at the Kaiser Facility.

Restoration Time Frame

The time frame needed for recovery to occur through natural attenuation processes under Alternative B1 will be long. The criteria in WAC 173-340-360(4)(b) are used to determine whether Alternative B1 provides a reasonable restoration time frame. Alternative B1 does not reduce the risk posed by the Facility to human health and the environment (WAC 173-340-360[4][b][i]) as discussed above and therefore does not provide a reasonable restoration time frame.

3.2.3 Evaluation of Remedial Alternative B2: Institutional Controls, Monitoring, MNA, and Containment

Alternative B2 adds the additional protection of containment to Alternative B1. The AOCs for each COC for deep vadose zone soil were defined in Section 3.5 of the FSTM. These COC-specific AOCs are consolidated on Figure 3-1, which depicts the COC-specific deep vadose zone soil AOCs that are present in each of the operating areas of the Kaiser Facility.

Many of the AOCs are located below existing floor slabs or pavement within the operating areas. Alternative B2 assumes that existing foundations, floor slabs, roads, and other paved surfaces at the Facility are acceptable as containment caps in their current condition. Alternative B2 includes installation of additional asphalt or concrete surfaces or multi-layer caps as shown on Figures 3-1 through 3-5. These containment surfaces will prevent the infiltration of rainwater through deep vadose zone soil and the migration of COCs from deep vadose zone soil to groundwater. The depth (greater than 20 feet) of the deep vadose zone soil AOCs will protect Facility workers and visitors from direct contact with COCs in these areas.

3.2.3.1 Threshold Requirements

Protect Human Health and the Environment

Physical and administrative controls, BMPs, and containment will be used to reduce the potential for COCs in deep vadose zone soil to migrate to groundwater. The depth of the deep vadose zone soil AOCs will protect Facility workers and visitors from direct contact with deep vadose zone soil COCs. Thus, Alternative B2 will cut the pathways by which COCs in deep vadose zone soil can reach human or ecological receptors, and eliminate the risk that the COCs pose to these receptors.

A containment surface (existing pavement and floor slabs, new asphalt or concrete caps, and an extension of an existing multi-layer cap) will be placed above each deep vadose zone soil AOC in Alternative B2. A stormwater collection system will be installed along with the new containment surfaces to direct stormwater to soil areas that are not contaminated and allowed to infiltrate, or to the Kaiser WWT facility. The natural attenuation processes discussed in Section 2.1.1.3 are assumed to continue; however, these processes will require a long time to reduce COC concentrations to SLs for the deep vadose zone soil. The containment surfaces will prevent rainwater infiltration from conveying COCs from deep vadose zone soil to groundwater.

Alternative B2 will not actively reduce (beyond natural attenuation) the concentration of the COCs in deep vadose zone soil at the Facility, or meet the SLs that have been established for these COCs for a long time. It is assumed that some natural attenuation of SVOCs and VOCs in deep vadose zone soil is occurring. However, cleanup actions that involve containment such as Alternative B2 can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Alternative B2 meets these requirements as discussed below. Groundwater quality that currently exceeds SLs below the containment surfaces is expected to be improved by Alternative B2 by preventing stormwater infiltration through contaminated deep vadose zone soil to groundwater. However, because the COCs currently present in smear zone (see Sections 4 and 5), soil will continue to contact groundwater, Alternative B2 alone is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time.

Comply with MTCA Cleanup Standards

The SLs developed for the Kaiser Facility were based on the requirements of MTCA and contaminant-specific state and federal ARARs. These SLs are currently exceeded in the AOCs identified on Figure 3-1. Although Alternative B2 is not expected to reduce the concentration of COCs that are present in these AOCs for a long time, Alternative B2 adds the additional protection of containment to Alternative B1. Cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met:

(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;

The assessment of whether Alternative B2 uses permanent solutions to the maximum extent practicable is summarized in Section 3.3. This assessment is conducted for AOCs that contain VOCs, SVOCs, PCBs, and metals. Alternative B2 is compared to Alternatives B1 and B3 (for VOCs), to Alternatives B1 and B4 (for SVOCs and PCBs comingled with SVOCs), to Alternative B5 (for PCBs that are not comingled with other COCs), and to Alternatives B1 (for metals).

(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;

The depth of the deep vadose zone soil AOCs eliminates the human health direct contact and ingestion pathways and eliminates the risk posed by the COCs present in deep vadose zone soil to Facility workers and visitors. The containment surfaces will prevent rainwater infiltration from continuing to mobilize COCs present in deep vadose zone soil to groundwater. Thus, Alternative B2 cuts the pathways by which COCs in deep vadose zone soil can reach human or ecological receptors, and eliminates the risk that the COCs pose to these receptors.

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative B2 alone is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time. The SLs for COCs in groundwater were established to prevent unacceptable risk to human health (drinking water and ingestion of aquatic organisms) and the environment (protection of aquatic life) in the Spokane River. Additional treatment alternatives for smear zone soil and for groundwater (Section 4) are discussed later in this FS. Alternative B2 together with the alternatives selected in Sections 2, 4, and 5 are expected to protect receptors in the Spokane River.

(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;

The point of compliance for terrestrial ecological receptors is located at a maximum depth of 15 feet bgs. Because the deep vadose zone soil segment of the Facility is delineated from a depth of 20 feet bgs to the water table, it is assumed that direct contact risk to ecological receptors does not exist for vadose zone soil at the Facility (refer to Pioneer 2012).

(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;

A restrictive covenant for portions of the Kaiser property will be prepared and will contain the restrictions as described in WAC 173-340-440(9). These restrictions are summarized in Section 2.1.1.1.

(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and

The protection and performance monitoring aspects of compliance monitoring, as defined by MTCA, have been underway at Kaiser for many years. This monitoring is guided by a Sampling and Analysis Plan (Hart Crowser 2007a), as amended (Kaiser 2010a) that has been approved by Ecology. Protection and performance monitoring are discussed in Section 2.1.1.2.

(vi) The types, levels, and amount of hazardous substances remaining on site and the measures that will be used to prevent migration and contact with those substances are specified in the draft Cleanup Action Plan.

This information will be included in the CAP that will be prepared by Ecology.

Comply with Applicable State and Federal Laws

Alternative B2 is judged to meet contaminant-specific ARARs as discussed above. No location-specific ARARs have been identified for the deep vadose zone soil at the Facility that are judged to be applicable to Alternative B2 (Appendix G, Table G-4). The identified action-specific ARARs for Alternative B2 consist of requirements associated with implementation of the alternative, such as substantive requirements of grading permits (see Appendix G, Table G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.

Alternative B2 is judged to meet MTCA threshold requirements for deep vadose zone soil.

3.2.3.2 Other Requirements

Other requirements that remedial alternatives must fulfill once they meet threshold requirements are defined by WAC 173-340-360(2)(b) to include the use of permanent solutions to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]).

Use of Permanent Solutions to the Maximum Extent Practicable

Protectiveness. Alternative B2 will not actively reduce (beyond natural attenuation) the concentration of the COCs in deep vadose zone soil AOCs at the Facility, or meet the SLs that have been established for these COCs for a long time. Some natural attenuation of SVOCs in deep vadose zone soil is assumed to be occurring, similarly to what has been observed in near-surface soil at the Facility. However, cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Alternative B2 meets these criteria as discussed above.

The depth of the deep vadose zone soil AOCs eliminates the exposure pathway by which Facility workers and visitors can directly contact and/or ingest deep vadose zone soil within these AOCs. The additional containment surfaces installed in Alternative B2 provide another degree of protection for Facility workers and visitors, and will prevent rainwater infiltration from continuing to mobilize COCs present in deep vadose zone soil to groundwater. Thus, Alternative B2 cuts the pathways by which COCs in deep vadose zone soil can reach human or ecological receptors, and eliminates the risk that the COCs pose to these receptors.

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative B2 is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time. Additional treatment alternatives for smear zone soil and for groundwater (Section 4) are discussed later in this FS.

Permanence. The BMPs in place at the Facility are reducing the release of hazardous substances to the environment.

The existing pavement and floor slab and the additional containment provided by Alternative B2 will prevent rainwater from infiltrating into the deep vadose zone and potentially transporting COCs to groundwater. The depth of the deep vadose zone soil AOCs prevents Facility workers and visitors from directly contacting COCs in these areas, which eliminates the risk to Facility workers and the public from potential direct contact or ingestion of contaminated deep vadose zone soil.

The natural attenuation processes that are assumed to be occurring in deep vadose zone soil will reduce SVOC concentrations over time; however, the attenuation processes will require a long time to reach SLs for SVOCs.

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative B2 is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time.

Since the depth of the deep vadose zone soil AOCs eliminates the human health risk to Facility workers and visitors of contact with deep vadose zone soil, and since the implementation of containment in Alternative B2 will sever the soil to groundwater exposure pathway. Alternative B2 cuts the pathways by which COCs in deep vadose zone soil can reach human or ecological receptors, and eliminates the risk that the COCs pose to these receptors.

Cost. The NPV of implementing Alternative B2 over a 30-year time period is estimated to total approximately $14.7 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 3.1.2 and in the cost tables contained in Appendix B.

Effectiveness over the Long Term. This alternative will not reduce the concentration of COCs currently present in deep vadose zone soil to concentrations below SLs for a long time. The existing pavement and floor slabs and new containment surfaces provided by Alternative B2 will prevent rainwater from conveying COCs to groundwater. The depth of the deep vadose zone soil AOCs prevents Facility workers and visitors from directly contacting or ingesting impacted deep vadose zone soil. Alternative B2 cuts the pathways by which COCs in deep vadose zone soil can reach human or ecological receptors, and eliminates the risk that the COCs pose to these receptors.

Institutional controls will be put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system. An inspection and maintenance plan that will assure the integrity of the existing pavement, floor slabs, and new containment surfaces will be prepared and implemented. The containment surfaces are expected to remain effective for an extended period of time.

Alternative B2 will not generate treatment residues or waste materials. Surface water runoff from the containment surfaces will be collected and allowed to infiltrate in areas of the Facility without soil contamination or transported to the Kaiser WWT facility for treatment.

Management of Short-Term Risks. This alternative will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces will be mitigated by their adherence to the HASP prepared to guide health and safety practices during the construction work.

The short-term risks associated with the installation of containment surfaces include the following:

- Exposure of Facility workers to hazardous materials (e.g., fumes from hot-mix asphalt);
- Construction area hazards (e.g., working near heavy equipment); and
- Hazards associated with the industrial activities taking place at various locations within the Facility.

The procedures contained in the HASP and the inspection and maintenance plan have been shown to effectively manage the limited risk associated with these activities.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place at the Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years.

Restoration Time Frame

The containment surfaces in Alternative B2 can be installed within 1 year. The time frame needed for the concentration of COCs in deep vadose zone soil to fall below SLs is expected to be long. However, soil under the containment surfaces may be determined to comply with cleanup standards after the containment surfaces are in place if the requirements under WAC 173-340-740(6)(f) are met. Alternative B2 meets these requirements as described above.

An assessment of the factors used to determine whether Alternative B2 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) follows:

(i) Potential risks posed by the site to human health and the environment;

Alternative B2 cuts the pathways by which COCs in deep vadose zone soil can reach human or ecological receptors and eliminates the risk that the COCs pose to these receptors. Alternative B2 is judged to be protective of human health and the environment (see discussion above).

(ii) Practicability of achieving a shorter restoration time frame;

The restoration time frame that Alternative B2 provides for each COC group is compared to the other remedial alternatives for deep vadose soil in Section 3.3. Alternative B2 (and alternatives with similar restoration time frames) provides the shortest practicably achievable restoration time frame.

(iii) Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

There are no current releases of COCs that could reach groundwater or potential receptors in the Spokane River. Alternative B2 includes physical and administrative controls, BMPs, and containment to reduce the potential risk to receptors that may be posed by future releases.

(iv) Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site"

A restrictive covenant will limit future uses of the site. The Spokane River is likely to continue to be a potential source of receptors for releases from the Facility. Currently, SVOCs are not reaching the river at concentrations above SLs.

(v) Availability of alternative water supplies;

Alternative water supplies are abundant. A considerable amount of high quality groundwater exists at the Facility that is outside of the footprint of the AOCs and this groundwater is available for use by Kaiser under a water right.

(vi) Likely effectiveness and reliability of institutional controls;

The institutional controls implemented in Alternative B1 (refer to Sections 2.1.1.1 and 2.1.1.2 and Table 2-2) have been shown to be effective and reliable at the Facility. Most of these measures have been successfully used at the Facility for many years.

(vii) Ability to control and monitor migration of hazardous substances from the site;

The groundwater monitoring program at the Facility is governed by a Sampling and Analysis Plan (Hart Crowser 2007a), as amended (Kaiser 2010a), that has been approved by Ecology.

(viii) Toxicity of hazardous substances at the site; and

VOCs, SVOCs, PCBs, and metals have been identified as COCs for deep vadose zone soil at the Facility. The toxicity of these COCs will depend on their concentration and the duration of exposure to them. The implementation of Alternative B2 will further reduce the possibility that these COCs will reach potential receptors in the future.

(ix) Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar conditions.

In some instances, as discussed in the FSTM (Hart Crowser 2012c), analytical results showed that the concentration of COCs (e.g., SVOCs) has declined over time without any known human intervention (see Section 2.1.13).

The restoration time frame for Alternative B2 is judged to be reasonable, as defined by WAC 173-340-360(4).

3.2.4 Evaluation of Alternative B3: Institutional Controls, Monitoring, Monitored Natural Attenuation, Containment, and SVE

Alternative B3 adds SVE to Alternative B2 for those deep vadose zone soil AOCs that contain VOCs at concentrations above SLs. The AOCs for each COC for deep vadose zone soil were defined in Section 3.5 of the FSTM.

The deep vadose zone AOCs that contain VOCs at concentrations above SLs are located in the vicinity of the Tank Farm Kensol Spill area (two AOCs) and in the Oil House French Drain area (one AOC). The characteristics of these AOCs are summarized in Section 3.1.3.1.

The SVE process envisioned for the deep vadose zone soil at the Facility is described in Section 3.1.3.2. Figure 2-13 presents a process flow diagram for a typical SVE system. The SVE process removes VOCs from the contaminated soil and captures them on carbon beds, which will be regenerated. The regeneration process will destroy the VOCs adsorbed on the carbon.

Alternative B3 also employs containment to enhance the performance of the SVE process and to reduce the mobility of the COCs that are present in deep vadose zone soil at the Facility. The ability of Alternative B3 to meet the cleanup requirements established by MTCA is summarized below.

3.2.4.1 Threshold Requirements

Protect Human Health and the Environment

Physical and administrative controls, BMPs, and containment are used to reduce the potential for worker exposure to COCs and to reduce the potential for COCs in deep vadose zone soil to migrate to groundwater and potentially to groundwater receptors and the Spokane River.

A containment surface (existing pavement and floor slabs and new asphalt, concrete, or multi-layer cap) will be placed above each deep vadose zone soil AOC that contain VOCs. A stormwater collection system will be installed along with the new containment surfaces to direct stormwater to areas without soil contamination for infiltration or to the Kaiser WWT facility for treatment. Thus, containment surfaces installed in Alternative B3 cut the pathways by which COCs in deep vadose zone soil can reach human or ecological receptors, and eliminate the risk that the COCs pose to these receptors.

Some natural attenuation of COCs in deep vadose zone soil has occurred, and is expected to continue below the containment surface. However, natural attenuation alone will require a long time to reduce COC concentrations to SLs for deep vadose zone COCs.

Alternative B3 actively removes and destroys VOCs in deep vadose zone soil and is expected to meet the SLs that have been established for VOCs (100 mg/kg for Stoddard solvent). SVE treatment eliminates the risk of Stoddard solvent being conveyed to groundwater. The Stoddard solvent will be removed and destroyed in a relatively short time (about 3 years).

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative B3 alone is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time.

Comply with MTCA Cleanup Standards

Alternative B3 directly reduces the concentration of VOCs that are present in the three deep vadose zone soil VOC AOCs. SVE treatment is expected to reduce the concentration of VOCs in the three AOCs where it is employed to concentrations below SLs. The SLs developed for the Facility were based on the requirements of MTCA and contaminant-specific state and federal ARARs.

The containment surfaces prevent rainwater from conveying COCs from deep vadose zone soil to groundwater and potentially to groundwater receptors and the Spokane River.

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative B3 alone is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time. The groundwater SLs were established to prevent risk to human health resulting from the ingestion of water and organisms in the Spokane River. Additional treatment alternatives for smear zone soil and for groundwater (Sections 4 and 5) are discussed later. Alternative B3, together with the alternatives selected by Sections 2, 4, and 5, are expected to protect groundwater receptors and the Spokane River.

Comply with Applicable State and Federal Laws

Alternative B3 is judged to meet contaminant-specific ARARs as discussed above. No location-specific ARARs have been identified for deep vadose zone soil at the Facility applicable to Alternative B3 (Appendix G, Table G-4). The identified action-specific ARARs for Alternative B3 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These include construction-related requirements (e.g., grading permit acquisition) and regulations related to SVE system operation that may require use of best available technology to control potential air emissions of the treatment system. These ARARS are judged to be attainable and do not affect the alternative selection process.

3.2.4.2 Other Requirements

Other requirements that remedial alternatives must fulfill once they meet threshold requirements are defined by WAC 173-340-360(2)(b) to include the use of permanent solutions to the maximum extent practicable (WAC 173-340-

360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]).

Use of Permanent Solutions to the Maximum Extent Practicable

The use of permanent solutions to the maximum extent practicable is a primary evaluation criterion for the remedial alternatives being considered for deep vadose zone soil. The specific criteria that must be addressed are specified in WAC 173-340-360(3)(f) and are discussed below.

Protectiveness. Alternative B3 directly reduces the concentration of Stoddard solvent that is present in the three deep vadose zone soil VOC AOCs. Alternative B3 adds an SVE system, which removes and destroys (once spent carbon is regenerated) Stoddard solvent, to the containment, MNA, monitoring, and institutional controls provided by Alternative B2.

Alternative B3 will reduce the future transport of COCs from deep vadose zone soil to the groundwater and potentially to groundwater receptors and the Spokane River. Natural attenuation of VOCs in vadose zone soil is expected to continue to occur below containment surfaces.

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative B3 alone is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time. Additional treatment alternatives for smear zone soil and for groundwater (Sections 4 and 5) are discussed later. Alternative B3 together with the alternatives selected by Sections 2, 4, and 5 will protect groundwater receptors and the Spokane River.

Spent carbon used in the off-gas treatment system containing VOCs will be shipped off site to be regenerated. The VOCs released from the carbon during the regeneration process will be destroyed. The spent carbon will be sent to a vendor that holds the environmental and other permits needed to operate a carbon regeneration facility.

Permanence. The BMPs in place at the Facility will reduce the release of hazardous substances to the environment.

Alternative B3 destroys approximately 330 pounds of VOCs and is the most permanent treatment alternative for VOCs in deep vadose zone soil at the Facility. Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative B3 alone is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time.

However, Alternative B3 together with the alternatives selected by Sections 2, 4, and 5 is expected to protect groundwater receptors and the Spokane River.

Cost. The NPV of implementing Alternative B3 over a 30-year time period is estimated to total approximately $15.3 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 3.1.3 and listed in the cost tables contained in Appendix B. The portion of total cost of Alternative B3 that represents SVE treatment is approximately $600,000.

Effectiveness over the Long Term. Alternative B3 will reduce the concentration of VOCs in deep vadose zone soil in the three AOCs that would be treated to concentrations below SLs within a relatively short (about 3 years) time period. It will not reduce the concentration of other COCs (SVOCs, PCBs, metals) currently present in deep vadose zone soil to concentrations below SLs for a long time. Alternative B3 generates spent carbon from off-gas treatment that will be handled and regenerated by an experienced subcontractor.

The existing pavement and floor slabs and new containment surfaces provided by Alternative B3 will protect Facility workers and visitors from direct contact with COCs in these areas, and prevent rainwater from conveying COCs to groundwater and potentially to groundwater receptors and the Spokane River.

Institutional controls are put in place that prohibit or limit activities that could interfere with the long-term integrity of the containment system and alert future Facility workers to the presence of contaminated soil below the cap so they can implement appropriate HASP procedures. An inspection and maintenance plan that will assure the integrity of the existing pavement, floor slabs and new containment surfaces will be prepared and implemented. The containment surfaces are expected to remain effective for an extended period of time.

Surface water runoff from the containment surfaces will be collected and directed to infiltrate uncontaminated areas, or transported to the Kaiser WWT facility for treatment.

Management of Short-Term Risks. This alternative uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces will be mitigated by their adherence to the HASP prepared to guide the construction work. The procedures contained in the HASP and the inspection and maintenance plan have been shown to effectively manage the limited risk associated with these activities.

Short-term risks to workers operating the SVE system will be mitigated by their adherence to the SVE HASP and O&M Plan prepared to guide that work. An experienced subcontractor will manage the removal, transportation, and regeneration of spent carbon.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. SVE is a presumptive remedy for the removal of VOCs from soil and is considered an implementable conventional technology but will require technical expertise for design and execution. Regeneration of spent carbon (and incineration of VOCs released from the carbon) is a complex process that must be conducted at a facility designed and permitted for this purpose. The nearest carbon regeneration facility to the Kaiser Facility is located in Cattlesburg, Kentucky (York, T., Calgon, personal communication, 2010). The handling and disposal of spent carbon will be performed by an experienced subcontractor.

Restoration Time Frame

Containment surfaces can be installed in a relatively short time frame (about 1 year). Natural attenuation processes at the Facility are expected to continue. The concentration of VOCs in deep vadose zone soil in the three AOCs that are treated will be reduced to concentrations below SLs within a relatively short (about 3 years) time period. The time frame needed for the concentration of other COCs in deep vadose zone soil to fall below SLs is expected to be long. However, soil under the containment surfaces may be determined to comply with cleanup standards after the containment surfaces are in place if the requirements under WAC 173-340-740(6)(f) are met. Alternative B3 meets these requirements as discussed above.

An assessment of the factors used to determine whether Alternative B3 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) is generally the same as the assessment presented for Alternative B2 (Section 3.2.3.2). The practicability of achieving a shorter restoration time frame is addressed in the comparative analysis for remedial alternatives for each deep vadose zone COC group in Section 3.3, which concludes that the restoration time frame for Alternative B3 is considered to be reasonable, as defined by WAC 173-340-360(4).

3.2.5 Evaluation of Alternative B4: Alternative B2 Plus In Situ Treatment (Chemical Oxidation)

Alternative B4 adds *in situ* chemical oxidation to Alternative B2 for those AOCs containing SVOCs that can be treated (Section 3.1.4). Some of the AOCs are located below floor slabs within the operating areas. For the purposes of Section 3 of this FS, it is assumed that AOCs that exist under a floor slab will not be treated *in situ* because of potential interruptions to Facility operations and since the floor slabs prevent rainwater and other liquids from reaching the vadose zone. Approximately 83 percent of the total deep vadose zone soil is judged amenable to *in situ* treatment processes (refer to Section 3.1.4.2).

The purpose of Alternative B4 is to contain and chemically destroy SVOCs in deep vadose soil to eliminate the potential for the SVOCs to migrate to groundwater. There are two AOCs where SVOCs are comingled with PCBs (the Hoffman Tank area and the Oil Drum Storage and French Drain area). The concentrations and mass of PCBs in these areas are significantly lower than the concentrations and mass of SVOCs (see Section 3.1.4.3). For the purposes of evaluating Alternative B4, the treatment of PCBs is considered incidental to the treatment of SVOCs because of the significantly higher mass of SVOCs in the deep vadose zone. Oxidation of PCBs may be occurring, but the destruction of PCBs is not being considered in the evaluation of Alternative B4. Refer to Appendix F for a discussion of degradation processes considered applicable to PCBs that are comingled with SVOCs.

Threshold Requirements

Protect Human Health and the Environment

Physical and administrative controls, BMPs, and containment will be used to reduce the potential for COCs in deep vadose zone soil to migrate to groundwater, as discussed for Alternative B2 (Section 3.2.3). The depth of the deep vadose zone soil AOCs will protect Facility workers and visitors from direct contact with deep vadose zone soil COCs.

Physical and administrative controls, BMPs, and existing paved surfaces (e.g., roads and floor slabs), as discussed for Alternative B1, will be used to reduce the potential for SVOCs in deep vadose zone soil to migrate to groundwater. Thus, containment surfaces installed in Alternative B4 cut the pathways by which COCs in deep vadose zone soil can reach human or ecological receptors, and eliminate the risk that the COCs pose to these receptors.

Alternative B4 will actively remove and destroy SVOCs in deep vadose zone soil at the Facility, but is not expected to reduce deep vadose zone soil concentrations of SVOCs to below the SLs that have been established for the Facility. Alternative B4 will remove (or destroy) approximately 56 percent of the mass, or 124,000 pounds, of SVOCs. SVOCs at concentrations above SLs will still be present in deep vadose zone soil (approximately 97,000 pounds in areas that are being treated and 55,000 pounds of SVOCs under existing floor slabs). Additionally, Alternative B4 is expected to remove approximately 56 percent of the 700 pounds (390 pounds) of the VOCs comingled with SVOCs in the Tank Farm Kensol Spill area.

For the purpose of evaluating Alternative B4, the oxidation of PCBs is considered incidental to the oxidation of SVOCs. That is, oxidation of PCBs may be occurring, but the destruction of PCBs is not being considered in the evaluation of Alternative B4. Refer to Appendix F for a discussion of degradation processes considered applicable to PCBs that are comingled with SVOCs.

Some natural attenuation of SVOCs in deep vadose zone soil has occurred and is expected to continue; however, it will take a long time for concentrations of SVOCs and VOCs to fall below SLs. However, cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Alternative B4 meets these standards as discussed above.

Groundwater quality is not expected to be improved by Alternative B4 since the COCs currently present in smear zone soil will continue to contact groundwater. However, soil treated under this alternative will reduce the COC mass in the deep vadose zone soil that could potentially migrate to groundwater.

The risk posed by deep vadose zone SVOCs is expected to be reduced by the addition of containment surfaces in a relatively short time period (about 1 year). The reduction in contaminant mass using Alternative B4 is expected to take approximately 26 years. Short-term risks are manageable and will be mitigated by following a site-specific HASP. Ozone may react with metals in the subsurface and oxidize them to their highest oxidative state. For instance, ozone may convert chromium (Cr^{+3}) to a more toxic hexavalent chromium (Cr^{+6}).

Comply with MTCA Cleanup Standards

Alternative B4 is expected to directly reduce the concentration of SVOCs that are present in the deep vadose zone soil, where treatment is judged to be possible, as shown on Figure 3-8.

Alternatives B4 is expected to reduce the concentration of SVOCs in the portion of the deep vadose zone AOCs that are treated by approximately 56 percent; however, it will not reduce the SVOC concentrations to below SLs. Containment surfaces will eliminate the possibility that these SVOCs could be carried by rainwater infiltration to groundwater below the AOCs, cut the deep vadose zone soil to groundwater pathway, and eliminate the risk to receptors posed by deep vadose zone soil. Since the SVOCs currently present in smear zone soil will continue to contact groundwater, Alternative B4 alone is not expected to cause the concentration of SVOCs in groundwater to fall below SLs for a long time.

Comply with Applicable State and Federal Laws

Alternative B4 is judged to meet contaminant-specific ARARs as discussed above. No location-specific ARARs have been identified for the deep vadose zone soil at the Facility applicable to Alternative B4 (Appendix G, Table G-4). The identified action-specific ARARs for Alternative B4 consist of requirements associated with implementation of the alternative including the underground injection program (Chapter 173-218 WAC) (see Appendix G, Table G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.

Alternative B4 is judged meet the threshold requirements established by WAC 173-340-360(2) for deep vadose zone soil.

3.2.5.2 Other Requirements

Other requirements that remedial alternatives must fulfill once they meet threshold requirements are defined by WAC 173-340-360(2)(b) to include the use of permanent solutions to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]).

Use of Permanent Solutions to the Maximum Extent Practicable

The use of permanent solutions to the maximum extent practicable is a primary evaluation criterion for the remedial alternatives being considered for deep vadose zone soil. The specific criteria that must be addressed are specified in WAC 173-340-360(3)(f) and are discussed below.

Protectiveness. Alternative B4 will actively work to destroy SVOC mass in deep vadose zone soil AOCs that are accessible for treatment. Alternative B4 will destroy approximately 124,000 pounds of SVOCs and 390 pounds of VOCs.

The SVOCs will be destroyed and treated in approximately 26 years. The natural attenuation processes in deep vadose zone soil are expected to continue to reduce SVOC concentrations over time.

The depth of the deep vadose zone soil AOCs eliminates the exposure pathway by which Facility workers and visitors can directly contact and/or ingest deep vadose zone soil within these AOCs. Thus, the risk to Facility workers and visitors from the possibility of direct contact or ingestion of deep vadose zone soil is eliminated by the nature of its depth.

Containment surfaces added by Alternative B4 will reduce the future transport of COCs from deep vadose zone soil to groundwater, cut the vadose zone soil to groundwater pathway, and eliminate the risk to receptors posed by deep vadose zone soil. Alternative B4 provides an additional level of protection beyond the protection provided by containment surfaces by destroying SVOC mass.

Ozone may react with metals in the subsurface and will oxidize them to their highest oxidative state. This may increase the toxicity and potential mobility of the metals in the deep vadose zone. Because containment surfaces prevent rainwater infiltration, an increased potential for mobility is not expected to occur.

Permanence. Alternative B4 is assumed to destroy approximately 56 percent of the mass of SVOCs and VOCs in the deep vadose zone AOCs. The natural attenuation processes in deep vadose zone soil are expected to continue to reduce SVOC and VOC concentrations over time.

The existing pavement and floor slab and the additional containment included in Alternative B4 will prevent rainwater from infiltrating into the deep vadose zone and potentially transporting COCs to groundwater. The depth of the deep vadose zone soil AOCs prevents Facility workers and visitors from directly contacting COCs in these areas, which eliminates the risk to Facility workers and the public from potential direct contact or ingestion of contaminated deep vadose zone soil.

There is a potential risk of changing the valence state of metals increasing their toxicity and mobility as ozone is added to vadose zone soil. Metal concentrations will be monitored during treatment.

Since the COCs currently present in smear zone soil will continue to contact groundwater, Alternative B4 is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time.

Cost. The NPV of implementing Alternative B4 (*in situ* chemical oxidation) combined with Alternative B2 over a 30-year time period is estimated to total approximately $23.2 million (-35 to +50 percent). The incremental cost of the chemical oxidation elements unique to Alternative B4 is about $8.5 million. The assumptions used to prepare this estimate are described in Section 3.1.4 and listed in the cost tables contained in Appendix B.

Effectiveness over the Long Term. This alternative will not reduce the concentration of COCs currently present in deep vadose zone soil to concentrations below SLs for a long time. However, Alternative B4 can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. These requirements are met by Alternative B4 as discussed above.

The depth of the deep vadose zone soil AOCs prevents Facility workers and visitors from directly contacting or ingesting impacted deep vadose zone soil. The existing pavement and floor slabs and new containment surfaces provided in Alternative B4 will prevent rainwater infiltration from conveying COCs to groundwater.

Alternative B4 will reduce the concentration of SVOCs in deep vadose zone soil AOCs by approximately 56 percent in approximately 26 years.

Institutional controls will be put into place that prohibit or limit activities that could interfere with the long-term integrity of the containment system and alert future Facility workers to the presence of contaminated soil below the pavement and buildings so that they can implement appropriate HASP procedures. An inspection and maintenance plan that will assure the integrity of the existing pavement and floor slabs will be prepared and implemented. The containment surfaces are expected to remain effective for an extended period of time.

Surface water runoff from the containment surfaces will be collected and directed to areas that do not have soil contamination for infiltration or will be transported to the Kaiser WWT facility for treatment.

Management of Short-Term Risks. Short-term risks associated with Alternative B4 include worker exposure to contaminants during well installation. Controls to protect workers will be defined in the HASP and implemented during all construction and remediation activities. Short-term risks to construction workers during the installation of the containment surfaces will also be mitigated by their adherence to the HASP.

Because of its short half-life, ozone will be generated on site and minimizes oxidant storage and handling risks. There is a risk of potential ozone buildup in system enclosures or other enclosed spaces. The SVE air stream may be passed through a nickel catalyst bed to decompose any ozone that may be present in the off-gas based on the results of a pilot test. Other risks associated with the generation and injection of ozone and the operation of SVE wells will be mitigated by following the HASP that is prepared to guide these activities.

Ozone may react with metals in the subsurface and oxidize them to their highest oxidative state. The presence of a containment surface and absence of rainwater or other liquids in the vadose zone should prevent the oxidized compounds from reaching the groundwater.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place at the Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. On-site pilot-scale testing will be required for design and implementation of *in situ* oxidation to confirm its technical implementability.

Restoration Time Frame

The risks to Facility workers and visitors from direct contact or ingestion of COCs in deep vadose zone soil is eliminated by the depth (greater than 20 feet) of the deep vadose zone soil AOCs. Containment surfaces will sever the soil to groundwater exposure pathway within a short period of time (about 1 year) and may be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. These requirements are met by Alternative B4 as discussed above.

Approximately 56 percent of the SVOC and VOC mass it expected to be destroyed within approximately 26 years. The time frame needed for the concentration of COCs in deep vadose zone soil to fall below SLs by natural attenuation is expected to be long.

An assessment of the factors used to determine whether Alternative B4 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) is generally the same as the assessment presented for Alternative B2 (Section 3.2.3.2). The practicability of achieving a shorter restoration time frame is addressed in the comparative analysis for remedial alternatives for each deep vadose zone COC group in Section 3.3, which concludes that the restoration time frame for Alternative B4 is considered to be reasonable, as defined by WAC 173-340-360(4).

3.2.6 Evaluation of Remedial Alternative B5: Containment of Non-Comingled PCB AOCs

Alternative B5 adds the additional protection of containment to Alternative B1 for AOCs where PCBs are not comingled with other COCs in deep vadose zone soil. These AOCs are located in the Remelt and the Oil House French Drain areas of the Facility and are shown on Figures 3-1 and 3-15.

The PCB AOCs in the Remelt area are located below the floor slab of the existing building. The PCB AOC in the Oil House French Drain area is under an existing paved surface. Alternative B5 assumes that the floor slab and paved surface are acceptable as containment caps in their current condition. The containment surfaces will prevent the infiltration of rainwater to deep vadose zone soil and the potential migration of PCBs from deep vadose zone soil to groundwater, and additionally will prevent infiltration of contaminants into underlying soil in the event of a spill. The depth (greater than 20 feet) of the deep vadose zone soil AOCs will protect Facility workers and visitors from direct contact with PCBs in these areas.

3.2.6.1 Threshold Requirements

Protect Human Health and the Environment

Physical and administrative controls, BMPs, and containment will be used to reduce the potential for PCBs in deep vadose zone soil to migrate to groundwater. The depth of the deep vadose zone soil AOCs will protect Facility workers and visitors from direct contact with deep vadose zone soil PCBs. Thus, containment surfaces used in Alternative B5 cut the pathways by which PCBs in deep vadose zone soil can reach human or ecological receptors, and eliminate the risk that the PCBs pose to these receptors.

Alternative B5 will not actively reduce the concentration of PCBs in deep vadose zone soil at the Facility, or meet the SLs that have been established for PCBs. Groundwater quality that currently exceeds SLs below the containment surfaces is not expected to be improved by Alternative B5. Because the PCBs currently present in smear zone soil will continue to contact groundwater, Alternative B5 is not expected to cause the concentration of PCBs in groundwater to fall below SLs for a long time.

Comply with MTCA Cleanup Standards

The SLs developed for the Facility were based on the requirements of MTCA and contaminant-specific state and federal ARARs. Although Alternative B5 is not expected to directly reduce the concentration of PCBs that are present in the deep vadose zone soil AOCs below the Remelt area, Alternative B5 adds the protection of containment to Alternative B1. Cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met:

(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;

The practicability assessment for Alternative B5 is summarized in Section 3.3. Alternative B5 is a unique remedial alternative for deep vadose zone soil because it applies strictly to the PCB AOCs in the Remelt area and the Oil House French Drain area, where PCBs are not comingled with other COCs. Alternative B5 is considered the most practicable permanent remedial alternative for these deep vadose zone PCB AOCs in the Remelt and Oil House French Drain areas.

(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;

The depth of the deep vadose zone soil AOCs eliminates the human health direct contact and ingestion pathways and eliminates the risk posed by the deep vadose zone soil PCB AOCs to Facility workers and visitors. The existing floor slab and paved surface above these AOCs will prevent rainwater from infiltrating into the subsurface and potentially mobilizing the PCBs present in deep vadose zone soil to groundwater. Kaiser has initiated an extensive program to preempt process and non-process water leaks from piping and storm sewers in the Remelt area to reduce the potential for water releases to infiltrate PCBs to groundwater in the vicinity of the PCB source area. Additionally, the existing floor slab and paved surface will prevent the infiltration of contaminants into soil in the event of a spill. Thus, containment surfaces used in Alternative B5 cut the pathways by which PCBs in deep vadose zone soil can reach human or ecological receptors, and eliminate the risk that the PCBs pose to these receptors.

Since the PCBs currently present in smear zone soil will continue to contact groundwater, Alternative B5 alone is not expected to cause the concentration of PCBs in groundwater to fall below SLs for a long time. The SLs for COCs in groundwater were established to prevent unacceptable risk to human health (drinking water and ingestion of aquatic organisms) and the environment (protection of aquatic life) in the Spokane River. Additional treatment alternatives for smear zone soil and for groundwater are discussed later in this FS (Sections 4 and 5). Alternative B5, together with the alternatives selected in Sections 2, 4, and 5, are expected to protect the human and ecological receptors in the Spokane River.

(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;

The point of compliance for terrestrial ecological receptors is located at a maximum depth of 15 feet bgs. Because the deep vadose zone soil segment of the Facility is delineated from a depth of 20 feet bgs to the water table, it is assumed that the direct contact risk to ecological receptors does not exist for vadose zone soil at the Facility.

(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;

A restrictive covenant on portions of the Kaiser property that contain residual PCBs above SLs will be prepared and will contain the restrictions as described in WAC 173-340-440(9). These restrictions were summarized in Section 2.1.1.1.

(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and

The protection and performance monitoring aspects of compliance monitoring, as defined by MTCA, have been underway at the Facility for many years. This monitoring is guided by a Sampling and Analysis Plan (Hart Crowser 2007a), as amended (Kaiser 2010a) that has been approved by Ecology. Protection and performance monitoring are discussed in Section 2.1.1.2.

(vi) The types, levels, and amount of hazardous substances remaining on site and the measures that will be used to prevent migration and contact with those substances are specified in the draft Cleanup Action Plan.

This information will be included in the CAP that will be prepared by Ecology.

Comply with Applicable State and Federal Laws

Alternative B5 is judged to meet contaminant-specific ARARs as discussed above. No location-specific ARARs have been identified for the deep vadose zone soil at the Facility applicable to Alternative B5 (see Appendix G, Table G-4). The identified action-specific ARARs for Alternative B5 consist of requirements associated with implementation of the alternative, such as grading permit acquisition (see Appendix G, Table G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.

In summary, Alternative B5 is judged to meet regulatory threshold requirements for deep vadose zone soil for the PCB AOCs, where PCBs are not comingled with other COCs (Remelt and Oil House French Drain areas). Alternative B5 together with the alternatives judged appropriate in Sections 2, 4, and 5 are expected to meet regulatory requirements for the Facility as a whole.

3.2.6.2 Other Requirements

Other requirements that remedial alternatives must fulfill once they meet threshold requirements are defined by WAC 173-340-360(2)(b) to include the use of permanent solutions to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]).

Use of Permanent Solutions to the Maximum Extent Practicable

The use of permanent solutions to the maximum extent practicable is a primary evaluation criterion for the remedial alternatives being considered for deep vadose zone soil. The specific criteria that must be addressed are specified in WAC 173-340-360(3)(f) and are discussed below.

Protectiveness. Alternative B5 will not actively reduce the concentration of the PCBs in deep vadose zone soil AOCs where PCBs are not comingled with other COCs. Alternative B5 will not meet the SLs that have been established for PCBs. Cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Alternative B5 meets these requirements as discussed above.

The depth of the deep vadose zone soil AOCs eliminates the exposure pathway by which Facility workers and visitors can directly contact and/or ingest deep vadose zone soil PCBs within these AOCs. Thus, the risk to Facility workers and visitors from the possibility of direct contact or ingestion of deep vadose zone soil is eliminated by the nature of its depth. Implementation of Alternative B5 will reduce the future transport of PCBs from deep vadose zone soil to groundwater. Thus, containment surfaces used in Alternative B5 along with the process water and wastewater leak prevention BMPs implemented by Kaiser cut the pathways by which PCBs in deep vadose zone soil can reach human or ecological receptors, and eliminate the risk that the PCBs pose to these receptors.

Since the PCBs currently present in smear zone soil will continue to contact groundwater, Alternative B5 alone is not expected to cause the concentration of PCBs in groundwater to fall below SLs for a long time. Additional treatment alternatives for smear zone soil and for groundwater are discussed later in this FS (Sections 4 and 5).

Permanence. The BMPs in place at the Facility are reducing the release of hazardous substances to the environment.

The existing floor slab and paved surface along with the ongoing water leak preemption BMPs implemented in the PCB source area by Kaiser provide containment in Alternative B5 that will prevent water from infiltrating into the deep vadose zone and potentially transporting PCBs to groundwater. The depth of the deep vadose zone soil AOCs prevents Facility workers and visitors from directly contacting PCBs in these areas, which eliminates the risk to Facility workers and the public from potential direct contact or ingestion of contaminated deep vadose zone soil. Alternative B5, however, does not actively destroy PCBs in deep vadose zone soil.

Since the PCBs currently present in smear zone soil will continue to contact groundwater, Alternative B5 alone is not expected to cause the concentration of PCBs in groundwater to fall below SLs for a long time.

Since the depth of the deep vadose zone soil AOCs eliminates the human health risk to Facility workers and visitors from contact with deep vadose zone soil, and since the implementation of containment in Alternative B5 along with ongoing water leak preemption BMPs in the PCB source area will sever the soil to groundwater exposure pathway, it is judged to meet MTCA requirements for deep vadose zone soil.

Cost. As discussed in Section 3.1.5.1, the estimated NPV cost for Alternative B5 equates to the estimated NPV cost for Alternative B1. Assuming an operating period of 30 years and a discount rate of 7 percent, the total NPV cost of Alternative B5 totals approximately $13.6 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 3.1.5 and in the cost tables contained in Appendix B.

Effectiveness over the Long Term. This alternative will not reduce the concentration of PCBs currently present in deep vadose zone soil to concentrations below SLs for a long time. The containment provided by the existing floor slab and paved surface in Alternative B5 and ongoing water leak preemption BMPs in the PCB source area will prevent water from conveying PCBs to groundwater. The depth of the deep vadose zone soil AOCs prevents Facility workers and visitors from directly contacting or ingesting impacted deep vadose zone soil.

Institutional controls will be put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the floor slab and paved surface containment system. An inspection and maintenance plan that will assure the integrity of these surfaces will be prepared and implemented. These containment surfaces are expected to remain effective for an extended period of time.

Alternative B5 will not generate treatment residues or waste materials. The existing containment surfaces will prevent rainwater or contaminants that are spilled or leak onto the surfaces from infiltrating into the soil underlying the AOCs.

Management of Short-Term Risks. This alternative will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to workers during the implementation of Alternative B5 will be mitigated by their adherence to the HASP prepared to guide health and safety practices during completion of the work. The short-term risks associated with the implementation of Alternative B5 include hazards associated with the industrial activities taking place in the Remelt and Oil House French Drain areas at the Facility. The procedures contained in the HASP and the inspection and maintenance plan have been shown to effectively manage the risk associated with these activities.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place at the Facility. Implementation of Alternative B5 uses the existing building floor slab and paved surface as containment surfaces and will not require the installation of new containment surfaces. Kaiser's water leak preemption process is ongoing and will continue in the Remelt area until potential leak sources are investigated and/or eliminated.

Restoration Time Frame

The time frame needed for the concentration of PCBs in deep vadose zone soil to fall below SLs is expected to be long. Containment surfaces are already in place above the non-comingled PCB AOCs. These surfaces will be monitored and maintained over time. Soils under the containment surfaces may be determined to comply with cleanup standards after the containment surfaces are in place if the requirements under WAC 173-340-740(6)(f) are met. Alternative B5 meets these requirements as discussed above.

An assessment of the factors used to determine whether Alternative B5 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) is generally the same as the assessment presented for Alternative B2 (Section 3.2.3.2). The practicability of achieving a shorter restoration time frame is addressed in the comparative analysis for each COC group in Section 3.3. The restoration time frame for Alternative B5 is considered to be reasonable, as defined by WAC 173-340-360(4).

3.3 COMPARATIVE ANALYSIS OF ALTERNATIVES FOR DEEP VADOSE ZONE SOIL

Alternatives B1 through B5 are evaluated individually in Section 3.2.2 through 3.2.6 using the evaluation criteria that are established by Ecology (WAC 173-340-360). The comparative analysis presented in this section assesses the relative capability of the alternatives, as applicable to the COC groups identified for deep vadose zone soil, to meet threshold requirements; to use permanent solutions to the maximum extent practicable; and to provide a reasonable restoration time frame. A disproportionate cost analysis is used to determine whether a cleanup action uses permanent solutions to the maximum practicable extent. The disproportionate cost analysis procedure is summarized in Section 2.3.1.

The remedial alternatives judged to be potentially applicable to the COC groups present in deep vadose zone soil at the Facility were identified in Section 3.6.1 (Table 3-17) of the FSTM (Hart Crowser 2012c). A comparative analysis of alternatives is applied to these COC groups in the following sections:

- Section 3.3.1 – VOCs (Alternatives B1, B2, and B3);
- Section 3.3.2 – SVOCs and comingled PCBs (Alternatives B1, B2, and B4);
- Section 3.3.3 – Non-comingled PCBs (Alternatives B1, B2, and B5); and

- Section 3.3.4 – Metals (Alternatives B1 and B2).

3.3.1 Comparative Analysis of Alternatives Applicable to VOCs

Alternatives B1 (institutional controls, monitoring, and MNA), B2 (institutional controls, monitoring, MNA, and containment), and B3 (institutional controls, monitoring, MNA, containment, and SVE) are assessed in Sections 3.2.1 through 3.2.3, respectively. The outcome of this comparative assessment of alternatives applicable to VOCs is summarized in Table 3-2.

Alternative B3 is considered for treatment of the three VOC AOCs that are impacted by Stoddard solvent as described in Section 3.1.3. It is assumed that SVE treatment will be effective for VOC removal because of high soil permeability and volatility of the contaminant. Conservatively, it was assumed that post-treatment concentrations will be slightly below SLs; therefore, the quantity of VOCs removed from AOC-6 through AOC-8 is estimated to be approximately 330 pounds.

The ability of the Alternatives B1, B2, and B3 to meet threshold requirements, to use permanent solutions to the maximum practicable extent (disproportionate cost analysis), and to provide a reasonable restoration timeframe are presented below.

3.3.1.1 Threshold Requirements

Threshold requirements required for cleanup actions are defined in WAC 173-340-360(2). These requirements include protection of human health and the environment, compliance with MTCA cleanup standards and applicable state and federal laws, and the inclusion of compliance monitoring. Since compliance monitoring is a part of these Alternatives (B1 through B5), it is not evaluated here. For further discussion of these threshold requirements, see Section 2.2.1.1.

Protect Human Health and the Environment

Alternatives B2 and B3 each provide physical and administrative controls and BMPs that are used to reduce the potential for VOCs in deep vadose zone soil to migrate to groundwater receptors and the Spokane River.

Approximately 75 percent of the three deep vadose zone VOC AOCs present at the Facility are currently located under pavement or floor slabs. The pavement and floor slab prevent rainwater from conveying VOCs from deep vadose zone soil to groundwater and potentially to receptors in groundwater or the Spokane River. Alternatives B2 and B3 provide additional containment surfaces to cover the remaining VOC AOC surfaces. Thus, both Alternatives B2 and B3 cut the pathways by which VOCs in deep vadose zone soil can reach human or ecological receptors, and eliminate the risk that the VOCs pose to these receptors.

In addition, Alternative B3 removes and destroys approximately 330 pounds of VOCs in the AOCs that are treated in a relatively short period of time (about 3 years). This destruction will further reduce the risk of future transport of VOCs from deep vadose zone soil to the groundwater and potentially to the receptors in the Spokane River. SVE has been successfully demonstrated at many installations, but bench- and pilot-scale tests may be needed to prove its suitability for the deep vadose zone soil at the Kaiser Facility.

Alternative B3 is more permanent and provides a greater degree of protection than Alternative B2.

Comply with MTCA Cleanup Standards

The SLs developed for the Facility were based on the requirements of MTCA and contaminant-specific state and federal ARARs. Alternative B1 will not directly reduce the concentration of VOCs that are present in the three VOC AOCs. Natural attenuation processes may reduce the concentration of VOCs to SLs over a very long time.

In addition, Alternative B1 will not break the deep vadose zone soil to groundwater pathway that presents potential risk to groundwater receptors and the Spokane River. Thus, Alternative B1 will not meet existing MTCA cleanup requirements or contaminant-specific ARAR standards promulgated by state and federal laws.

Alternatives B2 and B3 add containment surfaces that prevent rainwater from conveying VOCs from deep vadose zone soil to groundwater and potentially to groundwater receptors and the Spokane River. Thus, both Alternatives B2 and B3 cut the pathways by which VOCs in deep vadose zone soil can reach human or ecological receptors, and eliminate the risk that the VOCs pose to these receptors. As discussed in Section 2.1.1.3, cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Alternatives B2 and B3 meet these requirements as discussed above.

Since Alternative B3 removes and destroys VOCs (in applicable AOCs), it directly meets the SLs (i.e., 100 mg/kg) that have been established for VOCs at the Kaiser Facility.

Comply with Applicable State and Federal Laws

Alternatives B2 and B3 are judged to meet contaminant-specific ARARs for VOCs as discussed above. No location-specific ARARs have been identified for the deep vadose zone soil at the Facility (see Appendix G, Table G-4). The identified action-specific ARARs for Alternative B2 and B3 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.

3.3.1.2 Disproportionate Cost Analysis

Alternatives B2 and B3 meet the threshold requirements established by MTCA. This disproportionate cost analysis assesses whether Alternative B2 or B3 use permanent solutions to the maximum extent practicable. The specific criteria that must be addressed are specified in WAC 173-340-360(3)(f) and are discussed below.

Protectiveness

Alternatives B2 and B3 each provide physical and administrative controls, BMPs, and containment surfaces that are used to reduce the potential for VOCs in deep vadose zone soil to migrate to groundwater and eventually to receptors in the Spokane River. Thus, both Alternatives B2 and B3 cut the pathways by which VOCs in deep vadose zone soil can reach human or ecological receptors, and eliminate the risk that the VOCs pose to these receptors.

Natural attenuation of VOCs in deep vadose zone soil is assumed to be occurring in Alternatives B2 and B3; however, it will take a long time for concentrations to fall below SLs.

Alternative B3 permanently reduces the toxicity and volume of VOCs in deep vadose zone soil present in AOCs that will be treated by SVE. Alternative B3 removes and destroys approximately 330 pounds of VOCs (Stoddard solvent). Alternative B3 is judged more protective than Alternative B2.

Permanence

Alternatives B2 and B3 will reduce the release of hazardous substances to the environment by the use of BMPs. Existing and newly installed paved surfaces (floor slabs, roads) prevent rainwater from conveying VOCs to potentially to groundwater receptors and the Spokane River. However, Alternative B2 does not actively treat VOCs (beyond natural attenuation) and thus provides less permanence than Alternative B3.

Alternative B3 provides more permanence than Alternative B2, since Alternative B3 destroys approximately 330 pounds of VOCs in a relatively short period of time (about 3 years).

Cost

The NPV of implementing Alternatives B2 and B3 over a 30-year time period is estimated to total approximately $14.7 and $15.3 million (-35 to +50 percent), respectively. The assumptions used to prepare these estimates are described in Section 3.1 and listed in the cost tables contained in Appendix B. Alternative B3 removes and destroys 330 pounds of VOCs. Based on this mass of VOCs, the cost per pound of Stoddard solvent contained by Alternative B2 is $44,500 (see Table 3-2). The cost of treating soil with VOCs using Alternative B3 is $46,400 per pound of Stoddard solvent destroyed.

Effectiveness over the Long Term

The existing pavement and floor slabs and new containment surfaces provided in Alternative B2 will prevent rainwater from conveying VOCs to groundwater and potentially to groundwater receptors and the Spokane River and cut the pathways by which VOCs in deep vadose zone soil can reach human or ecological receptors, and eliminate the risk that the VOCs pose to these receptors. This alternative does not generate treatment residues or waste materials. Surface water runoff from the containment surfaces will be collected and allowed to infiltrate in an area where soil is not contaminated or transported to the Kaiser WWT facility for treatment.

In addition to cutting the deep vadose zone soil to groundwater pathway, Alternative B3 will reduce the concentration of VOCs in deep vadose zone soil in the three AOCs to concentrations below SLs in a relatively short (about 3 years) time period. It prevents rainwater from conveying VOCs to groundwater and potentially to groundwater receptors and the Spokane River. Surface water runoff from the containment surfaces will be collected and allowed to infiltrate in an area where soil is not contaminated or transported to the Kaiser WWT facility for treatment.

Alternative B3 generates spent carbon that will be regenerated by an experienced subcontractor. The technologies employed by this alternative have been successfully demonstrated at other locations. Bench- and pilot-scale tests may be required to demonstrate the effectiveness of the SVE process for the deep vadose zone soil at the Kaiser Facility.

Alternative B3 is judged to provide a greater degree of long-term effectiveness than Alternative B2.

Management of Short-Term Risks

Both Alternative B2 and B3 use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces and SVE systems will be mitigated by their adherence to the HASP prepared to guide the construction work. The procedures contained in the HASP and the inspection and maintenance plan have been shown to effectively manage the limited risk associated with these activities.

Alternative B3 results in additional short-term risks to workers operating the SVE system, and in the transportation and regeneration of the spent carbon. The risks associated with these activities will be mitigated by adherence to the HASP prepared to guide this work. The regeneration of spent carbon is a complex process. An experienced carbon subcontractor will manage the removal, transportation, and regeneration of spent carbon.

Due to the additional complexity and risks inherent in operating the SVE system, Alternative B2 is judged to present fewer short-term risks than Alternative B3.

Technical and Administrative Implementability

BMPs, groundwater monitoring, and institutional controls employed by Alternatives B2 and B3 are already in place at the Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. The contained area will likely need to be monitored in perpetuity and a restrictive covenant for areas where COCs remain in place above SLs will need to be in place.

SVE is a presumptive remedy for the removal of VOCs from soil and is considered to be an implementable conventional technology, but requires technical expertise for design and execution. Regeneration of spent carbon (and the incineration of VOCs released from the carbon) is a complex process that must be conducted in a facility designed and permitted for this purpose. The nearest facility to Kaiser is located in Cattlesburg, Kentucky (York, T., Calgon, personal communication, 2010). The handling and disposal of spent carbon will be performed by an experienced contractor.

Alternative B3 has a greater level of technical complexity and more administrative requirements than Alternative B2.

Summary of Disproportionate Cost Analysis

Both Alternatives B2 and B3 meet the threshold requirements established by WAC 173-340-360(2)(a). They each provide institutional controls (e.g., physical and administrative controls, BMPs) and containment surfaces that reduce the potential for Facility workers and visitors to be exposed to VOCs and for VOCs in deep vadose zone soil to migrate to groundwater and potentially to receptors in groundwater or the Spokane River. Thus, both Alternatives B2 and B3 cut the pathways by which VOCs in deep vadose zone soil can reach human or ecological receptors, and eliminate the risk that the VOCs pose to these receptors. Alternative B3 provides a higher degree of protection to human health and the environment than Alternative B2 since it also removes and destroys VOCs using SVE treatment. For both Alternatives B2 and B3, the reduction in current risk will occur in a short time frame.

Alternative B3 permanently reduces the toxicity and volume of VOCs in deep vadose zone soil in the VOC AOCs in a short time period. Alternative B3 removes and destroys an estimated 330 pounds of VOCs (Stoddard solvent). Alternative B3 is thus judged to provide a more permanent remedy than Alternative B2.

The use of SVE and spent carbon regeneration technologies in Alternative B3 increases the level of short-term risk and technical and administrative implementability, above those levels associated with Alternative B2. The greater level of permanence and long-term effectiveness provided by the destruction of an estimated 330 pounds of VOCs by Alternative B3 costs approximately $15.3 million or about $600,000 more than implementing Alternative B2 alone.

This additional cost of SVE treatment ($600,000) in Alternative B3 does not provide any more potential future risk reduction (to potential receptors) than the risk reductions provided by Alternative B2, since both Alternatives B2 and B3 cut the pathways by which COCs in deep vadose zone soil can reach potential receptors and eliminate the risk posed by deep vadose zone soil to these receptors. In addition, Alternative B2 can be implemented with less short-term risk and fewer technical and administrative issues than Alternative B3. Thus, Alternative B2 is judged to use permanent solutions to the maximum practicable extent for deep vadose zone soil containing VOCs at concentrations above SLs.

As discussed in Section 3.1.3.1, a total of approximately 700 pounds of Stoddard solvent are present in the VOC AOCs. These AOCs also contain about 107,000 pounds of SVOCs. The Stoddard solvent is comingled with the SVOCs in the vadose zone soil. The selection of a remedial alternative for the vadose zone soil in these AOCs is likely to depend more on the potential risk reduction associated with the treatment of SVOCs, than the potential risk reduction associated with the treatment of the VOCs.

3.3.1.3 Restoration Time Frame for VOCs

The time frame needed for Alternative B1 to reduce the concentration of VOCs in deep vadose zone soil to SLs, and to reduce the potential risks posed by the site to human health and environment by natural attenuation will be long.

Alternative B2 does not directly reduce the toxicity or volume of the VOCs contained in deep vadose zone soil beyond natural attenuation. Containment surfaces can be installed in a relatively short time frame (about 1 year). Soil under the containment surfaces may be determined to comply with cleanup standards after the containment surfaces are in place if the requirements under WAC 173-340-740(6)(f) are met. Alternative B2 meets these requirements.

In addition to the containment surfaces installed under Alternative B2, Alternative B3 reduces the concentration of VOCs in deep vadose zone soil to concentrations below SLs within a relatively short time period (about 3 years).

A number of factors are used to determine whether an alternative provides for a reasonable restoration time frame (WAC-173-360(4)(b). These factors were discussed for each alternative in Section 3.2.

The restoration time frames for Alternatives B2 and B3 are equal and it is not practicable to achieve a shorter time frame with another alternative. Based on this and the evaluation of the other criteria in Section 3.2, Alternatives B2 and B3 are judged to have reasonable restoration time frames.

3.3.2 Comparative Analysis of Alternatives Applicable to SVOCs

Alternatives B1 (institutional controls, monitoring, and MNA), B2 (institutional controls, monitoring, MNA, and containment), and B4 (institutional controls, monitoring, MNA, and *in situ* chemical oxidation) are applicable to SVOCs and assessed in Section 3.2. Alternatives B3 and B5 are not applicable to SVOCs. The outcome of this assessment of alternatives applicable to SVOCs is summarized in Table 3-3.

PCBs are comingled with SVOCs in some of the SVOC AOCs (the Hoffman Tank area and the Oil Drum Storage and French Drain area). The mass of PCBs in these areas is significantly less than the mass of SVOCs. The alternatives applicable to SVOCs are considered applicable to the PCBs (institutional controls, containment or potentially applicable oxidation) in the areas where PCBs are co-located with SVOCs. Nonetheless, the discussion in this section assumes that the mass of PCBs will not be reduced as Alternative B4 is implemented. Refer to Appendix F for a discussion of the degradation mechanisms that are expected to reduce the mass of PCBs that are comingled with SVOCs.

The capability of Alternatives B2 and B4 to meet threshold requirements, to use permanent solutions to the maximum extent practicable (disproportionate cost analysis), and to provide a reasonable restoration time frame is presented below.

3.3.2.1 Threshold Requirements

Alternative B1 does not meet the threshold criteria and will not be assessed in the comparative analysis of alternatives applicable to SVOCs and to PCBs that are comingled with SVOCs. The capability of Alternatives B2 and B4 to meet threshold requirements is discussed below. Threshold requirements are defined in Section 2.2.1.1 of this FS.

Protect Human Health and the Environment

Alternatives B2 and B4 each include physical and administrative controls and BMPs that will reduce the potential for SVOCs and PCBs that are comingled with SVOCs in deep vadose zone soil to migrate to groundwater. Because of the depth of the deep vadose zone soil, the risk of direct exposure to these AOCs for Facility workers and visitors is eliminated.

Alternatives B2 and B4 include the installation of new containment surfaces for the AOCs that are not located below existing pavement or floor slabs. As a result, this alternative will cut the existing deep vadose zone soil to groundwater exposure pathway, and eliminate the risk posed to receptors by the SVOCs present in the deep vadose zone at the Facility.

Only Alternative B4 will permanently reduce the toxicity and volume of SVOCs in deep vadose zone soil. Alternative B4 will destroy approximately 124,000 pounds (56 percent) of SVOCs in the deep vadose zone soil. For the purposes of this section of the FS, the mass of PCBs potentially reduced is ignored. Alternative B4 is judged to be more protective of human health and the environment than Alternative B2.

Comply with MTCA Cleanup Standards

Alternatives B2 and B4 add containment surfaces that will prevent rainwater from conveying COCs from deep vadose zone soil to groundwater. As discussed in Section 3.2.3, cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Alternatives B2 and B4 meet these requirements.

Alternative B4 will destroy SVOCs in the soil and is expected to reduce the mass of SVOCs by 56 percent. It is not expected to reduce concentrations below the SLs.

Both Alternatives B2 and B4 are judged to meet MTCA cleanup requirements.

Comply with Applicable State and Federal Laws

Alternatives B2 and B4 are judged to meet contaminant-specific ARARs for SVOCs as discussed above. No location-specific ARARs have been identified for the deep vadose zone soil at the Facility (Appendix G, Table G-4). The identified action-specific ARARs for Alternative B2 and B4 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.

3.3.2.2 Disproportionate Cost Analysis

Alternatives B2 and B4 meet the threshold requirements established by MTCA. This disproportionate cost analysis identifies which alternative uses permanent solutions to the maximum extent practicable . Alternative B1 does not meet the threshold criteria and will not be assessed in this disproportionate cost analysis.

Protectiveness

Alternatives B2 and B4 provide physical and administrative controls and BMPs that will be used to reduce the potential for SVOCs and for PCBs that are comingled with SVOCs in deep vadose zone soil, to migrate to groundwater. Alternatives B2 and B4 both add containment surfaces that will prevent rainwater from conveying SVOCs and PCBs that are comingled with SVOCs from deep vadose zone soil to groundwater. Thus, both alternatives prevent SVOCs in deep vadose zone soil from reaching potential receptors and eliminate the risk to these receptors presented by SVOCs in deep vadose zone soil.

Cleanup actions that involve containment, like Alternatives B2 and B4, can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Both Alternatives B2 and B4 meet these requirements, as discussed above.

Alternative B4 is expected to destroy approximately 124,000 pounds of SVOCs, thereby reducing the toxicity and volume of SVOCs in deep vadose zone soil. Alternative B4 is not expected to significantly reduce the toxicity or volume of PCBs.

Alternative B4 is judged to be more protective of human health and the environment than Alternative B2 for SVOCs and for PCBs that are comingled with SVOCs.

Permanence

Alternatives B2 and B4 will provide containment surfaces, in addition to physical and administrative controls and BMPs, that will reduce the potential for SVOCs and for PCBs that are comingled with SVOCs in deep vadose zone soil to migrate to groundwater.

Alternative B2 will not reduce toxicity or volume of SVOCs in deep vadose zone soil for a long time. Alternative B4 will permanently reduce the toxicity and volume of SVOCs in deep vadose zone soil by approximately 56 percent. Alternative B4 is expected to destroy 124,000 pounds of SVOCs.

Alternative B4 is judged to be more permanent then Alternative B2.

Cost

The NPV of implementing Alternative B2 over a 30-year time period is estimated to total approximately $14.7 million (-35 to +50 percent). The mass of SVOCs that will be contained under new caps is approximately 221,000 pounds. Based on these values, the cost of capping per pound of SVOC for Alternative B2 is approximately $67 (see Table 3-3).

The NPV of implementing Alternative B4 over a 30-year time period is estimated to total approximately $23.2 million (-35 to +50 percent). The mass of SVOCs that will be destroyed is approximately 124,000 pounds. Alternative B4 costs approximately $187 per pound of SVOC destroyed (see Table 3-3).

The assumptions used to prepare these estimates are described in Section 3.1 and listed in the cost tables contained in Appendix B.

Effectiveness over the Long Term

Alternatives B2 and B4 will use institutional controls and containment to protect groundwater from SVOCs migrating from the deep vadose zone soil AOCs. The containment surfaces used by these alternatives have been successfully demonstrated at other locations.

Capping can be implemented in a relatively short time frame (about 1 year) and will not generate significant treatment residues or waste materials. The containment surfaces are expected to remain effective for an extended period of time. An inspection and maintenance plan that will assure the integrity of the existing pavement, floor slabs, and new containment surfaces will be prepared and implemented.

Alternative B2 will not actively reduce the mass, toxicity, or volume (beyond natural attenuation) of SVOCs contained in the deep vadose zone soil AOCs. Alternative B4 will destroy approximately 124,000 pounds of SVOCs in deep vadose zone soil over 26 years.

Alternative B4 is judged to have a higher degree of long-term effectiveness than Alternative B2.

Management of Short-Term Risks

Alternatives B2 and B4 will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks for both alternatives include risks to workers during the installation of the containment surfaces. These risks will be mitigated by adherence to the HASP prepared to guide the health and safety aspects of the construction work. The procedures contained in the HASP have been shown to effectively manage the limited risk associated with these activities.

Other risks associated with the generation and injection of ozone and the operation of SVE wells will be mitigated by following the HASP that is prepared to guide these activities.

Ozone may react with metals in the subsurface and oxidize them to their highest oxidative state. The presence of a containment surface and absence of rainwater or other liquids in the vadose zone should prevent the oxidized compounds from reaching the groundwater.

Alternative B2 is judged to present fewer short-term risks than Alternative B4.

Technical and Administrative Implementability

BMPs, groundwater monitoring, and institutional controls employed by the alternatives are already in place at the Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years.

On-site pilot-scale testing will be required for the design and implementation of *in situ* oxidation to confirm its technical implementability.

The technical and administrative requirements associated with Alternative B4 are more complex than the technical and administrative requirements associated with Alternative B2.

Summary of Disproportionate Cost Analysis

Alternatives B2 and B4 meet the threshold requirements established by WAC 173-340-360(2)(a). They each will provide physical and administrative controls, and BMPs, and containment surfaces that will reduce the potential for SVOCs in deep vadose zone soil to migrate to groundwater. This reduction in current risk will occur in a short time frame (about 1 year). Thus, both Alternatives B2 and B4 prevent SVOCs in deep vadose zone soil from reaching potential receptors and eliminate the risk to these receptors presented by SVOCs in deep vadose zone soil.

Cleanup actions that involve containment can be deemed to meet cleanup standards if certain requirements set out in WAC 173-340-740(6)(f) are met. Both Alternatives B2 and B4 meet these requirements.

Alternative B4 permanently reduces the toxicity and volume of SVOCs in treated deep vadose zone soil. This alternative destroys approximately 124,000 pounds of SVOC. There is a potential risk of changing the valence state of metals which could increase toxicity and mobility of these metals. The presence of a containment surface and absence of rainwater or other liquids in the vadose zone should prevent the oxidized compounds from reaching the groundwater.

Alternative B4 is judged to provide the most permanent remedy and to have greater long-term effectiveness than Alternative B2.

Cap construction is an established technology and poses minimal short-term risks during construction. However, chemical oxidation (Alternative B4) presents additional short-term risks and increase the technical and administrative implementability above those associated with Alternative B2.

The additional permanence and greater long-term effectiveness provided by the destruction of SVOCs in Alternative B4 is estimated to cost approximately $23.2 million (or about $190 per pound of SVOC destroyed). Alternative B2 is estimated to cost $14.7 million (or about $70 per pound of SVOC contained). The additional permanence and long-term effectiveness provided by Alternative B4 comes at a cost of $8.5 million and does not provide any additional potential future risk reduction via the soil to groundwater pathway than the risk reduction provided by Alternative B2. Both alternatives eliminate the risk to receptors posed by the SVOCs present in deep vadose zone soil. Thus, Alternative B2 is judged to use permanent solutions to the maximum extent practicable for deep vadose zone soil containing SVOCs.

3.3.2.3 Restoration Time Frame for SVOCs and Comingled PCBs

Alternative B1 does not reduce the potential risks posed by the site to human health and environment within a reasonable time frame. The time frame needed for the concentration of SVOCs in deep vadose zone soil to fall below SLs by natural attenuation will be long.

For Alternatives B2 and B4, the containment surfaces can be installed in a relatively short time frame (about 1 year). Soil under the containment surfaces may be determined to comply with cleanup standards after the containment surfaces are in place if the requirements under WAC 173-340-740(6)(f) are met. Alternatives B2 and B4 meet these requirements.

The mass of SVOCs in soil treated in Alternative B4 is expected to be reduced by approximately 56 percent in 26 years. This will not result in soil concentrations below the SLs for SVOCs. Natural attenuation processes are expected to further reduce SVOC concentrations in the deep vadose zone soil. The time frame needed for the concentration of SVOCs in deep vadose zone soil to fall below SLs will be long.

A number of factors are used to determine whether an alternative provides for a reasonable restoration time frame (WAC-173-360(4)(b). These factors are discussed for each alternative in Section 3.2.

The restoration time frames for Alternatives B2 and B4 are approximately equal, and it is not practicable to achieve a shorter time frame with another alternative. Based on this and the evaluation of the other criteria in Section 3.2, Alternatives B2 and B4 are judged to have reasonable restoration time frames.

3.3.3 Comparative Analysis for Alternatives Applicable to Non-Comingled PCBs

Alternatives B2 and B5 are applicable to AOCs where PCBs are not comingled with other COCs. Analysis of alternatives applicable to PCBs that are comingled with other COCs is discussed in the respective comparative analysis sections for these COCs (see Section 3.3.2).

Alternative B2 includes institutional controls, monitoring, MNA, and containment. Alternative B5 applies containment specifically to the PCB AOCs located in the Remelt and the Oil House French Drain areas, where PCBs are not co-located with other COCs. These are the only deep vadose zone soil AOCs where PCBs are not comingled with other COCs. Alternatives B2 and B5 are assessed in Sections 3.2.3 and 3.2.6, respectively.

Alternative B5 does not include unique remedial elements that are not already a part of Alternative B2. Alternative B5 assumes that the existing floor slab over the PCB AOCs in the Remelt area and the paved surface in the Oil House French Drain area are suitable as containment caps and that installation of new cap surface will not be required. The institutional controls element of Alternative B2 includes floor slab O&M and monitoring in the Remelt area and O&M and monitoring of the paved surface in the Oil House French Drain area, in addition to preparation of plans to guide these activities. Alternative B5 is essentially a part of Alternative B2, and, as a result, Alternative B5 does not demonstrate incremental benefit beyond this alternative. Thus, a disproportionate cost analysis is not conducted for Alternative B5.

Both Alternative B2 and B5 meet MTCA threshold criteria (see Alternative B5 evaluation in Section 3.2.6). Alternatives B2 and B5 provide physical and administrative controls and BMPs that will be used to reduce the potential for PCBs in deep vadose zone soil to migrate to groundwater. The depth of the deep vadose zone PCB AOCs eliminates the direct contact exposure pathway for Facility workers and visitors. As such, the reduction in risk to human health and the environment is already in place in these areas of the Facility. Alternative B5 is judged to be the alternative that uses permanent solutions to the maximum extent practicable for the deep vadose zone PCB AOCs in the Remelt and Oil House French Drain areas of the Facility. Alternative B5 is also judged to have a reasonable restoration time frame, as evaluated in Section 3.2.6, and because it is not practicable to achieve a shorter restoration time frame.

3.3.4 Comparative Analysis of Alternatives Applicable to Metals

The remedial technologies that are applicable to metal treatment include Alternative B1 (institutional controls, monitoring, and MNA) and Alternative B2 (institutional controls, monitoring, MNA, and containment). These alternatives are assessed in Sections 3.2.2 and 3.2.3, respectively. The results of this assessment are summarized in Table 3-4.

Alternative B1 does not meet MTCA threshold criteria (see Section 3.2.2). Alternative B2 meets threshold and other requirements for metals and is judged to be the alternative that uses permanent solutions to the maximum extent practicable for metals present in deep vadose zone soil at concentrations above SLs. A disproportionate cost analysis is not required for metals because only one applicable technology meets threshold criteria. Alternative B2 is also judged to have a reasonable restoration time frame, as evaluated in Section 3.2.3, and because it is not practicable to achieve a shorter restoration time frame.

There are seven metals-impacted deep vadose zone soil AOCs at the Facility. Six of the areas contain arsenic at concentrations above SLs, and one contains chromium at concentrations above SLs. Three of the arsenic areas are below existing pavement or building foundations (in the Oil House Eight USTs Excavation area and the Wastewater Treatment Hydrogen Sulfide Scrubber Building area). There are four metals-impacted AOCs considered for containment in Alternative B2, which are currently not below existing pavement or are partially below existing pavement. These AOCs include one arsenic-impacted area in the Oil House Tank area (which is partially below existing pavement); the chromium-impacted AOC in the Chromium Transfer Line area; and the two arsenic-impacted AOCs in the Hot Line area (see Figure 3-1). The mass of metals in these four areas is estimated to total approximately 340 pounds.

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Table 3-1 – Summary of Monitoring Requirements for Remedial Alternative B4: *In Situ* Treatment [a]

Monitoring Type and Location	Medium	Frequency	Parameters	Comment	Evaluation Criteria
Protection Monitoring					
Dust monitoring	Air	Daily, during well installation	Visual inspection of dust generation.	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD in HASP
System Enclosure	Air	Constantly while occupied	Ozone	Ozone concentrations in enclosure will be monitored constantly while in use.	TBD in HASP
Performance Monitoring					
Ozone System Manifolds	Air	Monthly	Pressures, Flow rates	As required by the O&M Plan.	TBD
SVE System Manifold	Air	Monthly	Pressures, Flow rates	As required by the O&M Plan.	TBD
SVE Discharge	Air	Monthly	Ozone, Oxygen, VOCs	As required by the O&M Plan.	TBD
AOC Footprint	Soil	Annual	SVOCs, VOCs, PCBs, Metals	Soil sampling from borings within the AOC footprint that are being treated to assess the radius of influence and performance of the system.	See Table 2-1.

Notes:

(a) Monitoring requirements for elements unique to B4 only; monitoring requirements for Alternatives B1 and B2 are the same as those for A1 and A2 (see Tables 2-3 and 2-4).

TBD - To be determined.

Table 3-2 - Summary of Detailed Analysis of Alternatives Applicable to VOCs in Deep Vadose Zone Soil at the Kaiser Facility

	Criteria	Alternative B1 Institutional Controls, Monitoring, and MNA	Alternative B2 Alternative B1 Plus Containment	Alternative B3 Alternative B2 Plus SVE
Threshold Requirements	Overall Protection of Human Health and the Environment	Some natural attenuation of VOCs may occur. Will not reduce the concentration of VOCs in deep vadose zone soil to below SLs for a very long time. Does not actively address the soil to groundwater pathway that could potentially transfer VOCs to groundwater receptors or the Spokane River. Provides less overall protection to the environment than Alternatives B2 or B3.	Physical and administrative controls, BMPs, and containment are used to reduce the potential for worker exposure to VOCs and reduce the potential for VOCs in deep vadose zone soils to migrate to groundwater and potentially to groundwater receptors or the Spokane River. Containment surfaces cut the vadose zone soil to groundwater pathway and eliminate the risk to receptors posed by the VOCs in the vadose zone soils. Some natural attenuation of VOCs may occur; however, it will take a long time for VOC concentrations to reach SLs by these processes. Short-term risks are manageable. More protective than Alternative B1 but less protective than Alternative B3.	Alternative B3 removes and destroys an estimated 330 pounds of VOCs in the AOCs that are treated. The VOCs will be destroyed in a relatively short time. This will reduce the future transport of VOCs from deep vadose zone soil to the groundwater and potentially to groundwater receptors or the Spokane River. The technologies employed by this alternative have been successfully demonstrated, but bench- and pilot-scale tests may be needed to prove their suitability for this Facility at this depth. Short-term risks are manageable. This alternative is more permanent and provides a greater degree of protection than Alternatives B1 and B2.
	Comply with Cleanup Standards	The concentration of VOCs in the AOCs containing VOCs will remain above SLs for a long time. Does not address the soil to groundwater pathway that could potentially transfer VOCs to groundwater receptors or the Spokane River. Does not meet existing MTCA cleanup standards.	The containment surfaces prevent rainwater from conveying VOCs from deep vadose zone soil to groundwater and potentially to groundwater receptors or the Spokane River. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. Alternative B2 meets these requirements.	SVE treatment is assumed to reduce the concentration of VOCs in the three AOCs where it is employed to concentrations below SLs. The containment surfaces prevent rainwater from conveying VOCs from deep vadose zone soil to groundwater and potentially to groundwater receptors or the Spokane River.
	Comply with Applicable State and Federal Law	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. No action- or location-specific ARARs have been identified for the deep vadose zone soil at the Facility applicable to Alternative B1 (see Appendix G, Tables G-3 and G-4).	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for the deep vadose zone soil at the Facility applicable to Alternative B2. The identified action-specific ARARs for Alternative B2 consist of requirements associated with implementation of the alternative (see Appendix G). These ARARS are judged to be attainable and do not affect the alternative selection process.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for the deep vadose zone soil at the Facility applicable to Alternative B3. The identified action-specific ARARs for Alternative B3 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-2 and G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.
	Provide for Compliance Monitoring	Alternative B1 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative B2 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative B3 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.
Disproportionate Cost Analysis	Protectiveness	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.
	Permanence	BMPs will reduce the release of hazardous substances to the environment. Existing floor slabs and paved surfaces do not contain all of the areas that have VOCs above SLs. Does not reduce the toxicity, mobility, or volume of VOCs present in deep vadose zone soils in a reasonable time frame. Less permanent than Alternatives B2 and B3.	BMPs will reduce the release of hazardous substances to the environment. Existing paved surfaces (floor slabs, roads) also reduce risk of VOCs in deep vadose zone soil to migrate into groundwater due to infiltration. Does not actively treat VOCs in the soils beyond natural attenuation, which would decrease VOC concentrations over a long restoration time frame. Provides a lower degree of permanence than is provided by Alternative B3 since Alternative B3 removes and destroys VOCs.	The BMPs in place at the Facility will reduce the release of hazardous substances to the environment. Alternative B3 will reduce the risk of VOCs migrating to groundwater. This option removes and destroys 330 pounds of VOCs in the AOCs that are treated. The VOCs will be removed and destroyed (as carbon is regenerated) in a relatively short time period. Provides a higher degree of permanence than Alternative B2 since Alternative B3 removes and destroys VOCs.
	Effectiveness over the Long Term	The institutional controls, BMPs, monitoring, and MNA employed by this alternative are currently in use at the Kaiser Facility. VOC concentrations will not be reduced to below SLs for a long time. Much less effective over the long term than Alternatives B2 and B3.	The paving surfaces employed by this alternative have been successfully demonstrated at Kaiser and other locations. Does not actively address the VOCs in deep vadose zone soils. The existing pavement and floor slabs and new containment surfaces provided by Alternative B2 will prevent rainwater from conveying VOCs to groundwater and potentially to groundwater receptors or the Spokane River which cuts the vadose zone soil to groundwater pathway and eliminates the risk to receptors posed by the VOCs in the vadose zone soils. Does not generate treatment residues or waste materials. Surface water runoff from the containment surfaces will be collected and allowed to infiltrate in uncontaminated areas or transported to the Kaiser WWTP for treatment. Judged to be less effective over the long term than Alternative B3.	The containment surfaces provided by alternative B3 will cut the soil to groundwater pathway and eliminate risk to receptors posed by the VOCs. In addition, Alternative B3 is expected to reduce the concentration of VOCs in deep vadose zone soils in the three AOCs that will be treated to concentrations below SLs within a relatively short time period. Alternative B3 generates spent carbon that will be regenerated by an experienced subcontractor. Surface water runoff from the containment surfaces will be collected and allowed to infiltrate in uncontaminated areas or transported to the Kaiser WWTP for treatment. The technologies employed by this alternative have been successfully demonstrated at other locations. Bench- and pilot-scale tests may be required to demonstrate their effectiveness at this Facility and at this depth. More effective over the long term than Alternative B2.

Table 3-2 - Summary of Detailed Analysis of Alternatives Applicable to VOCs in Deep Vadose Zone Soil at the Kaiser Facility

	Criteria	Alternative B1 Institutional Controls, Monitoring, and MNA	Alternative B2 Alternative B1 Plus Containment	Alternative B3 Alternative B2 Plus SVE
Disproportionate Cost Analysis	Management of Short-Term Risks	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create any new or additional risk to human health and the environment. Creates fewer short-term risks than Alternatives B2 and B3.	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces will be mitigated by their adherence to the HASP prepared to guide the construction work. Alternative B2 has fewer short-term risks than Alternative B3.	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces will be mitigated by their adherence to the HASP prepared for the construction work and the operation of the SVE systems. An experienced subcontractor will handle, remove, and regenerate spent carbon. Alternative B3 is judged to present greater short-term risk than Alternative B2.
Disproportionate Cost Analysis	Technical and Administrative Implementability	The actions associated with Alternative B1 are already in place at the Kaiser Facility. Thus, Alternative B1 provides a greater degree of technical and administrative implementability than Alternatives B2 and B3.	BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. Alternative B2 is a less complex technical process and requires fewer environmental permits than Alternative B3.	BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. SVE is a presumptive remedy for the removal of VOCs from soil and is considered to be an implementable conventional technology but requires technical expertise for design and execution. Management of spent carbon will require technical expertise and administrative support (contaminant profiling, coordinating with subcontractor). Alternative B3 is judged to have a greater level of technical complexity and more administrative requirements than Alternative B2. Thus, Alternative B3 is less technically and administratively implementable than Alternative B2.
Disproportionate Cost Analysis	Consideration of Public Concerns	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.
Disproportionate Cost Analysis	Conceptual-Level Cost (NPV -35/+50 percent)	$13.6 million	$14.7 million	$15.3 million
Disproportionate Cost Analysis	Total Cost per Pound of COC Treated or Contained	Not Evaluated - Baseline Cost	$44,500 per pound of VOC contained	$46,400 per pound of VOC destroyed
	Restoration Time Frame	Natural attenuation processes at the Facility are expected to continue. The time frame needed for recovery to occur will be long and is judged to be unreasonable.	Natural attenuation of VOCs in the deep vadose zone is expected to continue. The time frame needed for the concentration of VOCs in deep vadose zone soil to fall below SLs will be long. A cap can be installed in a relatively short time frame (about 1 year). This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).	Natural attenuation processes at the Facility are expected to continue. The concentration of VOCs in deep vadose zone soils in the three AOCs that will be treated will be reduced to concentrations below SLs within a relatively short time period (about 3 years). A cap can be installed in a relatively short time frame (about 1 year). This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).

Table 3-3 - Summary of Detailed Analysis of Alternatives Applicable to SVOCs in Deep Vadose Zone Soil at the Kaiser Facility

	Criteria	Alternative B1 Institutional Controls, Monitoring, and MNA	Alternative B2 Alternative B1 Plus Containment	Alternative B4 Alternative B2 Plus *In Situ* Chemical Oxidation
Threshold Requirements	Overall Protection of Human Health and the Environment	The depth of the deep vadose zone soil SVOC AOCs eliminates the direct contact exposure pathway for Facility workers and visitors. Does not reduce the concentration of SVOCs in deep vadose zone soil to below SLs for a very long time. Some natural attenuation of SVOCs is expected to occur. Does not address the soil to groundwater pathway. Provides less overall protection to the environment than Alternatives B2 and B4.	The depth of the deep vadose zone soil SVOC AOCs eliminates the direct contact exposure pathway for Facility workers and visitors. Physical and administrative controls, BMPs, and containment are used to reduce the potential for SVOCs in deep vadose zone soils to migrate to groundwater. Containment surfaces cut the vadose zone soil to groundwater pathway and eliminate the risk to receptors posed by the SVOCs in the vadose zone soils. Short-term risks are manageable. More protective than Alternative B1, less protective than Alternative B4.	The depth of the deep vadose zone soil SVOC AOCs eliminates the direct contact exposure pathway for Facility workers and visitors. New containment surfaces cut the remaining deep vadose zone soil-to-groundwater pathways and eliminate the risk to receptors posed by SVOCs in vadose zone soils. *In situ* treatment removes an estimated 270,000 pounds of SVOCs from deep vadose zone soil. The SVOCs will be treated in approximately 26 years. Short-term risks associated with the operation of the treatment systems are manageable. Alternative B4 is more permanent and provides a greater degree of protection than Alternatives B1 and B2.
	Comply with Cleanup Standards	The concentration of SVOCs in the AOCs containing SVOCs will remain above SLs for a long time. Does not actively address the soil to groundwater pathway that could potentially transfer SVOCs to groundwater receptors or the Spokane River. Does not meet existing MTCA threshold requirements.	The containment surfaces prevent rainwater from conveying SVOCs from deep vadose zone soil to groundwater. Judged to meet MTCA requirements for deep vadose zone soils (alone) and for groundwater and surface water when combined with the alternatives selected by Sections 2, 4, and 5. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. Alternative B2 meets these requirements.	Alternative B4 will prevent rainwater from conveying SVOCs from deep vadose zone soil to groundwater. *In situ* chemical oxidation is expected to reduce the mass of SVOCs in deep vadose zone soil by approximately 56 percent. It is not expected to reduce concentrations to below SLs within a reasonable time frame. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. Alternative B4 meets these requirements. Alternative B4 is judged to meet MTCA threshold requirements for treatment of SVOC-impacted deep vadose zone soil.
	Comply with Applicable State and Federal Law	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. No action- or location-specific ARARs have been identified for the deep vadose zone soil at the Facility applicable to Alternative B1 (see Appendix G, Table G-3 and G-4).	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for the deep vadose zone soil at the Facility applicable to Alternative B2. The identified action-specific ARARs for Alternative B2 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for the deep vadose zone soil at the Facility applicable to Alternative B3. The identified action-specific ARARs for Alternative B3 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.
	Provide for Compliance Monitoring	Alternative B1 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative B2 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative B4 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.
Disproportionate Cost Analysis	Protectiveness	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.
	Permanence	BMPs will reduce the release of hazardous substances to the environment. Existing floor slabs and paved surfaces provide partial containment of SVOCs. Does not actively reduce the toxicity, mobility, or volume of SVOCs present in deep vadose zone soils beyond the reductions provided natural attenuation. Less permanent than Alternatives B2 and B4.	BMPs will reduce the release of hazardous substances to the environment. Paved surface prevents infiltrated water from conveying COCs from deep vadose zone soil to groundwater. Does not actively treat the SVOCs in the soils within the AOCs except by natural attenuation processes, which would require a long time frame to reduce SVOC concentrations to SLs. Provides a lower degree of permanence than is provided by Alternatives B4 but provides more permanence than Alternative B1.	Alternative B4 will provide containment surfaces, in addition to physical and administrative controls and BMPs, that will reduce the potential for SVOCs in deep vadose zone soil to migrate to groundwater. The BMPs in place at the facility will reduce the release of hazardous substances to the environment. Alternative B4 destroys an estimated 270,000 pounds of SVOCs in the deep vadose zone AOCs that are treated under this alternative. The SVOCs will be treated in a approximately 26 years. Alternative B4 is more permanent than Alternatives B1 and B2.
	Effectiveness over the Long Term	The institutional controls, BMPs, monitoring, and MNA employed by this alternative are currently in use at the Kaiser Facility. Does not actively address the SVOCs in deep vadose zone soil. SVOC concentrations will not be reduced to below SLs for a long time. These soils will continue to pose potential risks to human health and the environment. Much less effective over the long term than Alternatives B2 and B4.	The new paving surfaces employed by this alternative have been successfully demonstrated at the Kaiser Facility and other locations. Does not actively treat the SVOCs in deep vadose zone soils other than through natural attenuation, which would require a long time frame to reduce SVOC concnetrations to SLs. Does not generate treatment residues or waste materials. Surface water runoff from the containment surfaces will be collected, discharged to surface soils, or transported to the Kaiser WWTP for treatment. Provides more effectiveness over the long term than Alternative B1, but is less effective over the long term than Alternative B4.	Alternative B4 will use institutional controls and containment to prevent SVOC migration from the deep vadose zone soil AOCs to groundwater. Alternative B4 actively reduces the mass contained in the deep vadose zone soil AOCs by approximately 56 percent. The containment surfaces used in this alternative have been successfully demonstrated at the Kaiser Facility and other locations. Capping can be implemented in a relatively short time frame (1 year) and will not generate significant treatment residues or waste materials. *In situ* oxidation will be implemented over 26 years. There is a potential risk of changing the valence state of metals in the deep vadose zone, thereby increasing their toxicity and mobility. Alternative B4 is expected to have greater long-term effectiveness than Alternatives B1 and B2.

Table 3-3 - Summary of Detailed Analysis of Alternatives Applicable to SVOCs in Deep Vadose Zone Soil at the Kaiser Facility

	Criteria	Alternative B1 Institutional Controls, Monitoring, and MNA	Alternative B2 Alternative B1 Plus Containment	Alternative B4 Alternative B2 Plus *In Situ* Chemical Oxidation
Disproportionate Cost Analysis	Management of Short-Term Risks	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create any new or additional short-term risk to human health and the environment. Presents fewer short-term risks than Alternatives B2 and B4.	Uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to construction workers during the installation of the containment surfaces will be mitigated by their adherence to the HASP prepared for the construction work. More short-term risks than Alternative B1, but fewer short-term risks than Alternative B4.	Short-term risks to construction workers during the installation and/or execution of this alternative will be mitigated by their adherence to the HASP prepared to guide the health and safety aspects of the construction work. Short-term risks are also associated with the generation and use of ozone, and these risks will be mitigated by adherence to a HASP. The procedures contained in the HASP have been shown to effectively manage the limited short-term risk associated with these activities. Alternative B4 poses more short-term risks than Alternatives B1 and B2.
	Technical and Administrative Implementability	The actions associated with Alternative B1 are already in place at the Kaiser Facility. Alternative B1 provides a greater degree of technical and administrative implementability than Alternatives B2 and B4.	BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. Alternative B2 is a less complex technical process and requires fewer environmental permits than Alternative B4.	The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. On-site pilot-scale testing will be required for design and implementation of *in situ* oxidation to confirm its technical implementability. Alternative B4 is a much more complex technical process and has more administrative requirements and will require more permits than Alternatives B1 and B2.
	Consideration of Public Concerns	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.
	Conceptual-Level Cost (NPV -35/+50 percent)	$ 13.6 million	$ 14.7 million	$ 23.2 million
	Total Cost per Pound of COC Treated or Contained	NA - baseline cost	$67/pound of SVOC contained	$187/pound of SVOC destroyed
	Restoration Time Frame	Natural attenuation processes at the Facility are expected to continue. The time frame needed for recovery to occur will be long and is judged to be unreasonable.	Natural attenuation processes at the Facility are expected to continue. The time frame needed for the concentration of SVOCs in deep vadose zone soil below the cap to fall below SLs will be long. The cap can be installed in a relatively short (1 year) time period. This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).	The containment surfaces can be installed in a relatively short time frame (1 year). The mass of SVOCs in the deep vadose zone will be reduced by approximately 56 percent in 26 years. Natural attenuation processes at the Facility are expected to continue for SVOCs in deep vadose zone soils. This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).

Table 3-4 - Summary of Detailed Analysis of Alternatives Applicable to Metals in Deep Vadose Zone Soil at the Kaiser Facility

	Criteria	Alternative B1 Institutional Controls, Monitoring, and MNA	Alternative B2 Alternative B1 Plus Containment
Threshold Requirements	Overall Protection of Human Health and the Environment	Alternative B1 does not reduce the concentration of metals in deep vadose zone soil to below SLs. However, the depth of the deep vadose zone soil AOCs eliminates the direct contact exposure pathway for Facility workers and visitors. Alternative B1 does not address the deep vadose zone soil to groundwater exposure pathway. Alternative B1 provides less overall protection to human health and the environment than Alternative B2.	Physical and administrative controls, BMPs, and containment reduce the potential for metals in deep vadose zone soil to migrate to groundwater, by cutting the vadose zone soil to groundwater pathway and eliminating the risk to receptors posed by metals in vadose zone soils. The depth of the deep vadose zone soil metal AOCs eliminates the direct contact exposure pathway for Facility workers and visitors. Alternative B2 is judged to be more protective than Alternative B1.
Threshold Requirements	Comply with Cleanup Standards	The concentrations of metals in the deep vadose zone AOCs will remain above SLs. However, the depth of the deep vadose zone soil metal AOCs eliminates the direct contact exposure pathway for Facility workers and visitors. Alternative B1 does not address the deep vadose zone soil to groundwater exposure pathway. Alternative B1 does not meet MTCA threshold requirements.	Alternative B2 will prevent rainwater from conveying metals from deep vadose zone soil to groundwater. Although Alternative B2 is not expected to directly reduce the concentration of metals that are present in the deep vadose zone soil AOCs, it adds the additional protection of containment to Alternative B1. Cleanup actions that involve containment can be deemed to meet cleanup standards if requirements set out in WAC 173-340-740(6)(f) are met. Alternative B2 meets these requirements. Alternatives B2 is judged to meet MTCA threshold requirements for treatment of metal-impacted deep vadose zone soil.
Threshold Requirements	Comply with Applicable State and Federal Law	Contaminant-specific ARARs were included in the development of SLs and compliance with these ARARs is discussed above. No action- or location-specific ARARs have been identified for the deep vadose zone soil at the Facility applicable to Alternative B1 (see Appendix G, Tables G-3 and G-4).	Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed in the text. No location-specific ARARs have been identified for the deep vadose zone soil at the Facility applicable to Alternative B2. The identified action-specific ARARs for Alternative B2 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These ARARS are judged to be attainable and do not affect the alternative selection process.
Threshold Requirements	Provide for Compliance Monitoring	Alternative B1 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative B2 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.
Disproportionate Cost Analysis	Protectiveness	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.
Disproportionate Cost Analysis	Permanence	In Alternative B1, BMPs will reduce the release of hazardous substances to the environment. Existing paved surfaces (e.g., floor slabs, roads) prevent the infiltration of rainwater that could transport metals from deep vadose zone soil to groundwater. Alternative B1 does not actively reduce the concentration of metals present in deep vadose zone soil. Alternative B1 provides less permanence than Alternative B2.	Alternative B2 will provide containment surfaces, in addition to physical and administrative controls and BMPs, that will reduce the potential for metals in deep vadose zone soil to migrate to groundwater. Although Alternative B2 will not actively work to reduce the concentration of metals in their respective AOCs, reducing the migration of metals from deep vadose zone soil to groundwater will provide increased permanence relative to not containing these metal-impacted AOCs. Alternative B2 is judged to provide greater permanence than Alternative B1.
Disproportionate Cost Analysis	Effectiveness over the Long Term	The institutional controls, monitoring, and MNA employed in Alternative B1 are currently in use at the Kaiser Facility. Alternative B1 does not actively reduce the concentration of metals in deep vadose zone soil. Alternative B1 does not sever the soil to groundwater exposure pathway for all deep vadose zone soil AOCs, but the depth of the deep vadose zone soil metal AOCs eliminates the direct contact exposure pathway for Facility workers and visitors. Alternative B1 is judged to provide less long-term effectiveness than Alternative B2.	Alternative B2 will use institutional controls and containment to prevent metal migration from the deep vadose zone soil AOCs to groundwater. Alternative B2 will not actively reduce the mass, toxicity, or volume of metals contained in the deep vadose zone soil AOCs. The containment surfaces used in this alternative have been successfully demonstrated at other locations. Capping can be implemented in a relatively short time frame (about 1 year) and will not generate significant treatment residues or waste materials. Alternative B2 is expected to have greater long-term effectiveness than Alternative B1.
Disproportionate Cost Analysis	Management of Short-Term Risks	Alternative B1 includes existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Alternative B1 does not create new or additional short-term risks to human health and the environment. Thus, Alternative B1 poses fewer short-term risks than Alternative B2.	For Alternative B2, short-term risks to construction workers during the installation and/or execution of this alternative will be mitigated by their adherence to the HASP prepared to guide the health and safety aspects of the construction work. The procedures contained in the HASP have been shown to effectively manage the limited short-term risk associated with these activities. Alternative B2 poses more short-term risks than Alternative B1, most of which are associated with the construction of the containment surfaces.
Disproportionate Cost Analysis	Technical and Administrative Implementability	The actions associated with Alternative B1 are already in place at the Kaiser Facility. Alternative B1 has a higher degree of technical and administrative implementability than Alternative B2.	BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. The installation of new containment surfaces for Alternative B2 is a routine activity and has been employed at the Facility for many years. Alternative B2 has a lower degree of technical and administrative implementability than Alternative B1.
Disproportionate Cost Analysis	Consideration of Public Concerns	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.
Disproportionate Cost Analysis	Conceptual-Level Cost (NPV -35/+50 percent)	$13.6 million	$14.7 million
Disproportionate Cost Analysis	Total Cost per Pound of COC Treated or Contained	Baseline cost	$92,000 per pound of metals contained
	Restoration Time Frame	The necessary time frame for recovery to occur will be long and is judged to be unreasonable.	For Alternative B2, the containment surfaces can be installed in a relatively short time frame (about 1 year). This time frame is judged to be reasonable per the requirements in WAC 173-340-360(4).

Alternative B2 - Potential Capping or Pavement Repair Areas

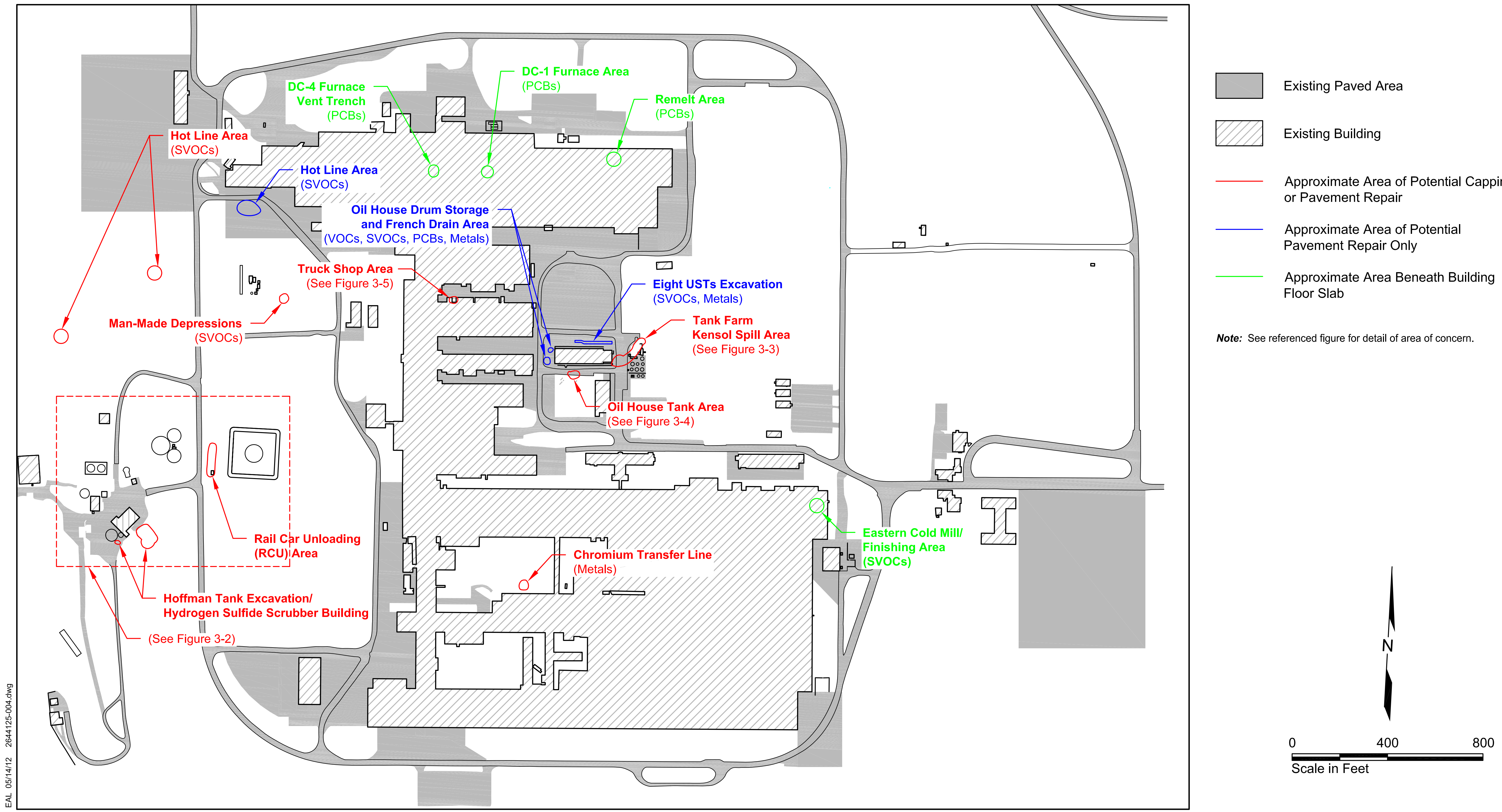

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Figure 3-1

Alternative B2 - Potential Capping or Pavement Repair Areas
Hoffman Tank and Wastewater Treatment/Rail Car Unloading (RCU) Areas

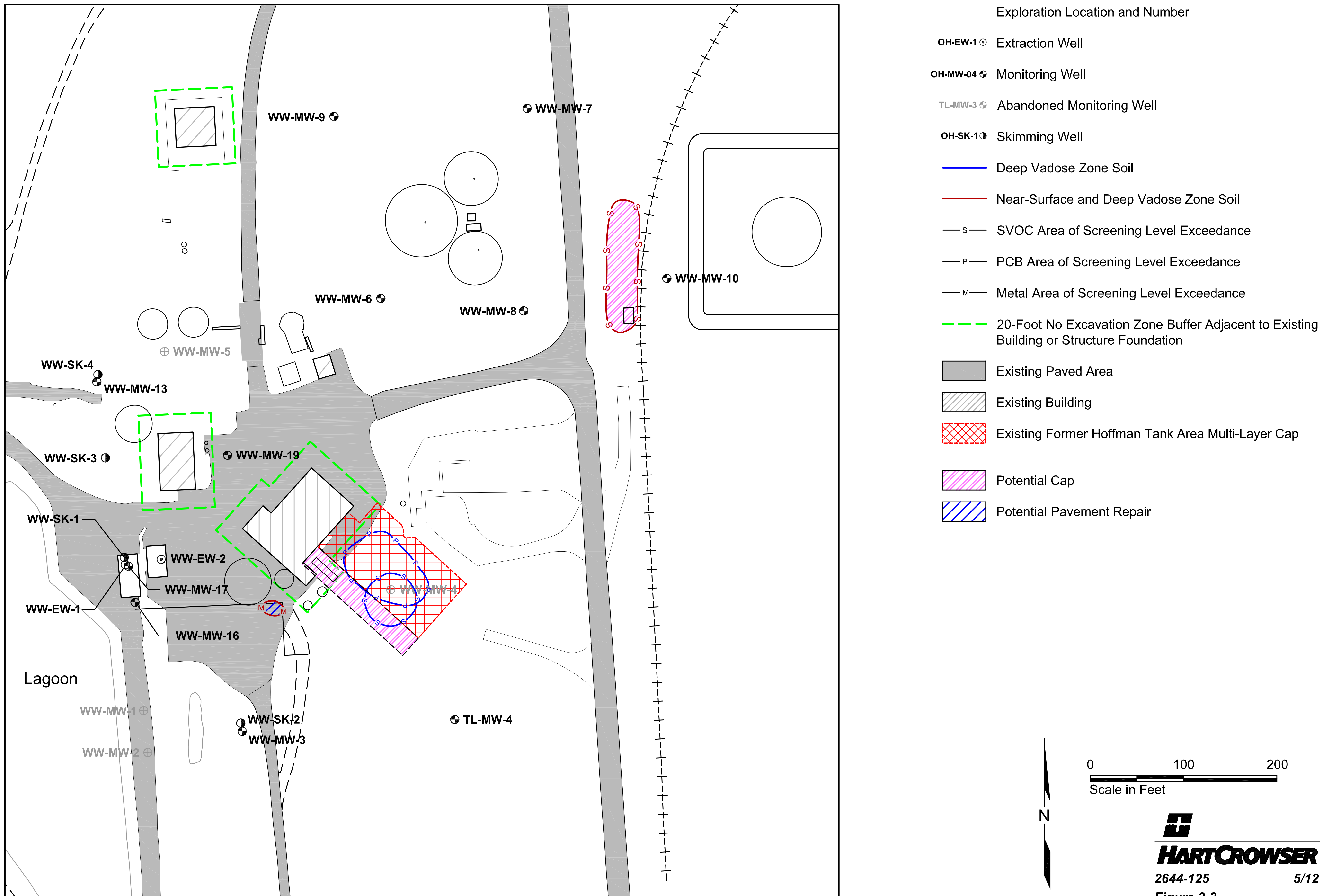

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Figure 3-2

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Alternative B2 - Potential Capping or Pavement Repair Areas
Tank Farm Kensol Spill Area

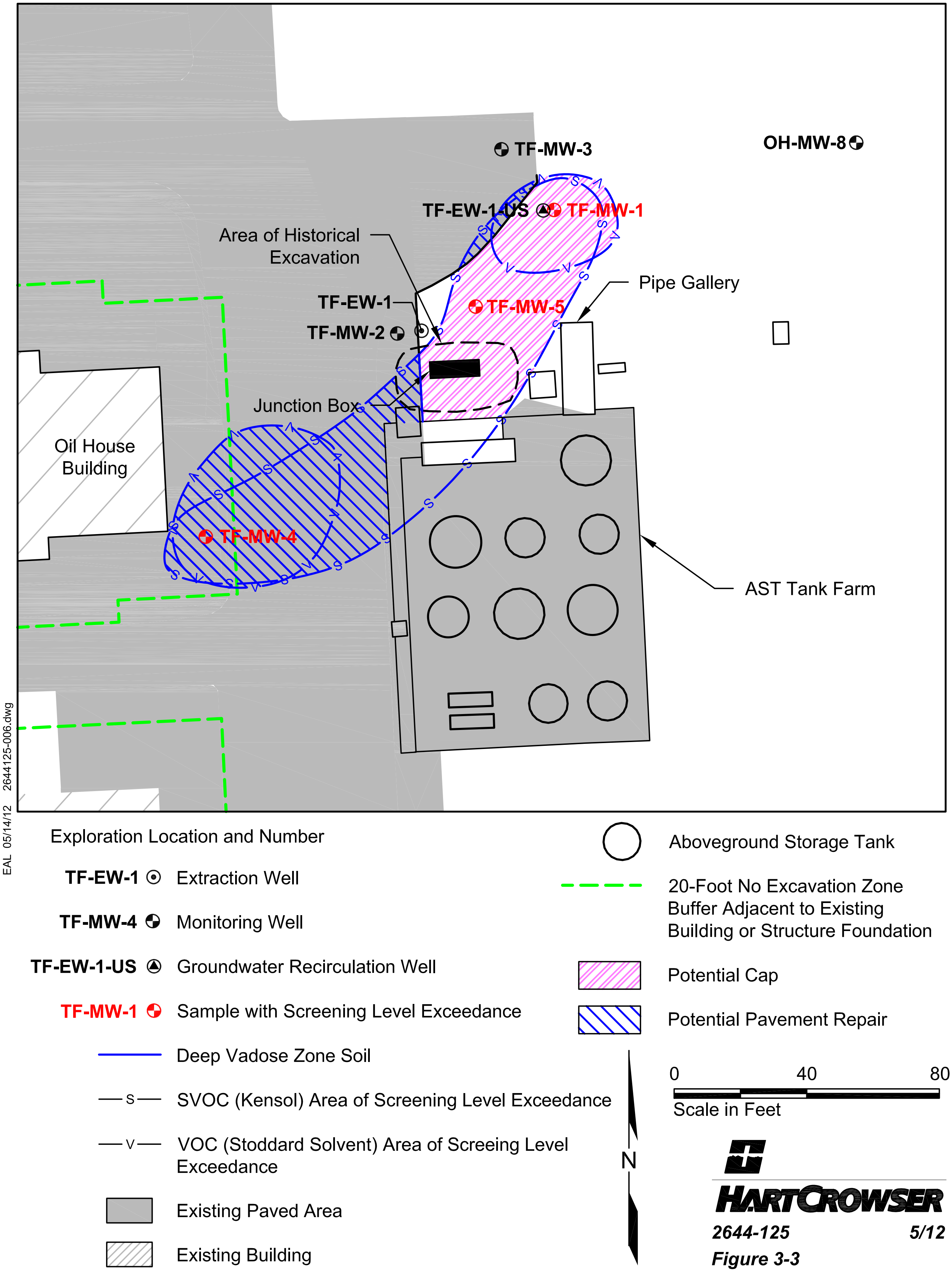

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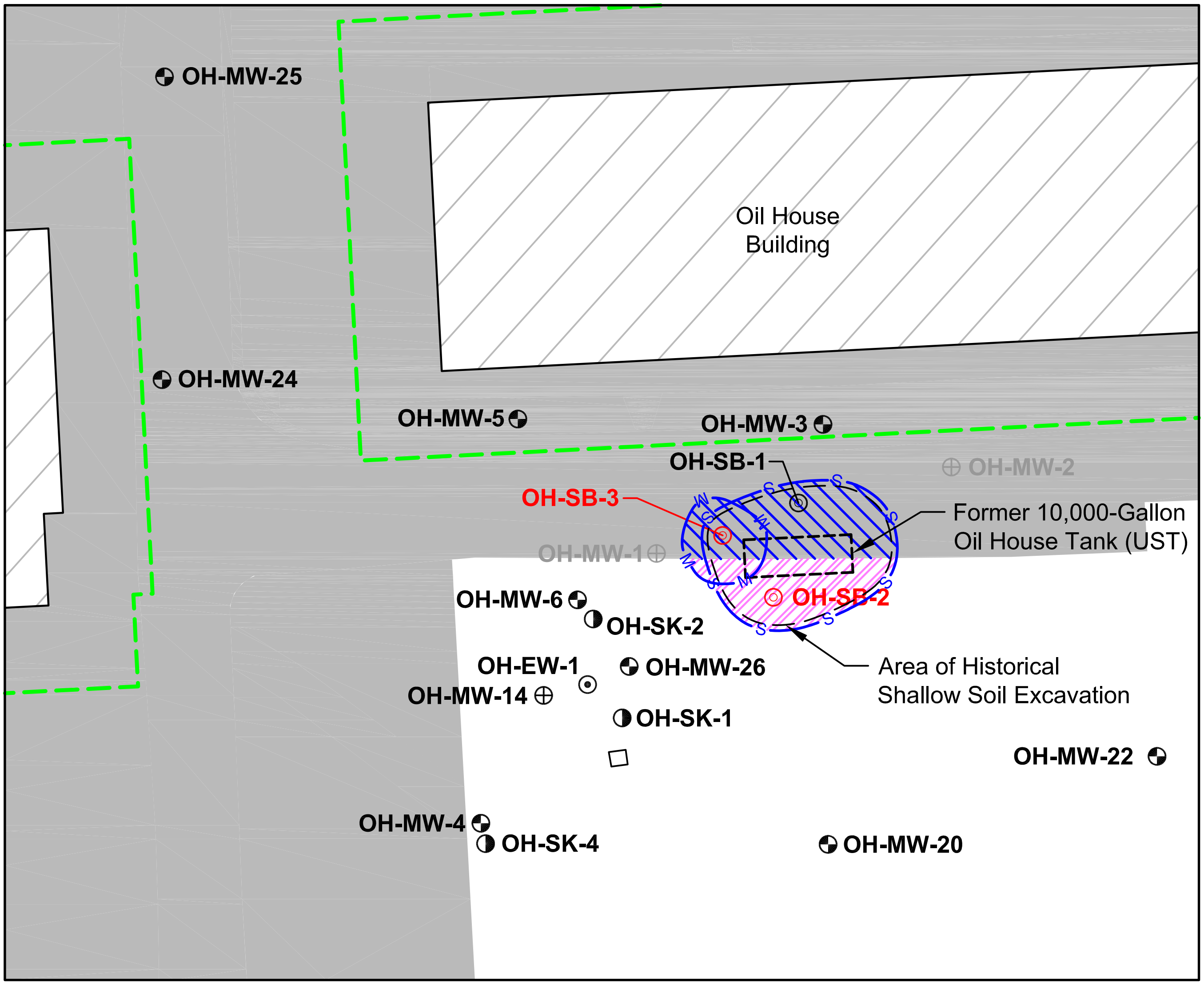
Figure 3-3

Alternative B2 - Potential Capping or Pavement Repair Areas

Oil House Tank Area



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Exploration Location and Number

OH-EW-1 ⦿ Extraction Well

OH-MW-4 Monitoring Well

OH-SK-1 ◑ Skimming Well

OH-SB-1 ◎ Soil Boring

OH-SB-2 ◎ Sample with Screening Level Exceedance

Deep Vadose Zone Soil

—S— SVOC (TPH) Area of Screening Level Exceedance

—M— Metals (Arsenic) Area of Screeing Level Exceedance

Existing Paved Area

Existing Building

Potential Cap

Potential Pavement Repair

20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation

N

0 40 80

Scale in Feet

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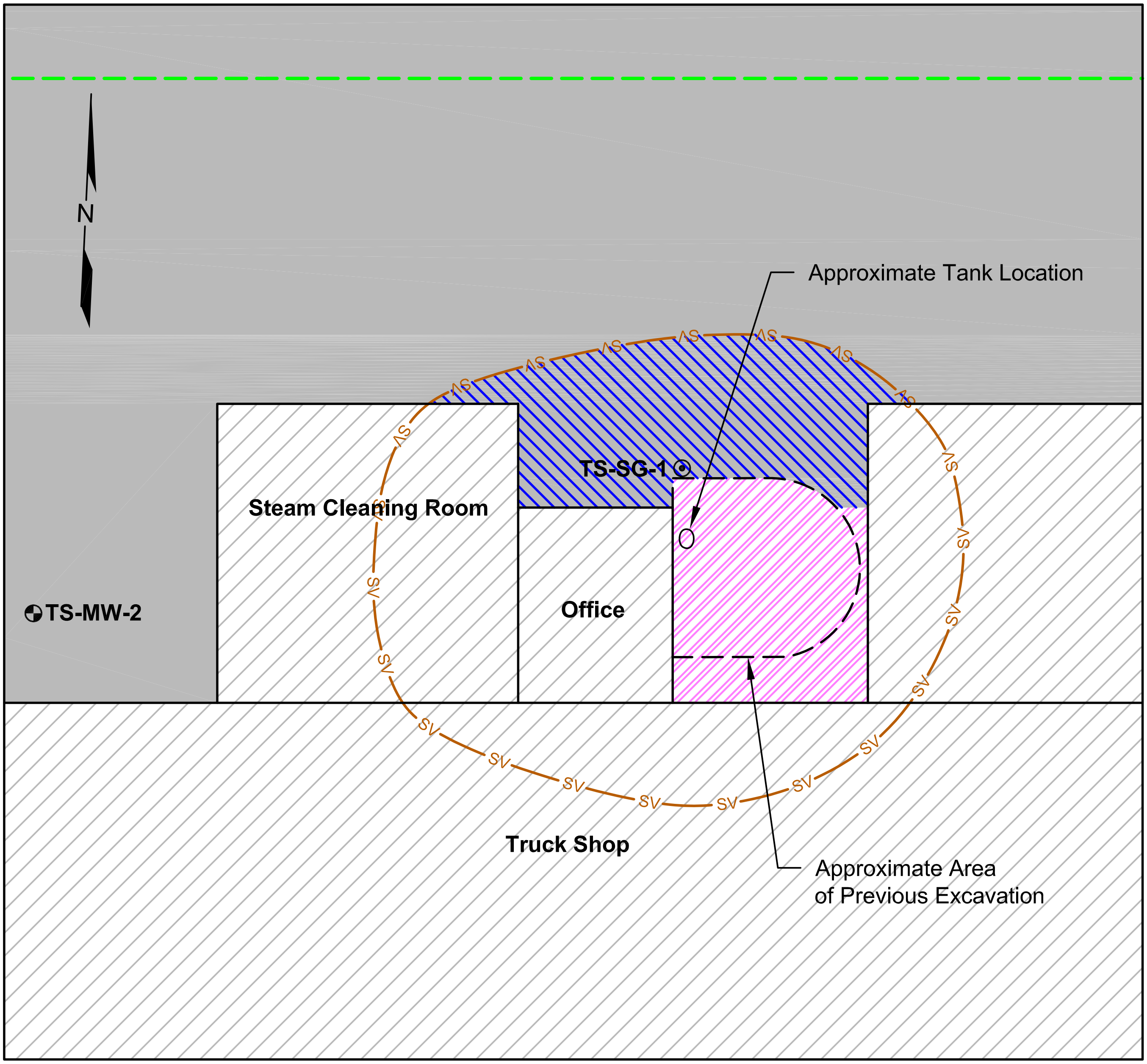
Figure 3-4

Alternative B2 - Potential Capping or Pavement Repair Areas
Truck Shop Area



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Potential Cap Only

Potential Pavement Repair

Near-Surface and Deep Vadose Zone Soil

—V— VOC (Stoddard Solvent) Area of Screening Level Exceedance

—S— SVOC (Heavy Oil) Area of Screening Level Exceedance

20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation

Existing Paved Area

Existing Building

Exploration Location and Number

TS-MW-2 Monitoring Well

TS-SG-1 Soil Gas Probe

0 10 20

Scale in Feet

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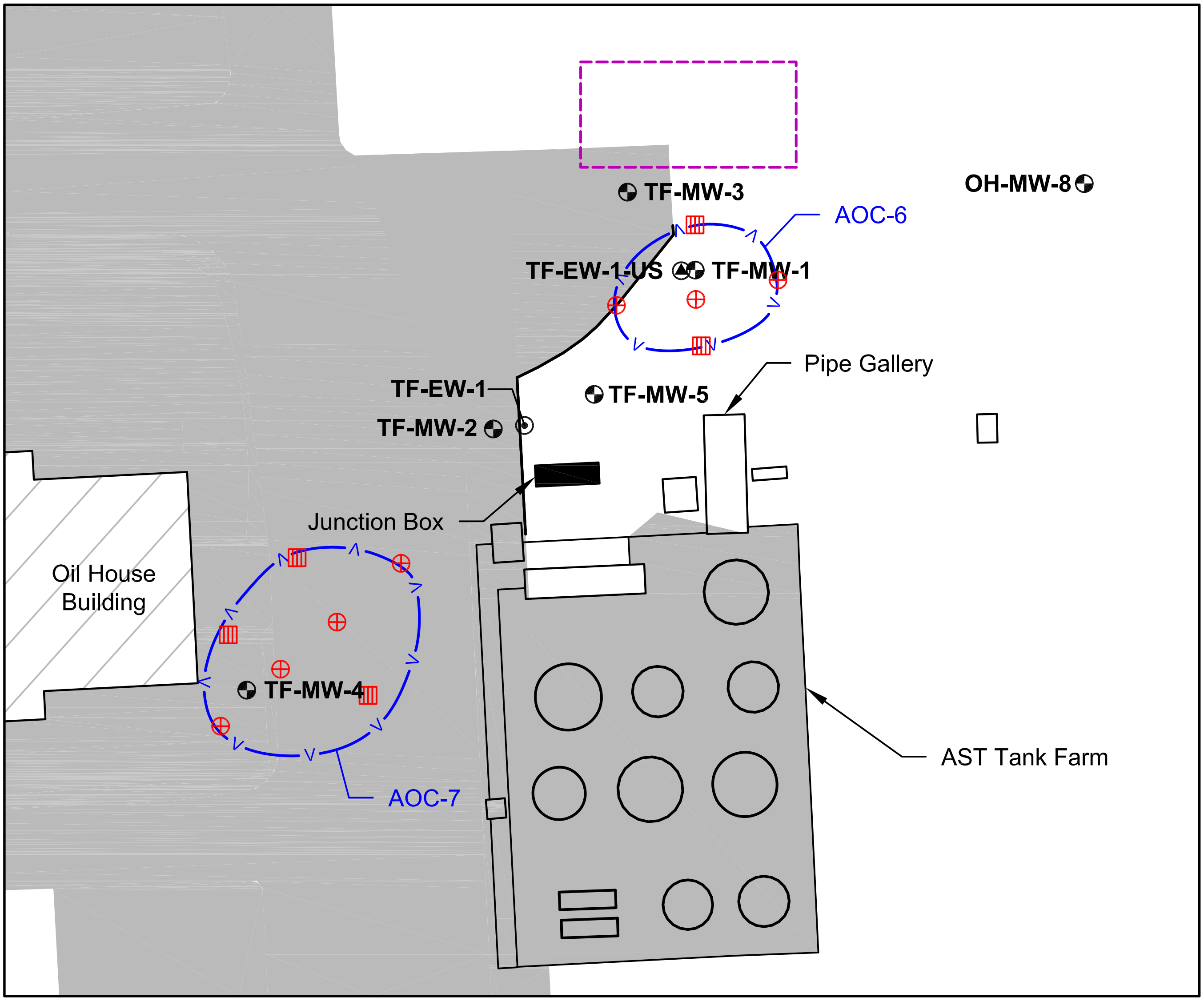
Figure 3-5

Alternative B3 - Site Plan for SVE Treatment
Tank Farm Kensol Spill Area



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Exploration Location and Number

TF-EW-1 ⊙ Extraction Well [a]

TF-MW-4 Monitoring Well

TF-EW-1-US Groundwater Recirculation Well [a]

⊕ Proposed SVE Well

Proposed Passive Venting Well

Deep Vadose Zone Soil

—v— VOC (Stoddard Solvent) Screening Level Exceedance

Existing Paved Area

Existing Building

Proposed SVE Treatment System Location (Estimated Footprint)

◯ Aboveground Storage Tank

a: Extraction wells and groundwater recirculation wells shown are part of historical remediation system at the Faciltiy.

N

0 40 80
Scale in Feet

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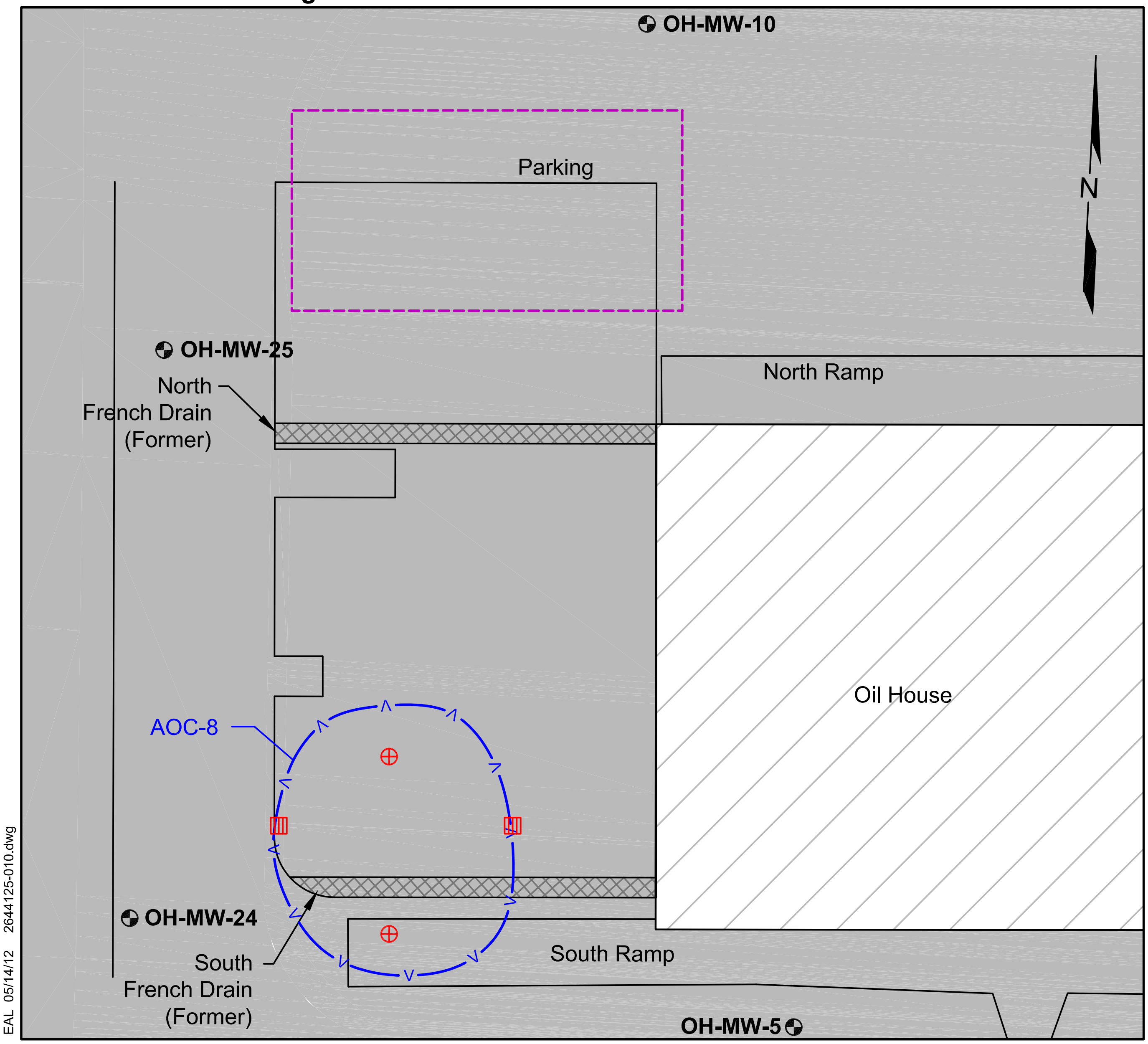
Figure 3-6

Alternative B3 - Site Plan for SVE Treatment
Oil House Drum Storage and French Drain Area



Exploration Location and Number

OH-MW-4 Monitoring Well

Proposed SVE Well

Proposed Passive Venting Well

Deep Vadose Zone Soil

VOC (Stoddard Solvent) Screening Level Exceedance

Existing Paved Area

Existing Building

Proposed SVE Treatment System Location (Estimated Footprint)

Former French Drain

0 20 40
Scale in Feet

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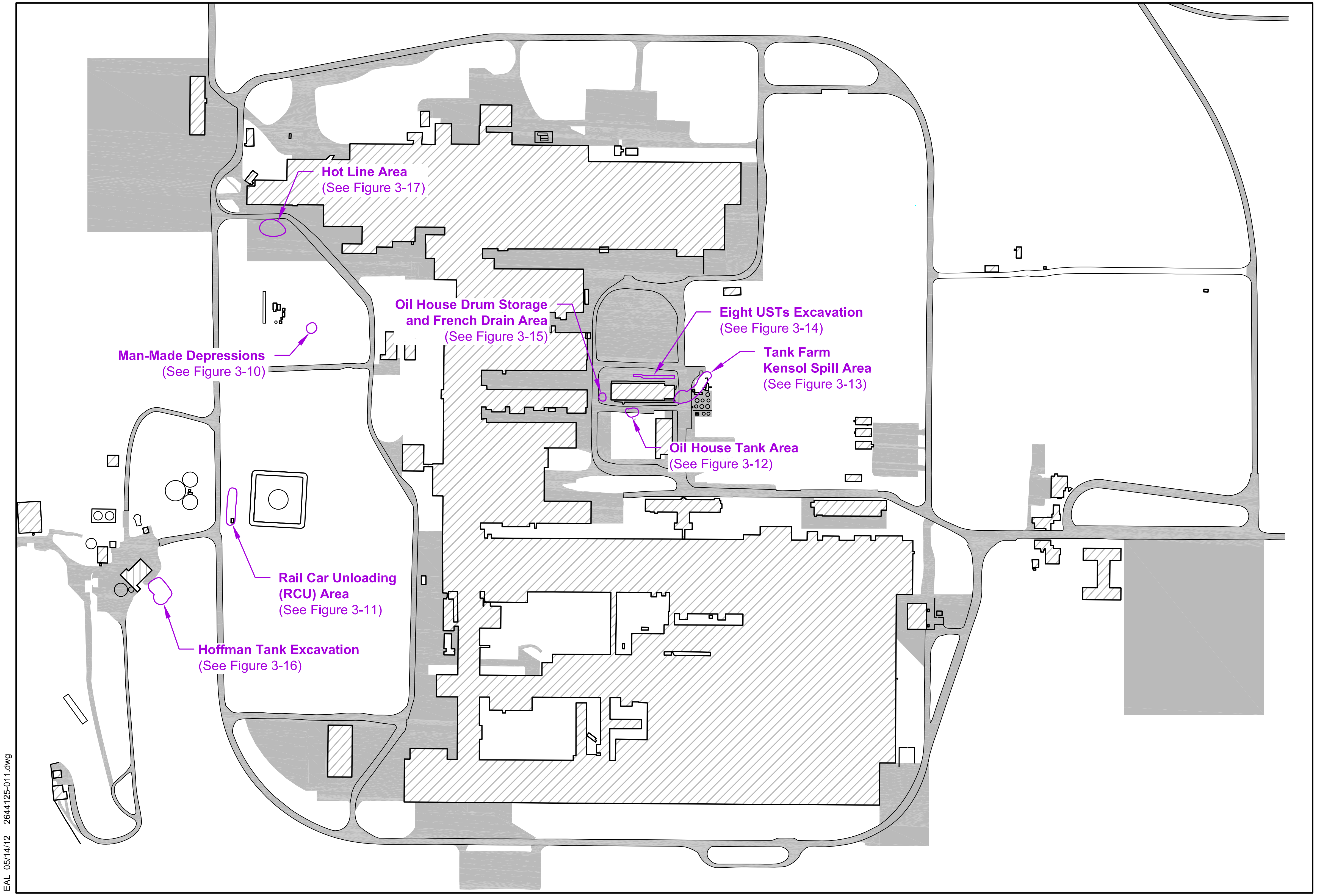
Figure 3-7

Alternative B4 - Potential In Situ Treatment Areas - Deep Vadose Zone Soil AOCs



Existing Paved Area

Existing Building

Approximate Area of Potential *In Situ* Treatment

Note: See referenced figure for detail of area of concern.

N

0 400 800
Scale in Feet

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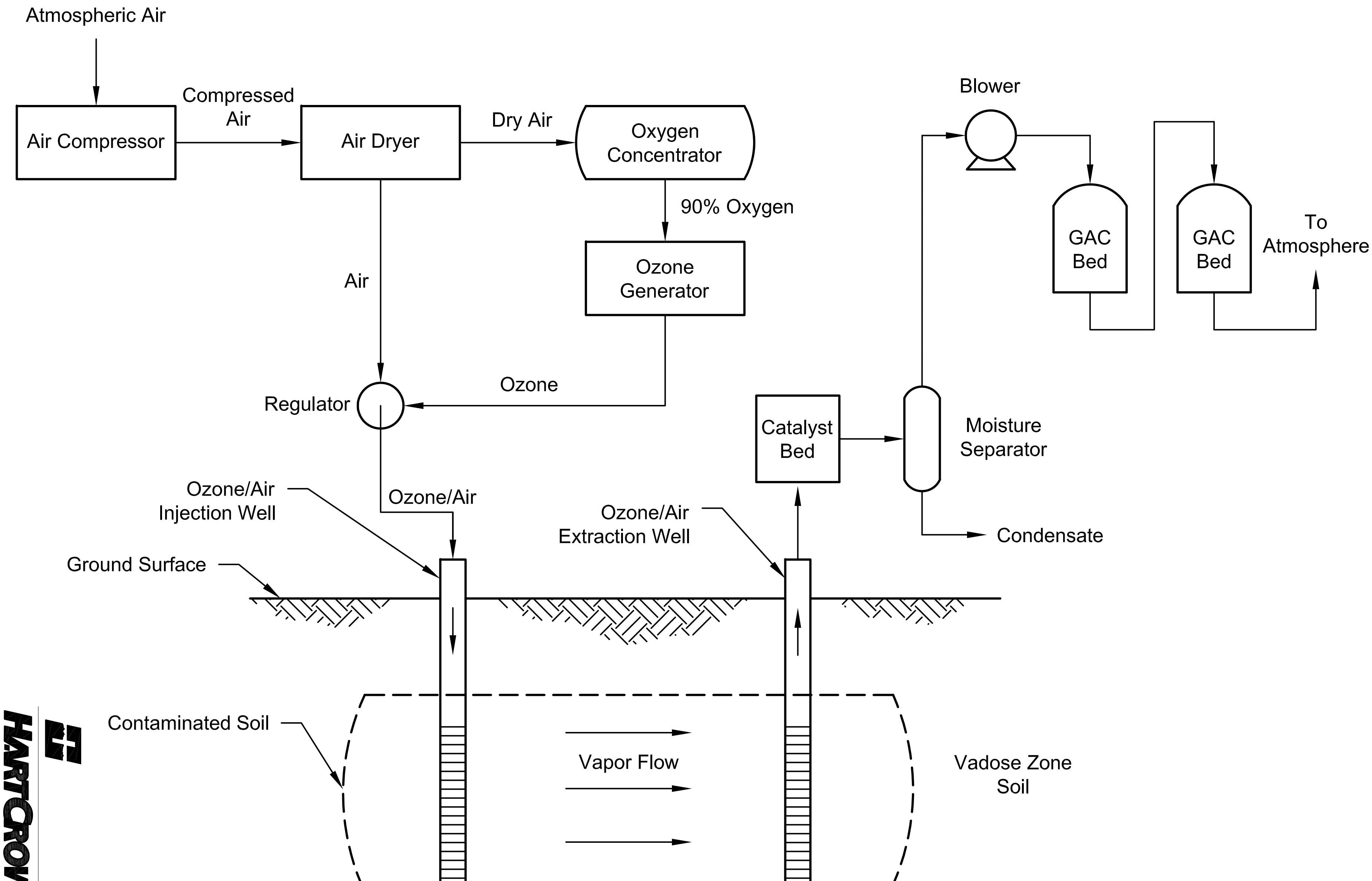
Figure 3-8

Alternative B4 - Process Flow Diagram for Ozonation



NOT TO SCALE

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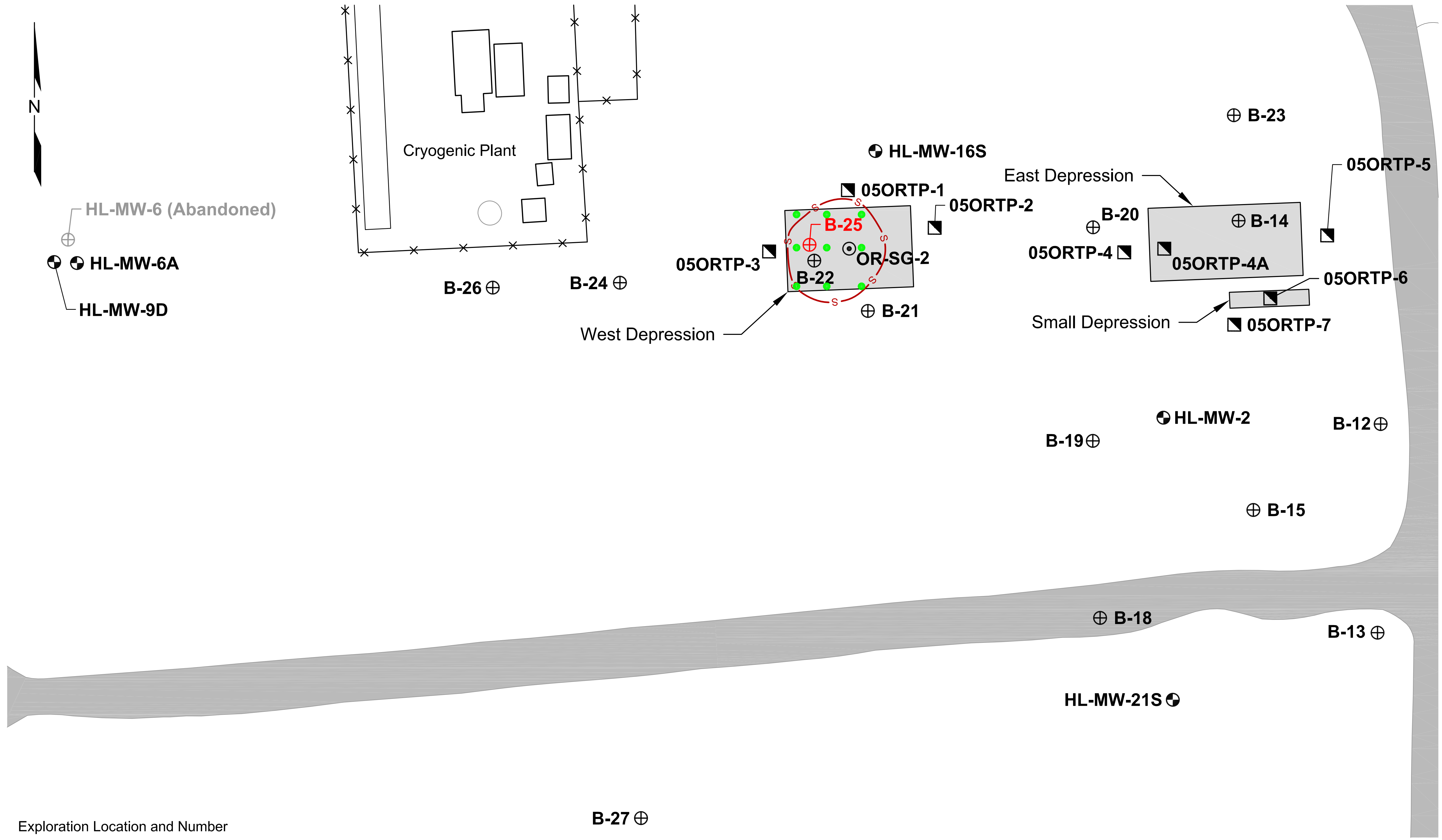
Figure 3-9

Alternative B4 - Injection/Extraction Well Location Plan

Man-Made Depressions



Exploration Location and Number

- Proposed Injection/Extraction Well
- B-25 ⊕ Samples with Screening Level Exceedance
- OR-SG-2 ⊙ Soil Gas Sample (Hart Crowser 2005)
- 05ORTP-1 Test Pit (Hart Crowser 2005)
- HL-MW-6A Monitoring Well
- B-12 ⊕ Soil Boring (Hart Crowser 1996)

—s— SVOC (Heavy Oil) Area of Screening Level Exceedance

Near-Surface and Deep Vadose Zone Soil

Estimated Location of Historical Man-Made Depression

Existing Paved Area

0 40 80

Scale in Feet

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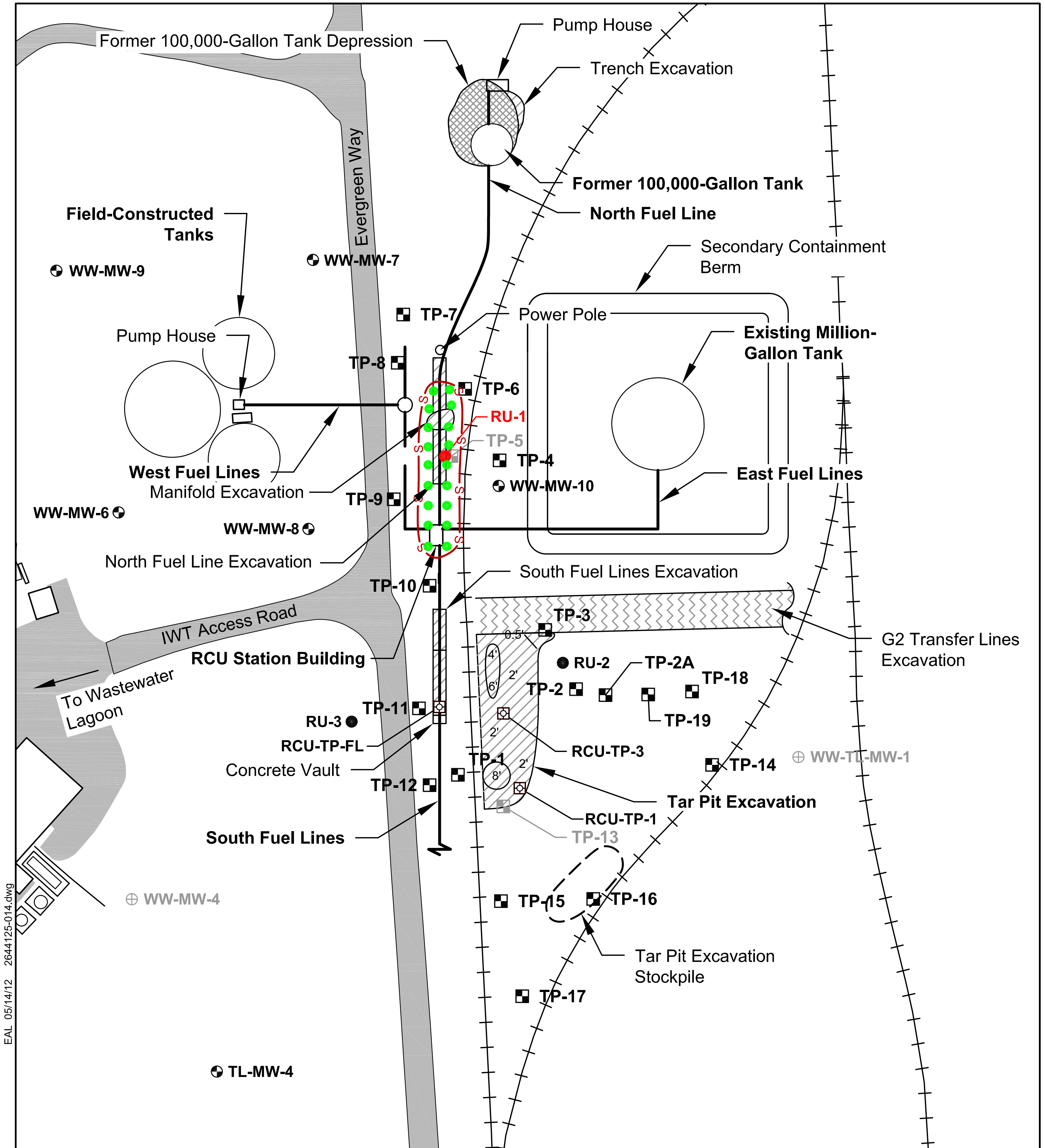
Figure 3-10

Alternative B4 - Injection/Extraction Well Location Plan

Rail Car Unloading (RCU) Area



Exploration Location and Number

- Proposed Injection/Extraction Well
- RCU-TP-1 Phase II RI Test Pit
- WW-MW-8 Monitoring Well
- RU-3 1996 Soil Boring
- TP-12 1996 Test Pit (Shaded Test Pit Excavated)
- 2' Depth of Tar Pit Excavation in Feet
- RU-1 Soil Sampling Location with Screening Level Exceedance
- Fuel Line
- Existing Excavation
- Phase I Excavation
- Phase II Excavation
- S SVOC (Diesel) Area of Screening Level Exceedance
- Near-Surface and Deep Vadose Zone Soil
- Existing Paved Area

N

0 100 200
Scale in Feet

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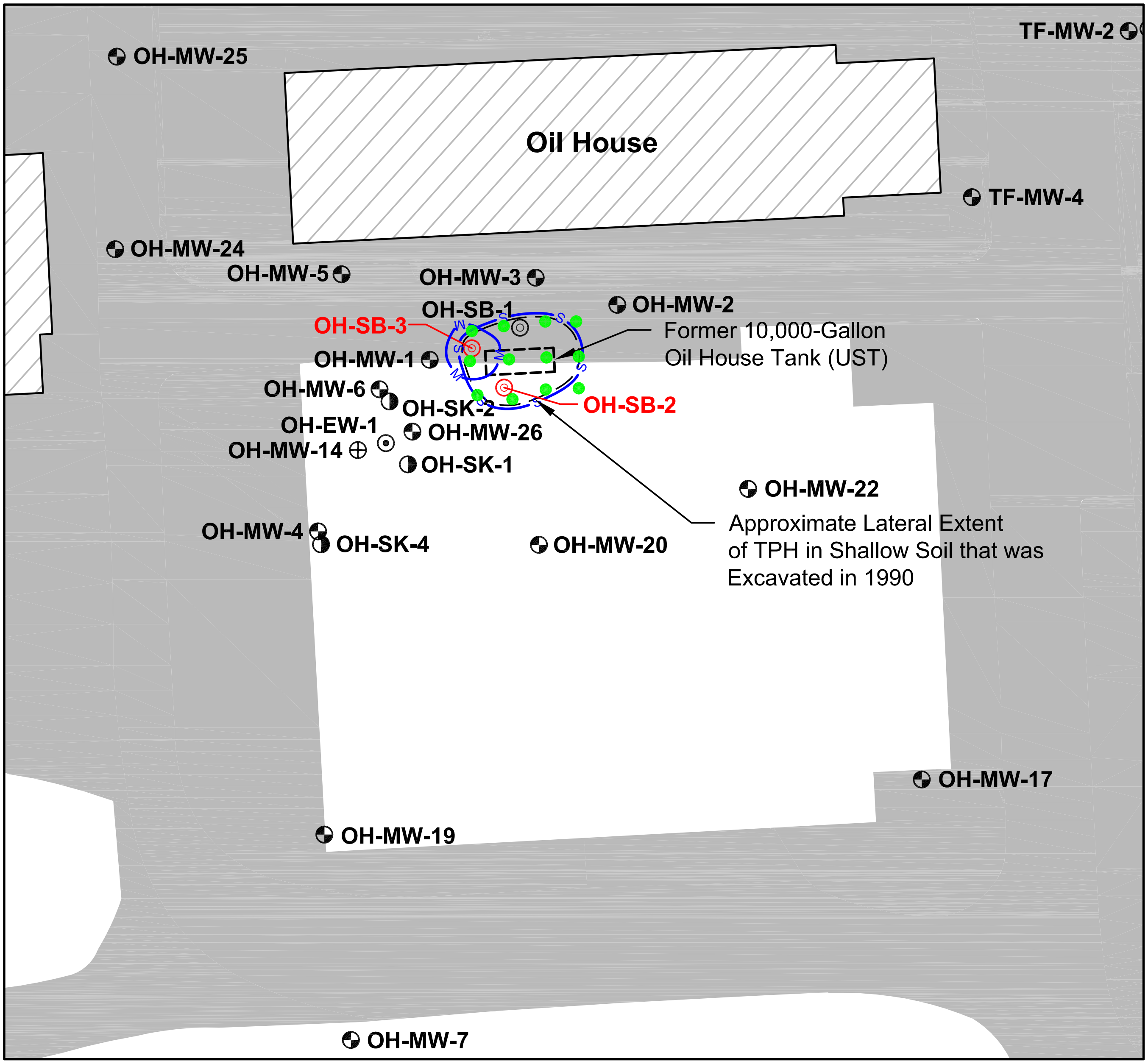
Figure 3-11

Alternative B4 - Injection/Extraction Well Location Plan
Oil House Tank Area



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Exploration Location and Number

- Proposed Injection/Extraction Well
- OH-SB-2 ◎ Samples with Screening Level Exceedance
- OH-EW-1 ⊙ Extraction Well
- OH-MW-4 Monitoring Well
- OH-SK-1 ◑ Skimming Well
- OH-SB-1 ◎ Soil Boring
- ——S—— SVOC (TPH) Area of Screening Level Exceedance
- ——M—— Metals (Arsenic) Area of Screening Level Exceedance
- ——— Deep Vadose Zone Soil

- Existing Paved Area
- Existing Building

N

0 60 120
Scale in Feet

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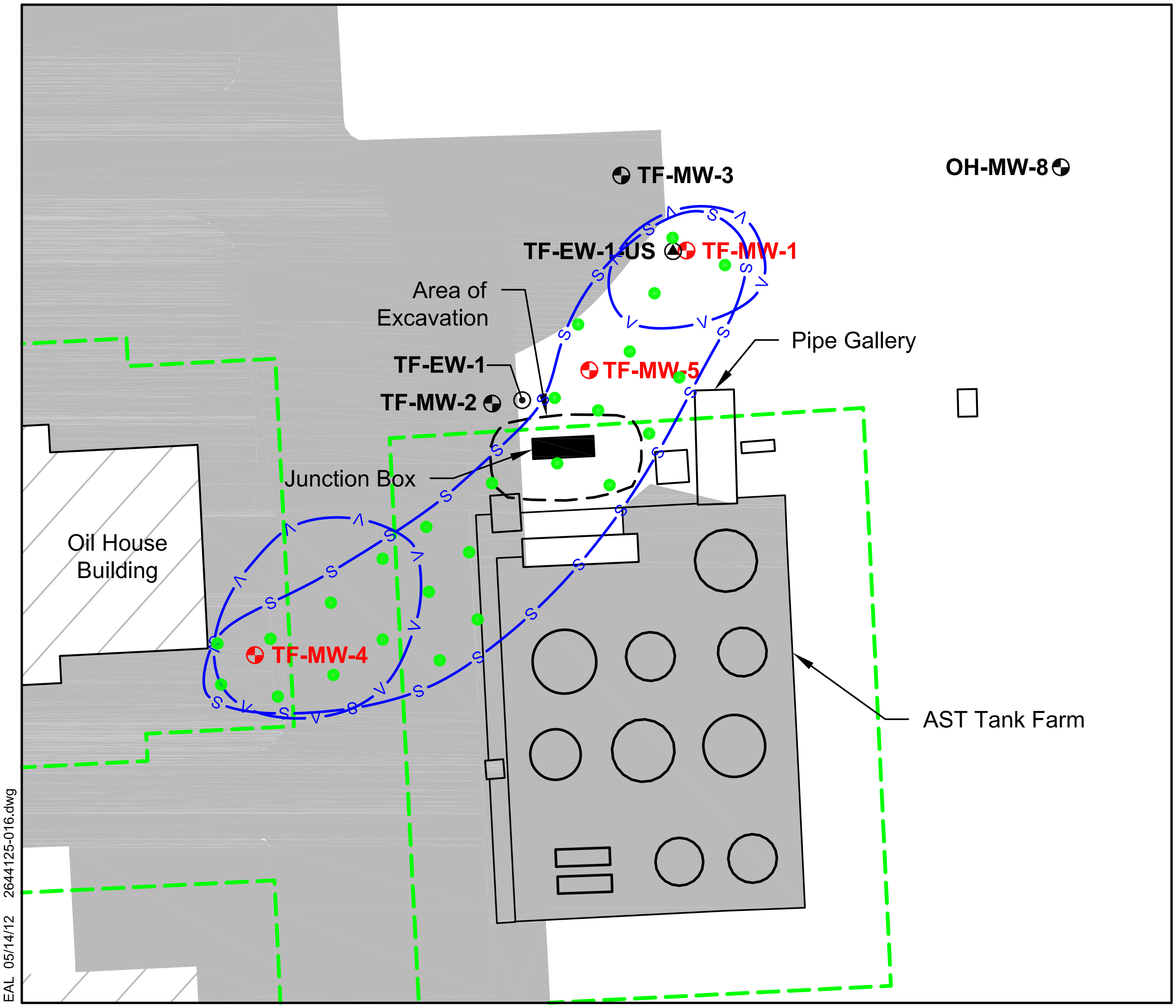
Figure 3-12

Alternative B4 - Injection/Extraction Well Location Plan
Tank Farm Kensol Spill Area



Exploration Location and Number

- Proposed Injection/Extraction Well
- **TF-EW-1** Extraction Well
- **TF-MW-4** Monitoring Well
- **TF-EW-1-US** Groundwater Recirculation Well
- **TF-MW-1** Samples with Screening Level Exceedance
- Deep Vadose Zone Soil
- S — SVOC (Kensol) Area of Screening Level Exceedance
- V — VOC (Stoddard Solvent) Area of Screeing Level Exceedance

- Aboveground Storage Tank
- Existing Paved Area
- Existing Building

N

0 40 80
Scale in Feet

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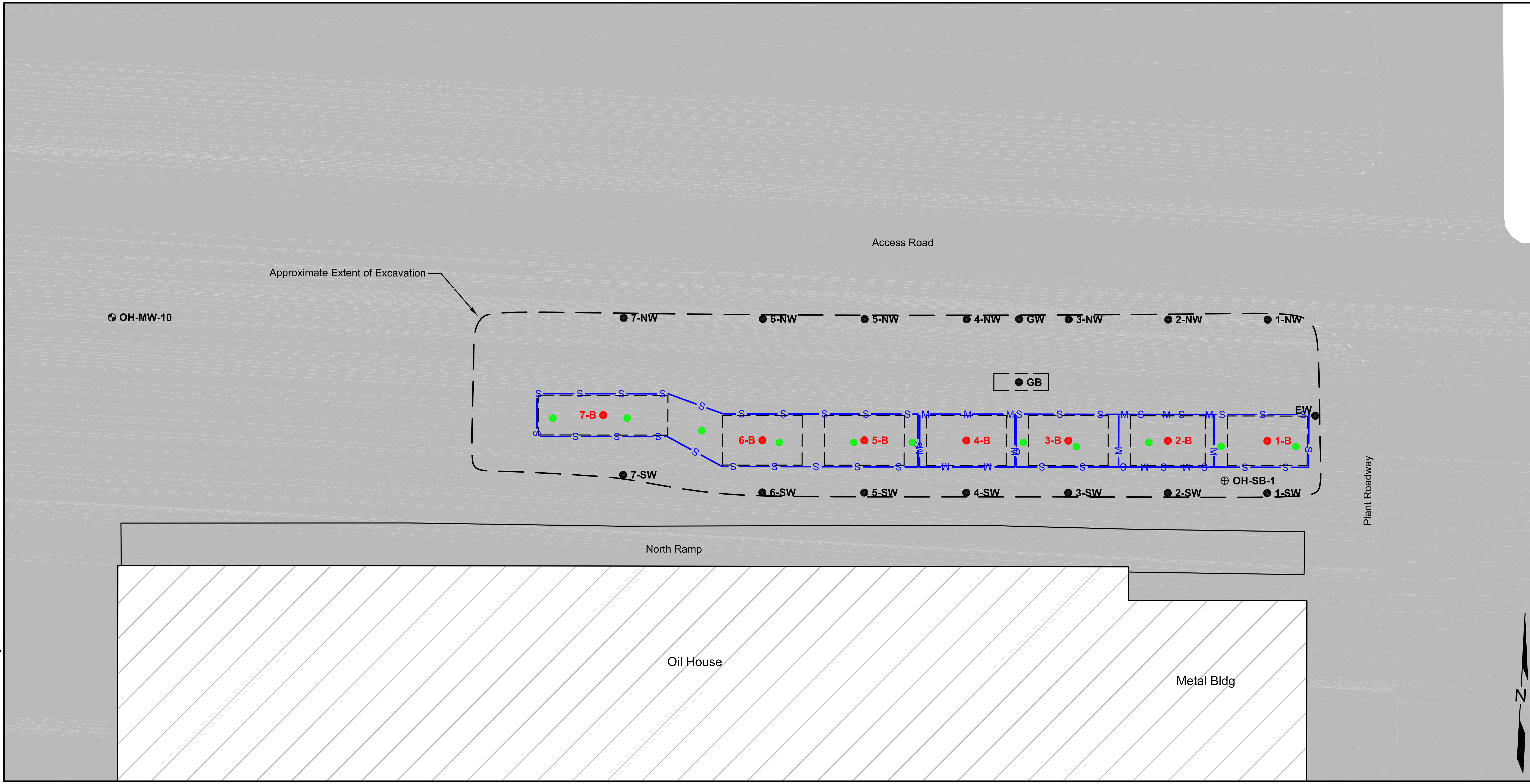
Figure 3-13

Alternative B4 - Injection/Extraction Well Location Plan

Eight USTs Excavation



Proposed Injection/Extraction Well Location

7-B Sample Location with Sceening Level Exceedance

OH-MW-10 Monitoring Well Location and Number

6-SW Soil Verification Sample Location and Number

OH-SB-1 Soil Boring Location and Number

S Kensol Area of Screening Level Exceedance

M Arsenic Area of Screening Level Exceedance

Deep Vadose Zone Soil

Former UST

Existing Paved Area

Existing Building

0 20 40

Scale in Feet

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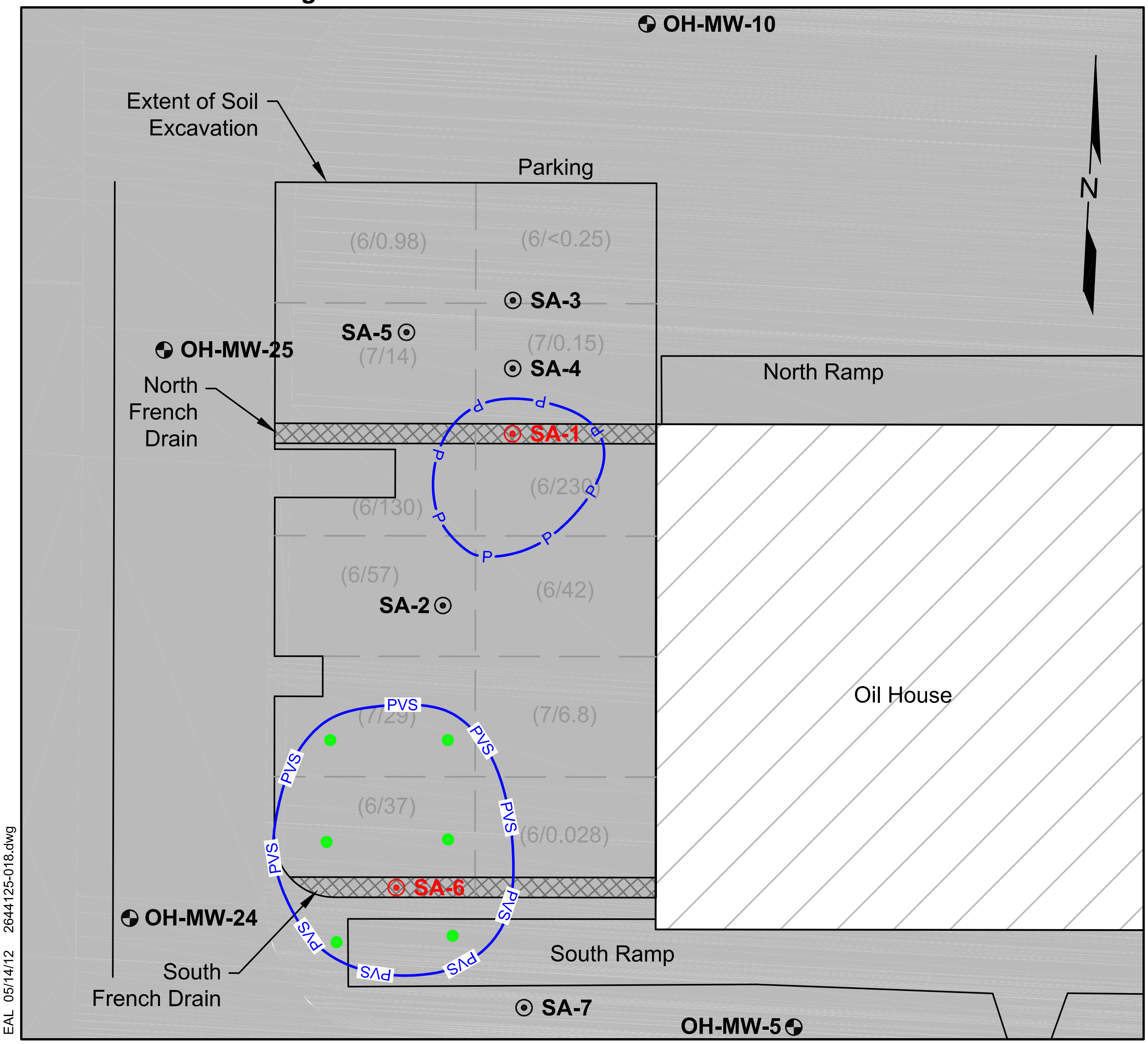
Figure 3-14

EAL 05/14/12 2644125-017.dwg

Alternative B4 - Injection/Extraction Well Location Plan

Oil House Drum Storage and French Drain Area



Monitoring Location and Number

- Proposed Injection/Extraction Well
- **SA-1** Sample Location with Screening Level Exceedance
- **SA-2** Storage Area Soil Boring Location and Number
- **OH-MW-4** Soil Boring and 4-inch Monitoring Well Location and Number
- Zones for Composite Sampling of Excavation Floor
- (6/<0.25) Depth of Excavation in Feet/Composited PCB Concentration in mg/kg
- PVS PCB, VOC, SVOC Area of Screening Level Exceedance
- P PCB Area of Screening Level Exceedance
- Deep Vadose Zone Soil

Existing Paved Area

Existing Building

0 20 40

Scale in Feet

HARTCROWSER

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Figure 3-15

Alternative B4 - Injection/Extraction Well Location Plan

Hoffman Tank Excavation

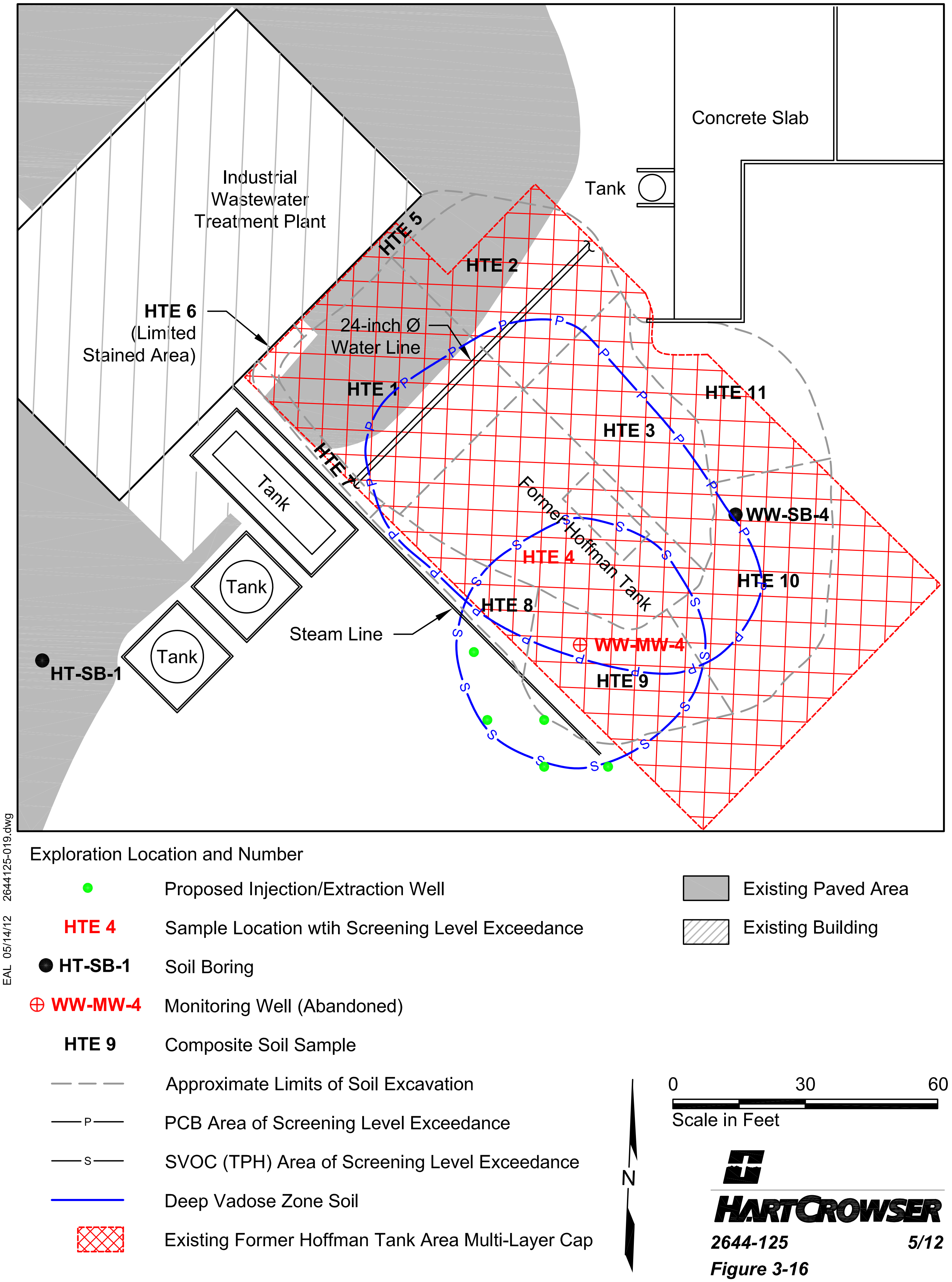

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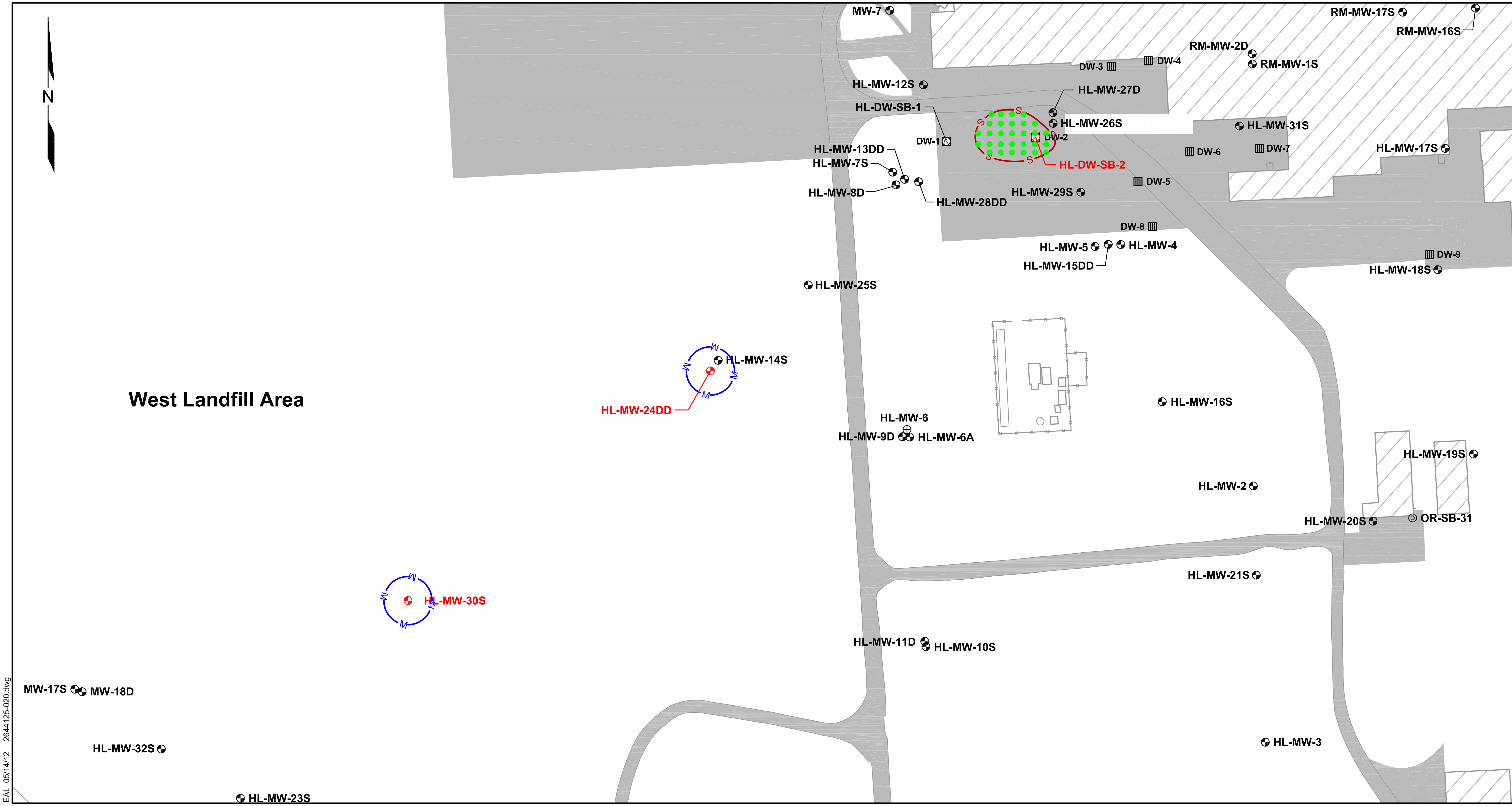
Figure 3-16

Alternative B4 - Injection/Extraction Well Location Plan

Remelt/Hot Line Area



Exploration Location and Number

OH-EW-1 ⊙ Extraction Well

OH-MW-4 Monitoring Well

WW-TL-MW-1 ⊕ Abandoned Monitoring Well

OH-SK-1 ◑ Skimming Well

TF-EW-1-US Groundwater Recirculation Well

North Supply Well ● Supply Well

East Supply Well ● Backup Supply Well

RM-F4-SB-1 ◎ Soil Boring

DW-1 Dry Well

—S— SVOC (TPH) Area of Screening Level Exceedance

—M— Metals (Arsenic) Area of Screening Level Exceedance

Deep Vadose Zone Soil

Near-Surface and Deep Vadose Zone Soil

HL-DW-SB-2 ◎ Sample Location with Screening Level Exceedance

● Proposed Injection/Extraction Well

Existing Paved Area

Existing Building

0 200 400

Scale in Feet

HARTCROWSER

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Figure 3-17

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TABLES (Continued)

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FIGURES (Continued)

4.0 REMEDIATION ALTERNATIVES FOR PETROLEUM HYDROCARBON GROUNDWATER PLUMES AND ASSOCIATED SMEAR ZONE SOIL

Section 4 of this feasibility study (FS) evaluates the technology-based remedial alternatives identified in the Feasibility Study Technical Memorandum (FSTM) (Hart Crowser 2012c) for the petroleum groundwater plumes that have been identified at the Facility (FSTM Section 5) and the smear zone soil associated with these plumes (FSTM Section 4). The smear zone soil acts as a secondary constituent of concern (COC) source area that seasonally comes into contact with groundwater, allowing the COCs present in smear zone soil to dissolve into the groundwater. As a result, the COCs in the smear zone are also typically present in groundwater at the Facility.

The potential remedial technologies identified in the FSTM for the petroleum groundwater plumes were similar to the technologies identified as potential remedial technologies for smear zone soil. Thus, Section 4 discusses both the process of identifying the most appropriate technology-based remedial alternatives for each individual COC, or mixture of COCs in the petroleum groundwater plumes, and in the smear zone soil associated with these plumes.

In a similar fashion, the evaluation of potential remedial technologies for the PCB groundwater plume (FSTM Section 6) at the Kaiser Facility and its associated smear zone soil (FSTM Section 4) is discussed in Section 5 of this FS.

The COCs identified for the petroleum groundwater plumes in Section 5 of the FSTM are:

- Free phase product (FPP);
- SVOCs, including diesel- and heavy oil-range petroleum hydrocarbons and carcinogenic polycyclic aromatic hydrocarbons (cPAHs);
- PCBs; and
- Metals (arsenic, lead, iron, and manganese).

Lead was detected at concentrations above the conservative screening level (SL) based on protection of aquatic life in 5 of 206 groundwater samples (Hart Crowser 2012a, Table 5-3). The maximum detected concentration of lead in groundwater of 12.7 µg/L does not exceed the drinking water criterion for protection of human health of 15 µg/L (Hart Crowser 2012a, Table 5-2). Because of the low frequency of detection and no detections above drinking water protection levels, lead is not considered a groundwater COC and is not addressed further in this groundwater and smear zone section of the FS.

The COCs identified for smear zone soil in Section 4 of the FSTM are:

- FPP;
- SVOCs, including diesel- and heavy oil-range petroleum hydrocarbons and cPAHs;
- PCBs;
- Metals (arsenic, lead, iron, and manganese); and
- VOCs.

Smear zone soil across the site is deeper than 20 feet below ground surface (bgs) and because of this depth, lead does not represent a human health risk from direct contact and ingestion or a terrestrial ecological risk. As discussed above, groundwater data indicate that lead above the conservative SL (Hart Crowser 2012a) has been detected in only about 2 percent of the samples analyzed. Thus, lead is not addressed further in the smear zone sections of the FS.

VOCs (gasoline and Stoddard solvent) were included as a potential COC in Facility soil in locations where it was thought that the VOCs could affect the indoor air quality for Facility workers or visitors (FSTM Section 1). It was judged to be unlikely that VOCs contained in smear zone soil would migrate upward through 55 to 68 feet of soil and reach indoor air, affecting Facility workers or visitors in the Wastewater Treatment area and Oil House area.

The Final Site-Wide Groundwater Remedial Investigation (RI) (Hart Crowser 2012a) did not identify VOCs as a COC, since VOCs were infrequently detected in groundwater. The most mobile VOC, benzene, was detected in only seven of the 827 samples collected through 2008, according to the data used in the Groundwater RI. Thus, it was concluded that the VOCs present in smear zone soil are not impacting groundwater. As a result, VOCs are not included as a COC, and are not evaluated for appropriate remedial alternatives to treat smear zone soil and petroleum groundwater plumes in this section.

PCBs that are comingled with SVOCs in smear zone soil and/or the petroleum hydrocarbon groundwater plumes are considered in this section. Remedial alternatives that treat PCBs alone (not comingled with other COCs) in smear zone soil and/or groundwater are discussed in Section 5 of this FS.

The most appropriate technology-based remedial alternatives identified in this section for the petroleum hydrocarbon groundwater plumes, and the smear zone soil associated with these plumes, are assembled to identify the appropriate area-based remedial alternative(s) for each operating area of the

Facility in Section 6 of this FS. The COCs evaluated for treatment in this section are SVOCs, PCBs comingled with SVOCs, and metals.

Section 4 is organized as follows:

- Section 4.1 – Description of Remedial Alternatives for Petroleum Hydrocarbon Groundwater Plumes and Associated Smear Zone Soil;

- Section 4.2 – Evaluation of Remedial Alternatives for Petroleum Hydrocarbon Groundwater Plumes and Associated Smear Zone Soil; and

- Section 4.3 – Comparative Analysis of Alternatives for Petroleum Hydrocarbon Groundwater Plumes and Associated Smear Zone Soil.

Estimated costs have been prepared for the remedial alternatives for the petroleum hydrocarbon groundwater plumes and the smear zone soil associated with these plumes. These costs are summarized for each alternative in their respective descriptions in Section 4.1. Cost estimate summary tables and backup calculations for each alternative are provided in Appendix C. Table C-1 in that appendix compares the net present value (NPV) costs for the remedial alternatives. These estimated costs were used in Sections 4.2 and 4.3 as part of the evaluation of each technology-based remedial alternative and selection of the most appropriate alternative for each COC group (SVOCs, PCBs comingled with SVOCs, and metals). The same cost estimation resources described in Section 2.2.1 were used in preparing estimated costs for the alternatives discussed in this section. The cost tables in Appendix C are annotated to reflect the resources used to develop the estimated cost for each line item.

Groundwater modeling is used in this section to assist in understanding the petroleum hydrocarbon groundwater plumes and to provide information needed to assess remedial alternatives (e.g., groundwater flow rates needed for containment, well locations for containment or for extraction and treatment of groundwater). The development, calibration, and output of the groundwater model are presented in Appendix E.

Natural attenuation of the petroleum hydrocarbon groundwater plumes has been ongoing and is continuing to occur, and is an integral part of the remedial alternatives evaluated in this section. An assessment of the natural attenuation processes that are ongoing at the Facility is provided in Appendix F.

Applicable or relevant and appropriate requirements (ARARs) for the Kaiser Facility are identified and evaluated in Appendix G, which discusses three types of ARARs: contaminant-specific, location-specific, and action-specific ARARs.

Appendix H provides an evaluation of the FPP recovery technologies that were carried forward from the FSTM as potentially implementable and reliable, and identifies the FPP technology judged appropriate for each alternative. Revised restoration time frame calculations are provided in Appendix I.

4.0.1 Development of Cleanup Standards for the Kaiser Facility

During preparation of this FS, Ecology began the development of cleanup standards for the Kaiser Facility, as discussed in Section 2.0.1. These cleanup standards include PCULs for unsaturated soil, saturated soil, surface water, and groundwater at the Facility. The PCULs developed for groundwater are compared to the screening levels (SLs) that were developed in Section 1 of the FSTM in Table 4-1 (see Table 2-1 for comparison of soil PCULs and SLs).

Groundwater PCULs were established using standard MTCA Method B criteria, which include consideration of criteria protective of both drinking water and surface water, since site groundwater discharges into the Spokane River.

The groundwater PCULs were developed for both a standard point of compliance (POC) and conditional POC (Ecology 2010a). If a conditional POC is granted, cleanup levels for groundwater COCs that are based on the protection of surface water should be met at the point or points where groundwater discharges into surface water. Concentrations for groundwater COCs elsewhere throughout the Facility may exceed surface water standards but would be required to meet drinking water standards.

The decision to grant a conditional POC will be made in the Cleanup Action Plan (CAP), in which final cleanup standards (i.e., cleanup levels and points at which these levels must be met) for the Facility will be determined. Recent groundwater data indicate detectable concentrations of PCBs in background samples. Background PCB concentrations have not been considered in the development of SLs or PCULs. However, background PCB concentrations in groundwater will be used to develop final CULs, as appropriate, to meet cleanup requirements per MTCA.

Although the groundwater PCULs were provided during the writing of this FS report, Ecology has allowed the continued use of the SLs in developing and evaluating the remediation alternatives herein (Ecology 2010b). Continuing to use the SLs in this regard ultimately does not significantly affect the evaluation of individual remediation alternatives, the evaluation of differences among alternatives, or the identification of a preferred alternative.

The SLs and PCULs for the groundwater COCs included in the FS are in general agreement, except for total polychlorinated biphenyls (PCBs), carcinogenic polycyclic aromatic hydrocarbons (cPAHs), and arsenic (refer to Table 4-1). The difference between SLs and PCULs affects the delineation of AOC boundaries, which in turn influences other estimated parameters, such as estimated total mass of COCs. For instance, the total AOC area for PCBs in groundwater (see Section 5) would likely increase in size if the PCUL for the standard POC were used to delineate the boundaries rather than the SL. Conversely, if a conditional POC were granted, the total AOC area would likely decrease in size.

The groundwater SLs for TPH, iron, and manganese are the same as the PCULs for both standard and conditional POCs, so there would be no change in total AOC size for these COCs. Both the SL and the PCUL for arsenic are based on its natural background concentration in the Spokane area and are not dependent on the POC. The PCUL for arsenic in groundwater is greater than the SL, and a smaller AOC may result if this PCUL is established as the final CUL by Ecology in the CAP.

The development and evaluation of remediation alternatives in this FS uses SLs; although, the PCULs developed by Ecology for the Kaiser Facility are used, as appropriate, in some aspects of evaluating the remedial alternatives, such as in estimating the restoration time frames for each alternative. Final determination of cleanup levels and POCs will be identified in the CAP, which will be prepared by Ecology.

4.1 DESCRIPTION OF REMEDIAL ALTERNATIVES FOR PETROLEUM HYDROCARBON GROUNDWATER PLUMES AND ASSOCIATED SMEAR ZONE SOIL

The technology-based remedial alternatives developed by the FSTM are discussed in this section as follows:

- Section 4.1.1 – Alternative C1: Institutional Controls, Monitoring, and Monitored Natural Attenuation, and Groundwater IRM System Operation
- Section 4.1.2 – Alternative C2: Institutional Controls, Monitoring, Monitored Natural Attenuation, Containment, and Expanded FPP Recovery
- Section 4.1.3 – Alternative C3: Alternative C2 Plus *In Situ* Treatment
- Section 4.1.4 – Alternative C4: Alternative C2 Plus Groundwater Extraction with *Ex Situ* Treatment

The continued natural attenuation (e.g. sorption, biodegradation, chemical stabilization) of petroleum hydrocarbons and comingled PCBs in groundwater at the facility is an element of Alternatives C1 and C2. The operation of the existing IRM at the site is part of these alternatives that provide protection to human health and the environment by containing petroleum hydrocarbon and comingled PCB plumes. Natural attenuation is an added enhancement to these alternatives.

Considerable evidence is available to prove that the bioremediation of petroleum hydrocarbons has occurred and is continuing to occur at the Site (refer to Appendix F). The biodegradation of PCBs that are comingled with petroleum hydrocarbons may also be occurring at the Site. The potential bioremediation of PCBs is one element of the natural attenuation processes that are part of Alternatives C1 and C2. Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established prior to the completion of the CAP for the Site.

4.1.1 Alternative C1: Institutional Controls, Monitoring, Monitored Natural Attenuation, and Groundwater IRM System Operation

Alternative C1 consists of institutional controls, monitoring, and monitored natural attenuation (MNA), and operation of the existing groundwater Interim Remedial Measure (IRM) system for the remediation of the petroleum hydrocarbon and free phase product (FPP) groundwater plumes and associated smear zone soil at the Kaiser Facility. The petroleum hydrocarbon smear zone and groundwater plumes also contain comingled PCBs and arsenic in some areas at the Facility (see Section 5 for evaluation of remedial alternatives for non-comingled PCBs).

The petroleum hydrocarbon plume, FPP, and smear zone soil areas of concern (AOCs) are shown on Figures 4-1 through 4-3. The petroleum and FPP AOCs shown on these figures are generally smaller in area than shown on the corresponding Figures 5-1 through 5-3 contained in the FSTM. The figures in the FSTM were based on data collected through 2008. Figures 4-1 through 4-3 in this FS include more recent data collected during 2009 and 2010. The footprint of the petroleum hydrocarbon groundwater plume AOCs in summer 2010 is discussed in Section 4.1.1.1.

The technical elements of Alternative C1 are evaluated in Sections 4.2 and 4.3.

The institutional control, monitoring, and MNA elements of Alternative C1 are common to each of the remedial alternatives evaluated in this section. Alternative C1 also includes operation of the existing groundwater IRM system in the Oil House and Wastewater Treatment areas of the Facility. The IRM system is used to control the migration of COCs and FPP with groundwater flow, to recover FPP from the surface of the water table, and to enhance biodegradation of dissolved and residual petroleum hydrocarbons in groundwater in localized areas of the Facility. Alternatives C2, C3, and C4 also include operation of the groundwater IRM system. Alternative C2 evaluates potential modifications to the IRM system to improve its performance. The IRM system operating mode selected in Alternative C2 is incorporated into Alternatives C3 and C4.

The existing groundwater IRM system is discussed below. Additional details on the IRM system and its operation are presented in the 2003 Draft Groundwater Remedial Investigation/Feasibility Study (Hart Crowser 2003). Groundwater IRM system well locations relative to the petroleum hydrocarbon groundwater plumes are shown on Figure 4-1. Potential improvements to the existing IRM system are discussed in Section 4.1.2.2 for Alternative C2. The evaluation of the existing and the potentially improved IRM system follows in Sections 4.2 and 4.3.

The institutional control and monitoring elements of Alternative C1 are essentially the same as the elements contained in Alternative A1 for near-surface soil. These elements are described in Sections 2.1.1.1 and 2.1.1.2, respectively, and in Table 2-3, and will not be described further in Section 4. Additional institutional controls (if any) that are associated with each remedial alternative proposed for smear zone soil and the petroleum hydrocarbon plumes are included in the description of that alternative provided in this section of the FS (Sections 4.1.1 through 4.1.4). Similarly, any additional monitoring requirements for each alternative are discussed in the section of the FS devoted to that alternative.

The MNA element of Alternative C1 includes groundwater monitoring to assess the natural attenuation occurring in the petroleum groundwater plumes and the smear zone soil associated with these plumes. These groundwater monitoring elements related to MNA were not included in Alternative A1 or B1. The MNA plan for Alternative C1 is described below (Section 4.1.1.3). An assessment of natural attenuation of petroleum hydrocarbons and comingled PCBs in groundwater at the Facility is discussed in Appendix F.

4.1.1.1 Footprint of the Petroleum Groundwater Plumes

Groundwater data presented on Figures 5-1 and 5-2 of the FSTM indicated that the petroleum hydrocarbon groundwater plume in the Wastewater Treatment area extended to the west beyond the capture zone of the existing IRM system. Since the FSTM was written, more recent groundwater data for the monitoring wells in this area have been evaluated (specifically, wells MW-21S, WW-MW-11, and WW-MW-18), which indicate that the leading edge of this plume no longer extends beyond the WW-UVB-1-HS groundwater infiltration system (see Figure 4-2).

The diesel and heavy oil plume AOCs presented on Figures 4-1 through 4-3 differ from the diesel and heavy oil plume AOCs presented in the FSTM (Hart Crowser 2012c). The diesel and heavy oil plume AOCs presented in the FSTM were primarily based on data from 2008. The configuration of the current diesel and heavy oil plume AOCs was based on the data collected through the spring of 2010. Based on the most recent data, both the Oil House area and Wastewater Treatment area diesel and heavy oil plumes were subdivided into two smaller AOCs each. These are referred to as the North and South plumes in each of these areas. Because ongoing groundwater monitoring indicates that there is no evidence that petroleum groundwater contamination is present west of the WW-UVB-1 horizontal infiltration galleries, the western boundary of the Wastewater Treatment area diesel and heavy oil AOC was redefined so that the AOC does not extend west of the WW-UVB-1 horizontal infiltration galleries.

Table 4-2 and Appendix E summarize the areal extent of the redefined petroleum groundwater plume boundaries. Table 4-2 and Appendix I provide the average diesel and heavy oil concentrations for each plume. Average contaminant concentrations in groundwater are based on the maximum concentration of diesel- and heavy oil-range petroleum hydrocarbons measured in 2009 and the first two quarters of 2010. One half of the laboratory reporting limit was used in the averaging calculation for non-detect sample analytical results for each AOC. The resulting average diesel-range petroleum hydrocarbon concentration in the North plume in the Oil House area was higher than the solubility limit for diesel. This average concentration was modified by using the estimated mass of diesel in smear zone soil in this AOC and the site-specific partitioning coefficient for diesel to estimate an approximate concentration of diesel in water, based on a chemical partitioning approach (see Appendix I).

The petroleum groundwater plume in the Cold Mill area is approximately 81,000 square feet in area, and the average concentration of diesel-range hydrocarbons is approximately 1.48 mg/L. The average concentration of heavy oil-range petroleum hydrocarbons in this plume is 0.53 mg/L.

Two petroleum groundwater plumes are located in the Wastewater Treatment area. The North plume is approximately 309,000 square feet in area and contains on average approximately 0.92 and 0.25 mg/L of diesel-range and heavy oil-range petroleum hydrocarbons, respectively. The South plume is smaller, at approximately 40,900 square feet. For the South plume, no data are available for 2009/2010, and the average concentration was not calculated. For the purpose of estimating restoration time frames, the South plume is assumed to have an approximate diesel concentration (0.92 mg/L) similar to the northern plume (see Appendix I).

The plume in the ORB area is approximately 37,400 square feet. The average concentration of diesel-range and heavy oil-range petroleum hydrocarbons is 0.25 mg/L for each type of petroleum hydrocarbons. This average concentration is below the PCUL for SVOCs or heavy oil provided by Ecology (Ecology 2010a).

Two petroleum groundwater plumes are located in the Oil House area. The Northern is approximately 191,500 square feet in area. The average concentrations of petroleum hydrocarbons are estimated to be approximately 1.32 and 0.25 mg/L for diesel-range and heavy oil-range petroleum hydrocarbons, respectively in the North plume. The South plume is smaller, at approximately 34,000 square feet. The average concentration of diesel-range hydrocarbons is approximately 0.88 mg/L, and the average concentration of heavy oil-range hydrocarbons is 0.25 mg/L in the South plume.

The extent of PCB concentrations associated with petroleum hydrocarbons in the Wastewater Treatment area defined for the FSTM was modified, since petroleum hydrocarbons were not detected in samples from WW-MW-11 collected in 2009 and 2010. The leading edge of the PCB detections was defined to coincide with the leading edge of the dissolved petroleum hydrocarbon plume, which does not extend beyond the WW-UVB-1 horizontal infiltration galleries. The revised delineation of PCB concentrations associated with petroleum hydrocarbons in the Wastewater Treatment area is presented on Figure 4-4. PCB concentrations associated with SVOCs in the Oil House area are shown on Figure 4-5.

An assessment of natural attenuation in groundwater at the Facility indicates that the majority of the petroleum hydrocarbon plumes are shrinking (Appendix F). This assessment also indicates that PCBs that are comingled with SVOCs in the petroleum plumes and associated smear zone soil may also be subject to biodegradation as the PCBs are released by the SVOCs or otherwise enter the aqueous phase, where biodegradation under anaerobic or aerobic conditions can occur.

Considerable evidence is available to support the assertion that biodegradation of the heavy oil and diesel fuels present in the petroleum plumes and associated smear zone soil has occurred in the past and is expected to continue in the future (refer to Appendix F). While there is considerable indication that the degradation of PCBs that are associated with the petroleum hydrocarbons at the Facility is likely to have occurred and continues to occur, evidence to support this assertion must still be collected and assessed.

4.1.1.2 Existing Groundwater Interim Remedial Measure

Objectives and Principles

The IRM for groundwater has been implemented at the Kaiser Facility to achieve three basic objectives. These objectives include:

- Prevention of downgradient migration and spreading of FPP and associated dissolved COCs near the Oil House and Wastewater Treatment areas;
- Recovery of FPP; and
- Enhancement of biodegradation of dissolved and residual COCs in the source areas (Oil House and Wastewater Treatment areas).

To prevent downgradient migration of dissolved COCs from the source areas, a hydraulic containment area has been established using high-capacity groundwater extraction wells at several Facility locations (see well locations on Figure 4-1). The extraction wells draw groundwater from the deep portion of the aquifer, from below zones of impacted groundwater. The pumping process creates a capture zone, within which groundwater is diverted toward the well rather than flowing past it, thus providing hydraulic containment.

FPP recovery has been facilitated by locating skimming wells near groundwater extraction wells where FPP pools exist (refer to Figures 4-1, 4-6, and 4-7). The depression of the water table resulting from groundwater extraction, although slight, promotes accumulation of FPP near the extraction well, where equipment installed in the skimming well (such as skimming pumps or mechanical belt skimmers, as discussed in FSTM Section 4.2.2) has been used to recover accumulated FPP.

Enhanced oxygenation systems have been installed at the Facility to promote the biodegradation of dissolved and residual petroleum hydrocarbons in the Wastewater Treatment and Oil House areas. Portions of these systems have been implemented to actively treat these COCs and to reduce the length of time that plume containment will be needed. The enhanced oxygenation systems are designed to raise dissolved oxygen concentrations in the upper part of the aquifer, where the dissolved and residual petroleum hydrocarbon plumes are located, to increase the rate of aerobic biodegradation by naturally occurring bacteria.

Enhanced oxygenation of the upper part of the aquifer is achieved by pumping oxygen-rich groundwater from deep within the aquifer and allowing it to infiltrate into the upper part of the aquifer via horizontal and, potentially, through vertical well screens. An added benefit of groundwater infiltration is that it provides additional hydraulic control at the leading edge of a plume through mounding of the water table in the vicinity of the infiltration well. These enhanced oxygenation systems are discussed in more detail below.

IRM System Description and Operation Status

The groundwater IRM system began operation in 1993 and was expanded in 2000 to implement enhanced bioremediation. The primary components of the groundwater IRM system include:

- Groundwater extraction wells that provide hydraulic containment and oxygenated groundwater for distribution to the shallow depths of the aquifer;
- Horizontal and vertical distribution wells for delivery of oxygenated groundwater to the shallow part of the aquifer;
- Skimming wells and belt skimmers for recovery of FPP; and
- Special deep observation wells to monitor for potential downward migration of petroleum hydrocarbons near groundwater extraction wells.

The components of the groundwater IRM system and their location relative to the petroleum hydrocarbon groundwater plumes are shown on Figure 4-1. Their operation status is summarized in Table 4-3 and discussed below.

Oil House Area. The IRM system components in the Oil House area consist of three extraction wells (OH-EW-1, OH-EW-2, and TF-EW-1); two vertical distribution wells (OH-EW-2-US and TF-EW-1-US); four skimming wells (OH-SK-1 through OH-SK-4); and a deep monitoring well (OH-MW-26). Currently, extraction well OH-EW-1 is operating at a pumping rate of approximately 1.2 million gallons per day (MGD). Extracted groundwater from OH-EW-1 is conveyed to plant processes for use as both contact process water and non-contact cooling water. The enhanced oxygenation system in the Oil House area (which consists of extraction wells OH-EW-2 and TF-EW-1 and vertical distribution wells OH-EW-2-US and TF-EW-1-US) is currently shut off.

The vertical distribution wells were operated for only a short period because they were shown to not provide effective treatment of the source area in the gravelly material present at the Facility. In 1998, at the request of Ecology, Kaiser conducted a groundwater sparging test to evaluate the feasibility of using vertical sparging wells to increase oxygen concentrations in the upper portion of the aquifer (Hart Crowser 2003, Appendix G). The month-long sparging test was performed in the Oil House area. The results indicated that groundwater sparging via vertical wells was not effective at consistently increasing dissolved oxygen concentrations because of the porous nature of the soil and the high transmissivity of the aquifer at the Facility. The study showed that the radius of effective oxygen enhancement around a vertical sparging well for this area was less than 15 or 20 feet. Based on the results of the sparging study and the positive aquifer oxygenation results of the horizontal infiltration systems installed in the Wastewater Treatment area (Appendix H, Hart Crowser 2003), the vertical extraction and injection systems were not operated but remain in place at the Facility. While this existing vertical system has been shown to be ineffective at providing oxygen to the shallow part of the aquifer, the infrastructure remains in place and could be used in the future, if deemed necessary.

Skimming operations began in 1993 at well OH-SK-2, and in 2000 at well OH-SK-4 (Figure 4-7). Skimming wells in the Oil House area are operated as needed when an accumulation of FPP is detected. FPP typically accumulates during periods of low water table elevation. The accumulation of FPP on the water table and the rate of FPP recovery vary depending on the groundwater hydrograph in any given year and have decreased over time as the areal extent and thickness of the FPP plume has decreased. For example, in 2001 over 160 gallons of FPP were recovered from the Oil House area, while in 2008 thirty gallons of FPP were recovered (Hart Crowser 2012a, Table 5-4). Currently, belt skimmers are operating at both OH-SK-2 and OH-SK-4.

Wastewater Treatment Area. The IRM system components in the Wastewater Treatment area consist of four wells used for extraction (WW-EW-1, WW-EW-2, WW-EW-3, and WW-UVB-1); two horizontal distribution wells (WW-EW-3-HS and WW-UVB-1-HS); four skimming wells (WW-SK-1 through WW-SK-4); and a deep monitoring well (WW-MW-17). Extraction wells WW-EW-3 and

WW-UVB-1 were installed as groundwater recirculation wells, designed to pump oxygenated water from the deeper depths of the aquifer into the shallower depths of the aquifer to promote biodegradation of petroleum hydrocarbons, and thus contain upper screens above the shallow part of the aquifer in addition to screens in the deeper portion of the aquifer. The upper screens in these two wells are currently not being used for groundwater recirculation for the same reasons that OH-EW-2-US and TF-EW-1-US are not being operated in the Oil House area. Rather, groundwater extraction piping has been routed to horizontal distribution wells WW-EW-3-HS and WW-UVB-1-HS, because this horizontal infiltration system has been shown to be more effective at increasing oxygen in the upper portion of the aquifer than the vertical injection wells (see Hart Crowser 2003, Appendices G and H). Extraction well WW-EW-3 and its associated horizontal distribution well (WW-EW-3-HS) are currently not operational because of potential adverse impacts to the PCB groundwater plume emanating from the Remelt area.

Extraction wells WW-EW-1, WW-EW-2, and WW-UVB-1 are currently operating at flow rates of approximately 4.5, 7.1, and 4.37 MGD, respectively. Groundwater extracted from WW-EW-1 is used in plant processes for contact and non-contact cooling. Groundwater from WW-EW-2, which is drawn from deep in the aquifer, is currently discharged to the Spokane River. Groundwater extracted from WW-EW-2 is not impacted by COCs as verified by quarterly sample analytical results presented in the Final Groundwater Remedial Investigation Report (Hart Crowser 2012a, Appendix F) and is not treated prior to discharge to the river. Groundwater from WW-UVB-1 is conveyed to a horizontal infiltration well (WW-UVB-1-HS) with a distribution system consisting of three screened intervals to deliver oxygenated groundwater to the upper portion of the aquifer. The three horizontal screens receive extracted groundwater at flow rates of 1.78 MGD (WW-UVB-1-HSS), 0.97 MGD (WW-UVB-1-HSM), and 1.62 MGD (WW-UVB-1-HSN).

The skimming wells in the Wastewater Treatment area are operated as needed when accumulation of FPP has been detected. Similar to the Oil House area, the rate of FPP recovery in the Wastewater Treatment area has declined over time. About 935 gallons of FPP were recovered from the Wastewater Treatment area skimming system in 2001, and only about 45 gallons of FPP were recovered in 2008 (Hart Crowser 2012a, Table 5-4).

IRM System Performance

The IRM system's performance in providing hydraulic containment has been assessed by monitoring COC concentrations and FPP levels in groundwater at the Facility over many years. Approximate petroleum groundwater plume and

FPP locations are shown on Figures 4-1 through 4-3, which are based on the most recent groundwater data available for the Facility. Note that dates on the groundwater data presented on Figures 4-2 and 4-3 vary depending on when the most recent samples were collected from specific wells. Data from wells that were not sampled in 2009 or 2010 are identified with the most recent sampling date on these figures.

The IRM system's performance in providing hydraulic containment has also been assessed by computer modeling of the effects of extraction and distribution well operation on groundwater flow. The assessment uses a groundwater flow model of the Facility that was first developed, calibrated, and verified in 1996. The model has been periodically updated as additional data became available or as conditions at the Facility changed (for example, after installation of additional pumping wells). For the 2003 Draft Groundwater Remedial Investigation/Feasibility Study (RI/FS) (Hart Crowser 2003), the model was used to support the analysis of remedial alternatives.

The Facility groundwater model was used for this FS to assess the groundwater capture zone created by the various components of the IRM. Development of the other remedial alternatives in this section uses the model to assess potential pumping rates and restoration time frames. Details of the modeling effort for this FS are provided in Appendix E.

Analysis of the capture zone of the existing IRM system shows that, under current operating conditions, the majority of the petroleum hydrocarbon groundwater plumes are located within the capture zone of the IRM system and are, thus, hydraulically contained (see Figure E-5 in Appendix E). The petroleum hydrocarbon plume in the Oil Reclamation Building (ORB) area, however, resides beyond the northern edge of the capture zone boundary (see Figure E-5). An assessment of historical groundwater data at the Facility indicates that this plume is shrinking (see natural attenuation discussion in Appendix F), with the concentration of total TPH at approximately 500 μg/l, which is the PCUL established by Ecology. Thus, the likelihood that the TPH in the non-contained portion of this plume would reach the Spokane River at concentrations above the PCUL is low.

Potential Modification of the IRM System

The Facility groundwater model was used to evaluate modifications of the IRM system to assess potential improvements in system performance. Potential modifications of the IRM system are discussed, where applicable, for the alternatives presented in this section. Potential improvements in hydraulic containment provided by the IRM system are discussed under Alternative C2 in Section 4.1.2.

IRM System FPP Recovery

One of the objectives of the IRM system is to recover FPP. Skimming wells with belt skimmers are currently being used in the Oil House and Wastewater Treatment areas on a periodic basis to meet this objective. Detection of sufficient FPP accumulation in the skimming wells triggers the operation of the belt skimmers to recover FPP.

In the Wastewater Treatment area, currently two extraction wells (WW-EW-1 and WW-EW-2) and one recirculation well (WW-UVB-1) are operating, with two skimming wells (WW-SK-1 and WW-SK-4) operating when FPP is present. In the Oil House area, skimming operations began in 1993 at well OH-SK-2, and in 2000 at well OH-SK-4 (Figure 4-7). Currently, there are belt skimmers operating at both wells, and one extraction well (OH-EW-1) is being used. Skimming wells and extraction wells are identified on Figures 4-6 and 4-7.

Migration and spreading of the contaminant plumes in the Wastewater Treatment and Oil House areas have been eliminated through natural attenuation processes, implementation of hydraulic control, and the use of horizontal infiltration wells to introduce oxygenated groundwater to enhance bioremediation. The extent and thickness of FPP in both areas have declined with time. Between 1994 and 2008, Kaiser recovered approximately 4,200 gallons of FPP from groundwater in the Oil House and Wastewater Treatment areas.

The costs associated with FPP recovery for Alternative C1 include continued operation of the four skimming wells that are part of the existing IRM system. The annual costs of belt skimmer systems are relatively low and include electricity required to operate the belt skimmers, monitoring FPP thicknesses in the wells, recording the total amount of product recovery at each recovery point, inspecting belt skimmer electrical and mechanical components, completing necessary maintenance and repair of the equipment, and transferring and disposing of the FPP from the collection tank, if necessary (EPA 1996b). Periodic costs include belt and motor replacement.

The treatment time frame for FPP recovery was determined based on the estimated FPP recovery rate at the Facility from 1994 to 2008. Over 14 years, approximately 4,200 gallons were recovered, which equates to approximately 300 gallons per year. However, most of the FPP recovery at the Facility (87 percent) occurred between 1993 and 2001 and only about 600 gallons have been collected in the last 7 years (Hart Crowser 2012a, Table 5-4). This dramatic reduction in the FPP recovery rate over time is primarily the result of the reduction of the FPP plume size through early product recovery operations and from natural attenuation of petroleum in the shallower depths of the aquifer. Based on the recovery rate over the last 7 years, it would take approximately 43 years to recover the approximately 3,700 gallons of FPP left in the Wastewater Treatment area (see Table 4-6), not taking into account diminishing returns that have been observed at the Facility and will continue in the future. For cost estimating purposes, a period of 50 years was conservatively assumed for the continued operation of belt skimmers at wells WW-SK-1 and WW-SK-4.

Using similar assumptions, it would take approximately 12 years to recover the approximately 980 gallons left in the Oil House area (Table 4-6) through belt skimming, not accounting for diminishing returns. It was conservatively assumed that skimming wells OH-SK-2 and OH-SK-4 would run for 20 years. Alternative C1 does not have skimming operations in some parts of the Wastewater Treatment and Oil House areas, where FPP has been documented to accumulate and FPP recovery operations would be necessitated (for example, at wells OH-SK-1, WW-MW-3, and WW-MW-6). This alternative would not actively remove FPP in these areas. The assumptions in Alternative C1 are used only to allow a cost estimate of the alternative to be prepared.

4.1.1.3 Monitored Natural Attenuation Plan

MNA will be implemented as part of each of the petroleum hydrocarbon groundwater plume and smear zone soil remedial alternatives. A summary of the MNA plan associated with Alternative C1 is discussed below. A discussion of the natural attenuation occurring at the Facility is provided in Appendix F.

Petroleum Hydrocarbon Groundwater Plume MNA. Groundwater analytical data that are applicable to MNA are being collected as part of the Kaiser Sampling and Analysis Plan (Hart Crowser 2007a), as amended (Kaiser 2010a). These data include dissolved petroleum hydrocarbon concentrations and biological indicators such as nitrate, iron, manganese, and arsenic concentrations (see Table 2-3). During sample collection, field parameters are typically measured, such as dissolved oxygen (DO) and oxidation-reduction potential (ORP), which can be used to interpret the microbial aspect of natural attenuation.

Natural attenuation of the petroleum hydrocarbon groundwater plumes is assessed primarily using the petroleum hydrocarbon concentration data to determine whether the plumes are continuing to shrink. The aforementioned biological indicators are used to supplement the assessment of the petroleum hydrocarbon concentration data. For the purpose of estimating costs for Alternative C1, it is assumed that the existing groundwater protection and performance monitoring regime (see Section 2.1.1.2) provides adequate petroleum hydrocarbon data to assess the plume boundaries. However, additional samples will be collected from within the footprint of the petroleum groundwater plume and analyzed to assess the biological parameters associated with natural attenuation. Analytes include electron acceptors and nutrients used in microbial metabolism, such as nitrate, sulfate, phosphate, ammonia, iron, manganese, potassium, and magnesium (see Table 4-4).

Natural Attenuation in Smear Zone Soil. The smear zone is a product of the vertical distribution of petroleum hydrocarbons caused by groundwater fluctuation, which ranges approximately 10 feet annually at the Facility. As defined in FSTM Section 4.0, based on April 2007 groundwater data (which represent the seasonal high water table, Hart Crowser 2012a), the vertical extent of the smear zone at the Facility ranges from approximately 68 to 78 feet bgs in the mill area, from 55 to 65 feet bgs in the Wastewater Treatment area, and from 33 to 43 feet bgs near the Spokane River. Natural attenuation in smear zone soil is assessed using groundwater data collected at the Facility. Compliance with cleanup standards for smear zone soil will be considered to be achieved when groundwater cleanup levels have been achieved (Ecology 2011).

4.1.1.4 Alternative C1 Estimated Cost

Assuming an operating period of 30 years and a discount rate of 7 percent, the total net present value (NPV) cost of Alternative C1, which includes institutional controls, monitoring, MNA, and operation of the existing groundwater IRM system, is $21.0 million (Appendix C, Table C-2). The estimated cost for Alternative C1 assumes baseline institutional control and monitoring costs that are similar to those for Alternative A1 (see Table A-2 in Appendix A).

4.1.2 Alternative C2: Institutional Controls, Monitoring, MNA, Containment, and Expanded FPP Recovery

Alternative C2 adds the additional protection of containment to Alternative C1. Alternative C2 considers the applicability of two types of containment technologies for petroleum-impacted groundwater and associated smear zone soil: surface containment and hydraulic containment. Alternative C2 also expands the source control measure of Alternative C1 through the operation of additional FPP recovery points.

The institutional control and MNA elements of Alternative C2 are the same as the elements presented in Alternative C1, described in Section 4.1.1, and are not discussed further in this section. Alternative C2 will require additional monitoring elements, which are described in Section 4.1.2.4.

4.1.2.1 Surface Containment

Because of the nature of the smear zone and ongoing contact between groundwater and smear zone soil, implementing surface containment of smear zone soil AOCs will not provide remedial benefit for these areas. The petroleum hydrocarbon smear zone in soil is an artifact of groundwater fluctuation, which causes FPP floating on the water table surface to spread vertically through the soil matrix, leaving behind a zone of residual "smeared" FPP. Because groundwater is in contact with FPP that caused the smear zone, and because groundwater remains in contact with the smear zone as the water table fluctuates seasonally, the smear zone is considered a secondary source of petroleum impacts on groundwater at the Facility. This constitutes an ongoing exposure pathway between impacted soil and groundwater that would not be controlled by installation of surface containment technology.

The purpose of surface containment is to sever exposure pathways that pose a potential threat to human health or the environment. At the Facility, surface containment would be used to sever the direct-contact exposure pathway between COC-impacted near-surface soil and Facility workers and visitors, and to prevent rainwater from infiltrating through impacted near-surface and deep vadose zone soil and potentially conveying COCs to groundwater. (Surface containment of near-surface soil AOCs and deep vadose zone soil AOCs is discussed under Alternatives A2 and B2, respectively in Sections 2.1.2.2 and 3.1.2.) Because of the depth of the smear zone and water table, the direct-contact exposure pathway does not exist for smear zone soil AOCs and petroleum hydrocarbon groundwater plumes. Thus, capping these AOCs would not provide additional benefit. Because smear zone soil and groundwater are in ongoing contact, rainwater that has infiltrated from the surface and traveled through the smear zone would not affect this exposure pathway. Thus, installing surface containment would not provide added benefit by mitigating rainwater infiltration. For these reasons, applying surface containment technology (e.g., a cap) to smear zone soil AOCs is not considered as an element of Alternative C2.

4.1.2.2 Hydraulic Containment

The petroleum hydrocarbon groundwater plumes at the Facility are currently hydraulically contained or within the capture zone of the IRM system. However, the current system does not capture the entire plume in the ORB area. Alternative C2 considers potential IRM system modifications to improve its capture zone and hydraulic containment of the petroleum hydrocarbon plumes at the Facility. Three modification scenarios are considered in Alternative C2, which are summarized below. These scenarios consider pumping non-impacted groundwater from the deeper depths of the aquifer to facilitate improvement of the system's plume capture zone and the hydraulic containment that it provides.

- **Scenario C2a – Expanded IRM System.** This scenario assesses adding the operation of extraction well WW-EW-3 to Alternative C1 to expand the IRM system capture zone.

- **Scenario C2b – Existing IRM System Plus Focused Containment in the ORB Area.** Scenario C2b adds the installation and operation of one extraction well (ORB-FEW-1) to Alternative C1 to provide local containment of the plume in the ORB area.

- **Scenario C2c – Focused Containment of Plumes with the IRM System Turned Off.** This scenario assesses localized hydraulic containment of each of the petroleum groundwater plumes at the Facility through installation and operation of extraction wells at the leading edge of each plume, rather than providing hydraulic control through operation of the IRM system.

Scenario Descriptions and Modeling Results

Modeling results for Scenarios C2a through C2c are summarized below, together with a description of each scenario. Each summary includes a baseline scenario, which is represented by Alternative C1 (operation of the existing groundwater IRM system). Scenarios C2b and C2c involve the installation of new groundwater extraction wells. The locations of these wells are shown on Figures 4-8 and 4-9. The details of model development, calibration, and results are provided in Appendix E.

Baseline Scenario. The modeling results for Scenarios C2a through C2c are compared against baseline operation of the existing groundwater IRM system, which is represented in Alternative C1 (see Section 4.1.1.2). The baseline system is modeled with a total extraction flow rate of 16.6 MGD and a groundwater infiltration rate of 4.37 MGD (see Table E-3 in Appendix E for specific well extraction and injection flow rates). Groundwater that is not re-infiltrated is used in the industrial plant processes or discharged to the Spokane River. The groundwater capture zone of the baseline scenario is shown on Figure E-5 in Appendix E.

Scenario C2a. The existing groundwater extraction well WW-EW-3 and horizontal distribution system WW-EW-3-HS in the Wastewater Treatment area (Figure 4-8), which are currently not operating, are added to the operation of the existing IRM system represented in the baseline scenario. To expand the capture zone of the baseline scenario to contain the petroleum groundwater plume in the ORB area, groundwater would need to be extracted from the deeper depths of the aquifer through well WW-EW-3 at a flow rate of 1.5 MGD, as determined by the model results. Extracted groundwater is distributed to the shallow depths of the aquifer via horizontal infiltration system WW-EW-3-HS at the same flow rate. The total extraction flow rate used in Scenario C2a is 18.1 MGD, and the total infiltration rate is 5.87 MGD. The groundwater capture zone provided in this scenario is shown on Figure E-7 in Appendix E.

Scenario C2b. This scenario adds one extraction well (ORB-FEW-1, Figure 4-8 and 4-9) in the ORB area to hydraulically contain the plume in this location. To achieve containment (see Figure E-9 in Appendix E), ORB-FEW-1 would extract groundwater from the deeper part of the aquifer at a flow rate of 0.60 MGD, increasing the baseline system flow rate from about 16.6 to 17.2 MGD. The groundwater infiltration rate remains at the baseline level of about 4.37 MGD. Groundwater extracted from ORB-FEW-1 would be used in plant processes or discharged to the Spokane River. Because groundwater would be extracted from the deeper part of the aquifer in this scenario, it is assumed that this water is not impacted by COCs.

Scenario C2c. The existing IRM system (except for the skimming well systems) is shut off in Scenario C2c, and groundwater extraction wells are installed and operated at the leading edge of each of the petroleum hydrocarbon groundwater plumes at the Facility. These extraction wells would be installed in the deeper part of the aquifer, similarly to Scenario C2b above, and it is assumed that the extracted groundwater is not impacted by COCs. To achieve containment of the plumes, well installation would include four wells in the Wastewater Treatment area (WW-FEW-1 through WW-FEW-4), two wells in the Cold Mill area (CM-FEW-1 and CM-FEW-2), and four wells in the Oil House area (OH-FEW-1 through OH-FEW-4). In the ORB area, well ORB-FEW-1 would be installed as in Scenario C2b above. Model results of the extraction flow rate for each well to achieve containment are summarized in Table E-3 in Appendix E, and the resulting capture zone is shown on Figure E-11 in that appendix. The total groundwater extraction flow rate used in Scenario C2c to achieve containment is about 9.87 MGD. Extracted groundwater in this scenario would be used in plant processes or discharged to the Spokane River. No groundwater is infiltrated to the aquifer under this scenario.

The new extraction wells employed in the scenarios described above will be installed outside of the buildings at the Facility, with the exception of wells CM-FEW-1 and CM-FEW-2, which will be installed inside the Cold Mill building (Figure 4-9). Because of the location of the petroleum groundwater plume in this area relative to the building (the majority of the plume is beneath the building footprint), as shown on Figure 4-9, localized containment would not be effectively achieved without installing extraction wells inside the building. For cost estimating purposes, it is assumed that the indoor well locations will be accessible to a drilling rig for well installation. The cost estimate also assumes that groundwater extraction piping will be installed aboveground and routed through the building rafters to minimize interference with Facility industrial activities.

Discussion of Results

The model results show that the total extraction flow rate necessary to achieve plume capture or hydraulic containment of the petroleum groundwater plumes decreases with increasing localized containment. The existing IRM system (baseline condition) plus operation of WW-EW-3 (Scenario C2a) requires a total extraction flow rate of about 18.1 MGD to provide containment of the petroleum groundwater plumes (by expanding the existing capture zone to the north to contain the plume in the ORB area). By operating an extraction well at the leading edge of the ORB plume, together with the existing IRM system to provide containment (Scenario C2b), the necessary total extraction rate decreases to about 17.2 MGD. In Scenario C2c, turning the IRM system off and providing localized containment at each plume reduces the total necessary extraction rate by almost half, to about 9.87 MGD. It should be noted that the total extraction flow rates used in the various model scenarios are within the limits of the maximum daily flow rate (about 20 MGD) stipulated by the water right that Kaiser holds for pumping water from the Spokane River and the aquifer.

Because each of the three scenarios achieve plume capture or containment of the plumes at the Facility, selection of the appropriate scenario for Alternative C2 would be based on the anticipated operating period of the containment system and associated capital and annual operation and maintenance (O&M) costs. Capital costs are defined as those expenditures that are initially incurred to construct a remedial action, whereas annual O&M costs are post-construction costs necessary to ensure the continued effectiveness of the remedial action and are incurred over the lifetime of the remedial action (EPA 2000a).

Employing existing equipment and infrastructure (Scenario C2a) greatly reduces capital expenditure; however, using elements of the existing IRM system requires higher flow rates to achieve plume capture or containment, and thus would incur higher annual O&M costs. The operating period is critical in determining the point at which the savings in capital costs would be lost to the cumulative annual costs of continued system operation. Scenario C2a would be preferable for shorter operating periods to preserve the savings in capital costs and the cost effectiveness of the remedial action.

Scenario C2a creates the capture zone shown on Figure E-7. This capture zone is located near the leading edge of the PCB groundwater plume that originates in the Remelt area of the Facility. Additional modeling of potential interactions between the capture zone created by extraction well WW-EW-3 and the leading edge of the PCB plume would be required to show that the operation of the well would not cause additional migration of PCBs toward the Spokane River.

Scenario C2c represents the opposite case. Existing equipment and infrastructure would not be employed; rather, new equipment and infrastructure would be installed to improve containment efficiency by reducing the total flow rate necessary to achieve containment. In this case, greater capital expense would be required, but annual O&M costs would be reduced because of greater system efficiency. This scenario is preferable for longer operating periods, in that the greater capital costs are offset by savings in annual costs over a longer time frame.

The ORB petroleum hydrocarbon groundwater plume is shrinking (refer to Appendix F). The SVOCs present in this plume are not migrating toward the river (refer to wells HL-MW-10S and HL-MW-21S on Figure 4-2). For the purpose of the alternative evaluation process in this FS (i.e., Section 4), we have assumed that the ORB groundwater plume containment system will be implemented in Scenario C2b. However, it may not be necessary and could be removed in Section 6 of this FS. In the event that SVOCs were to migrate from the ORB plume toward the river, Scenario C2b would provide additional protection to human health and the environment. This would be provided by employing the existing extraction system, but would more efficiently contain the ORB area petroleum groundwater plume by installing an extraction well at the leading edge of this plume. Scenario C2b has lower total capital cost but greater annual cost than Scenario C2c (which includes the elements of Alternative C1 in each scenario), yet is more cost-effective to operate on an annual basis than Scenario C2a.

Selected Hydraulic Containment Scenario Description

Scenario C2b has been selected as the preferred scenario for implementation of Alternative C2. The estimated costs for the three scenarios fall into a narrow range, assuming a 30-year operating period (about $22.9 million for Scenario C2a, $22.9 million for Scenario C2b, and $21.9 million for Scenario C2c [see Table C-1 and Tables C-3 through C-5 in Appendix C]). The estimated cost differences among these scenarios are well within the -30 to +50 percent range representative of the cost estimating procedure.

Scenario C2b is an intermediate between the other two scenarios. Scenario C2b requires less up-front capital expenditure than Scenario C2c (but more than Scenario C2a), but presents higher annual operating costs than Scenario C2c (but less than Scenario C2a). Although Scenario C2b has a higher estimated cost than Scenario C2c, Scenario C2b primarily consists of the operation of the existing IRM system, which has been successfully operating at the Facility since its installation first began in 1993, and is judged to be the most appropriate scenario. This comparison of the annual operating costs of the three scenarios incorporates the annual costs associated with the operation of the existing IRM system (provided in Alternative C1) for Scenarios C2a and C2b but not for Scenario C2c, in which the existing IRM system would be shut off.

Scenario C2b allows for continued use of the existing IRM system to provide hydraulic containment of the Wastewater Treatment area plumes and capture of the Oil House and Cold Mill area plumes, and includes the installation of one groundwater extraction well (ORB-FEW-1) to contain the petroleum groundwater plume in the ORB area. For cost estimating purposes, it is assumed that this extraction well will be 12 inches in diameter and will be installed to a depth of 195 feet with 30 feet of screen to facilitate extraction of groundwater from the deeper depths of the aquifer. This well diameter will provide more than enough capacity to facilitate the 0.6 MGD continuous flow rate necessary to contain the ORB area plume (per the groundwater modeling results).

In conjunction with the groundwater extraction well, an early warning well will be installed nearby for monitoring of potential COC migration from the shallower depths of the aquifer to deeper depths that may be caused by the groundwater extraction operation. For cost estimation purposes, it is assumed that the 2-inch-diameter early warning well will be installed to a depth of 100 feet.

A groundwater pump and associated piping will be installed in well ORB-FEW-1 to facilitate groundwater extraction in the ORB area at a flow rate of 0.6 MGD. Extracted groundwater will either be used as process water in the Facility or will be discharged to the Spokane River. Because the extraction process will be drawing groundwater from the deep part of the aquifer, it is assumed that this water is not impacted by COCs.

The groundwater extraction system will operate continuously to provide uninterrupted capture and hydraulic containment of the petroleum hydrocarbon groundwater plumes at the Facility. The performance of the system in providing hydraulic containment will be assessed through ongoing monitoring of groundwater COC concentrations at the Facility to determine whether COC migration toward the Spokane River is occurring. The monitoring requirements of the hydraulic containment element of Alternative C2 are discussed in Section 4.1.2.4.

4.1.2.3 Expansion of FPP Recovery

Alternative C2 will expand the FPP recovery provided by the existing IRM system described under Alternative C1 to meet MTCA threshold requirements for groundwater cleanup actions (WAC 173-340-360[2][c]). Expansion of FPP recovery will include installation of additional product skimming locations. Criteria based on historical product thickness data were used to determine these locations.

It is assumed that new belt skimmers will be installed where significant product thickness is regularly observed. To determine where belt skimmers should be installed and operated, two steps were taken:

- **Step 1.** The average product thickness based on measurable product thicknesses from January 2007 through December 2009 was calculated.

- **Step 2.** For wells from Step 1 that had an average measurable product thickness greater than 0.1 foot, the entire data set of depth to water and product (DTWP) measurements from January 2007 through December 2009 was analyzed. If the frequency of measurable product was over 25 percent for the entire data set, it was concluded that a skimming well should be installed and operated at that location.

Based on these criteria, it was determined that additional belt skimmers should be operated in the vicinity of wells OH-MW-4, OH-SK-1, WW-MW-3, and WW-MW-6. Based on existing skimming wells, it was determined that for Alternative C2, skimming operations will be resumed at WW-SK-2 (near WW-MW-3) and at OH-SK-1, and a new skimming well will be installed near WW-MW-6. Currently, there are active skimming operations taking place near monitoring well OH-MW-4 at skimming well OH-SK-4. Alternative C2 assumes that skimming wells that are currently part of the existing IRM (OH-SK-2, OH-SK-4, WW-SK-2, and WW-SK-4) will continue to operate. Current and proposed skimming well locations are shown on Figures 4-6 and 4-7.

The FPP recovery time for Alternative C2 is assumed to decrease, since the number of skimming wells in the Oil House and Wastewater Treatment areas increase by 50 percent or more from Alternative C1 (it is assumed that the FPP recovery time for Alternative C2 will be half of that for Alternative C1). Specifically, belt skimmer operating periods of 10 years for the Oil House area and 25 years for the Wastewater Treatment area are assumed for Alternative C2.

4.1.2.4 Monitoring Requirements for Alternative C2

Monitoring will be required during installation of improvements to the existing hydraulic containment and FPP recovery systems, in addition to subsequent monitoring during the O&M period of these systems. Monitoring requirements unique to Alternative C2 are summarized in Table 4-5.

Monitoring the performance of the hydraulic containment system (i.e., assessing the status of the petroleum hydrocarbon plume boundaries over time) will be included as part of the regular groundwater monitoring events at the Facility, as discussed in Section 4.1.1 for Alternative C1. Monitoring of early warning wells in the deep part of the aquifer will determine whether operation of the extraction wells is drawing impacted groundwater from the shallow part of the aquifer into its deeper depths. Monitoring of early warning wells will include existing wells in addition to any wells that would be installed in conjunction with new groundwater extraction wells.

The hydraulic containment and FPP recovery systems will be monitored regularly. This monitoring includes observing equipment operation on a regular basis, collecting system readings and measurements, and performing necessary system maintenance. For cost estimating purposes, it is assumed that system monitoring will be conducted by Kaiser personnel (one person) once per week. FPP recovery system monitoring will depend on the systems operating periods, which may change over time, as the system will be operated only as needed when sufficient accumulation of FPP is detected (see Section 4.1.2.3).

4.1.2.5 Alternative C2 Estimated Costs

Assuming an operating period of 30 years and a discount rate of 7 percent, the total NPV cost of the unique elements of Alternative C2 (Scenario C2b), which excludes the elements of Alternative C1 that are included in this alternative, is approximately $1.9 million (Appendix C, Table C-4). The combined estimated NPV cost of Alternative C2 (including elements of Alternative C1) totals about $22.9 million.

4.1.3 Alternative C3: Alternative C2 Plus In Situ Treatment

Alternative C3 adds *in situ* treatment to Alternative C2 for AOCs where SVOCs are present in smear zone soil and/or in petroleum-contaminated groundwater at concentrations above SLs, and for those AOCs where SVOCs are co-located with PCBs. Alternative C3a adds *in situ* enhanced bioremediation to Alternative C2, while Alternative C3b adds *in situ* chemical oxidation.

A detailed evaluation of the implementability and reliability of *in situ* chemical oxidation for the treatment of SVOCs and PCBs comingled with SVOCs, in smear zone soil and the petroleum groundwater plume AOCs at the Facility was conducted. As a result of this evaluation, *in situ* chemical oxidation was rejected as a potential remedial alternative for smear zone soil and the petroleum groundwater plume AOCs at the Facility. The remainder of this FS refers to *in situ* enhanced bioremediation as Alternative C3.

4.1.3.1 Areas of *In Situ* Treatment

The AOCs for each COC for smear zone soil and petroleum hydrocarbon-contaminated groundwater are defined in Sections 4.5 and 5.4 of the FSTM, respectively. The groundwater plume boundaries were redefined for this FS based on the most recent available data and the SLs established in the FSTM. The revised plumes are described in Section 4.1.1. These COC-specific smear zone and groundwater AOCs are consolidated on Figures 4-1 through 4-5 of this FS.

The total treatment footprint of the smear zone soil SVOC AOCs associated with the petroleum hydrocarbon groundwater plumes that will be treated *in situ* is approximately 694,000 square feet (refer to Table 4-2 and Appendix I). The depth interval for each smear zone soil AOC is discussed in the FSTM (Appendix D) and is approximately 68 to 78 feet bgs, except in the Wastewater Treatment area, where it is estimated to be approximately 55 to 65 feet bgs. There are an estimated 1,580,000 pounds of SVOCs (derived from Appendix I – Petroleum Hydrocarbon Areas of Concern Restoration Time Frame Evaluation, Table 1) and 10 pounds of PCBs in the smear zone soil associated with the petroleum hydrocarbon groundwater plumes within the treatment area described above. Additionally, there are an estimated 84,200 pounds of Stoddard solvent in smear zone soil within the treatment area in the Oil House area.

Although VOCs are not considered a COC for the purposes of Section 4, they can be treated by the *in situ* oxidation and *in situ* bioremediation technologies presented in this section for SVOC treatment. In the application of these technologies, VOC mass can consume injected oxygen, nutrients, and oxidants, which increases the necessary quantity of these substrates to achieve SVOC treatment. This consumption is considered in the conceptual design of the treatment system presented in this section.

The smear zone soil acts as an ongoing source area for SVOCs as it seasonally comes into contact with groundwater. The COCs present in the smear zone can migrate into the groundwater only during this contact period. Maximum estimated concentrations are presented on Figures 4-3 and 4-4. For wells that were not sampled in 2009/2010, the most recent data and year collected are presented on the figures. The estimated average concentrations of the SVOCs in the petroleum groundwater plumes were recalculated based on the new groundwater plume boundaries and the most recent data (from 2009 and the first two quarters 2010). The estimated maximum concentration from the most recent six quarters was used to calculate the average. Only wells with 2009/2010 data were used to calculate the average. Estimated average plume concentrations based on the 2009/2010 data are presented in Table 4-2.

The resulting average diesel-range petroleum hydrocarbon concentration in the North plume Oil House area was higher than the solubility limit for diesel. This average concentration was modified by using the estimated mass of diesel in smear zone soil in this AOC and the site-specific partitioning coefficient for diesel to estimate an approximate concentration of diesel in water, based on a chemical partitioning approach (see Appendix I).

Biodegradation of SVOCs and comingled PCBs occurs primarily in the dissolved phase because the constituents must be able to be transported across the microbial cell boundary (EPA 2004b). The concentration of dissolved SVOCs and comingled PCBs in groundwater is dependent on a variety of factors including solubility and the soil/water partitioning coefficient (K_d).

The theoretical solubility of diesel in water ranges from 0.00076 to 5.8 mg/L, assumed to be equivalent to the aliphatic and aromatic hydrocarbon fraction, respectively, in the 12- to 16-atom carbon chain length range (FSTM Table 2-4). The diesel present at the Facility consists mostly of the aliphatic fraction. The theoretical solubility of heavy oil in water is much lower than the solubility of diesel in water. The actual solubility may be higher or lower than these theoretical values based on site-specific variables and co-solvent effects.

Site-specific partitioning coefficients were determined for soil at the Kaiser Facility that contained diesel and heavy oil by conducting a synthetic precipitation leaching procedure (SPLP) analysis. The average partitioning coefficients for diesel and heavy oil were calculated to be 2,250 and 1,987 L/kg, respectively (Kaiser 2010b).

The measured concentrations of diesel and heavy oil in groundwater (Hart Crowser 2012a) far exceed theoretical solubility limits (FSTM Table 2-4). Diesel-range petroleum hydrocarbon concentrations as high as 200 mg/L were reported in the Oil House area petroleum plume (Figure 4-3). The presence of FPP and/or emulsified product are likely causing the measured groundwater concentrations of SVOCs to be greater than the theoretical concentration based on solubility limits.

For this evaluation, the dissolved SVOC concentrations in groundwater were predicted using site-specific soil/water partitioning coefficients. These predicted concentrations are considered to be more reflective of the dissolved SVOC concentrations that will be available for biodegradation. The SVOC concentration in groundwater is expected to decrease over time as the SVOC mass is extracted by the groundwater flowing through the area. In estimating the rate of mass removal, a linear equilibrium relationship was assumed to exist between SVOCs in smear zone soil and SVOCs in groundwater (see Appendices E and I). The predicted concentrations of SVOCs that are dissolved in groundwater for each plume are presented in Table 4-2. The assumptions implicit in this approach are provided in Appendices E and I.

An assessment of natural attenuation in groundwater at the Facility indicates that the majority of the petroleum hydrocarbon plumes are shrinking (Appendix F). This assessment also indicates that PCBs that are comingled with SVOCs in the petroleum plumes and associated smear zone soil may also be subject to biodegradation as the PCBs are released by the SVOCs or otherwise enter the aqueous phase, where biodegradation under anaerobic or aerobic conditions can occur. While there is considerable indication that the degradation of PCBs that are associated with the petroleum hydrocarbons in the Oil House and Wastewater Treatment areas is likely to have occurred and continues to occur, evidence to support this assertion must still be collected and assessed.

Leaching of contamination from smear zone soil into groundwater is expected to occur only within the approximately 10-foot-thick smear zone in most AOCs. The mass available for treatment is based on the groundwater flux into the smear zone AOCs, and the concentration of SVOCs dissolved in the groundwater. The groundwater flow rate through smear zone soil was calculated by multiplying the groundwater flux (gpd/square feet) (refer to Appendix E) by the widest portion of the plume (perpendicular to groundwater flow) and by the thickness of the smear zone (10 feet). A maximum of approximately 1.3 MGD of groundwater pass through the smear zone each day when the smear zone is fully saturated. The daily mass removal for each plume is based on the mass transfer from smear zone soil to groundwater and the flow rate through the plume. Since the mass removal rate is a function of the contaminant mass remaining in the smear zone, the removal rate will decrease over time as SVOC mass is extracted. Estimated plume-specific flow rates and mass removal rates are presented in Appendices E and I.

4.1.3.2 Evaluation of *In Situ* Chemical Oxidation

During *in situ* chemical oxidation, chemical oxidants that destroy SVOCs are introduced into the soil column. As described in Section 3.1.4.3, hydrogen peroxide (H_20_2), potassium permanganate ($KMn0_4$), ozone (O_3), and persulfate ($S_2 O_8{}^{2-}$) are the four most commonly used oxidants in this treatment process (EPA 2006b). Fenton's reagent uses hydrogen peroxide and an iron catalyst to create hydroxyl free radicals. These oxidants are described and evaluated below for *in situ* chemical oxidation at the Facility. Hydrogen peroxide/Fenton's reagent and ozone are the most commonly used and most effective oxidants for petroleum underground storage tank (UST) sites (EPA 2004b).

Treatment Design

Successful *in situ* chemical oxidation of smear zone soil requires contact between the oxidant and the SVOC mass. Oxidants have varying persistence in the subsurface ranging from a few months (permanganate) to hours (ozone) (EPA 2006b). Once injected, oxidants typically react quickly with contaminants and other natural chemical oxidant demand and are generally unstable, limiting the effective radius of influence of the oxidant from the injection well. To reduce the mass of SVOCs in the smear zone soil effectively, injection wells would need to be installed in a grid to provide adequate coverage. Well spacing would be determined during pilot-scale testing as part of remedial design. For the purposes of this conceptual design, well spacing was based on oxidant persistence in the subsurface.

In situ chemical oxidation can also be used to directly treat SVOCs in the petroleum-contaminated groundwater. This would significantly reduce the number of wells required, as compared to the number of wells needed to treat smear zone soil. A line of injection wells would be placed perpendicular to groundwater flow downgradient of smear zone soil, where groundwater would likely have the highest concentration of SVOCs. The SVOCs would leach into groundwater as it flows through smear zone soil; the SVOCs would then be oxidized as they pass through the line of injection wells. The length of treatment would be dictated by the leaching rate of SVOCs from soil to groundwater.

PCBs have been shown to be somewhat reactive under certain types of oxidation (ITRC 2005 and EPA 2006b). Considering that approximately 10 pounds of PCBs are comingled with 1,580,000 pounds of SVOCs (based on historical PCB soil data and on assumptions in Appendix I) in smear zone soil, the oxidation of PCBs is judged to be incidental to the oxidation of SVOCs (i.e., SVOCs are the targeted compound for the oxidation process, but, because ozone is not selective, PCBs may be oxidized).

Oxidant Evaluation

Potassium Permanganate. Potassium permanganate is most commonly used for treating chlorinated solvents. Oxidation by permanganate happens through electron transfer rather than via a direct rapid reaction that results when ozone and hydrogen peroxide are used as the oxidant. Thus, permanganate has the advantage of being more persistent in the subsurface lasting up to three months (EPA 2006b). This potentially would allow for a greater contact efficiency than other oxidants between the permanganate and the SVOCs that are present in the petroleum hydrocarbon groundwater plumes and the smear zone soil associated with the plumes (refer to Section 4.1.3.2). The stoichiometric demand for permanganate is approximately 14 pounds of permanganate per pound of petroleum hydrocarbons (ITRC 2005). For each pound of petroleum hydrocarbon treated, approximately 10 pounds of manganese would remain in the subsurface (ITRC 2005). Permanganate also contains elevated concentrations of heavy metal impurities (EPA 2006b).

Smear zone soil contains an estimated 1.58 million pounds of SVOCs (based on historical soil data and the assumptions presented in Appendix I) and 84,200 pounds of VOCs. Approximately 11 million pounds of potassium permanganate would have to be added to react with the large mass of SVOCs to attain the SL and PCUL for SVOCs (see Table 4-1), including potential consumption of oxidant by VOCs. Up to approximately 8 million pounds of permanganate could remain in the soil column as manganese oxide (MnO_2).

The presence of large quantities of excess manganese oxide, heavy metal impurities, and potentially unknown byproducts of oxidation creates additional performance risks. As a result of this additional performance risk, the very large quantities of oxidant required, and attendant risk to operating personnel of the reagent, permanganate oxidation is rejected as not implementable at the Facility.

Persulfate. Persulfate is a new and developing oxidant. Persulfate behaves in a manner similar to permanganate, although it is less persistent in the environment (EPA 2006b). Limited information about the use and performance of persulfate is available. No information about its use at the scale needed at the Facility, or its expected performance in the smear zone soil and petroleum hydrocarbon groundwater plumes at the Facility was identified. Thus, persulfate was judged to be neither implementable nor reliable for use at the Facility.

Ozone. Ozone is the oxidant selected to treat SVOCs in vadose zone soil (see Section 3.1.4.3) at the Facility. An injection well spacing of 15 feet was specified for dry vadose zone soil. If this spacing were used to treat the SVOCs in smear zone soil associated with the petroleum hydrocarbon groundwater plumes, over

3,000 injections wells would be required to assure contact between the ozone and the SVOCs. Ozone has a shorter half-life in water than in air (20 minutes versus three days) (EPA 2006b). An even closer injection well spacing may be required to effectively treat the SVOCs during the portion of the year that the smear zone soil is saturated.

There are also challenges associated with producing enough ozone for the SVOC contaminant loading in smear zone soil associated with the petroleum hydrocarbon groundwater plumes at the Facility. As discussed in Section 3.1.4.3, approximately 4 pounds of ozone are required per pound of petroleum. Ozone delivery is limited by the capacity of the ozone generators, which have a finite amount of ozone production per unit (50 pounds/day). Approximately six ozone generators would be required to treat the mass of SVOCs in the smear zone soil to attain the SL and PCUL for SVOCs in a 30-year time period, assuming ideal conditions and not accounting for system inefficiencies and losses. These generators would have to run continuously for the duration of treatment and would potentially need to be replaced prior to final cleanup.

Ozone wells for groundwater treatment alone would be installed, at a minimum, on 10-foot centers perpendicular to groundwater flow downgradient of the smear zone soil. The actual radius of influence would be determined by pilot-scale testing. One or more ozone generators would be required to treat the daily groundwater SVOC loading. These ozone generators would need to run continuously for the extent of the restoration time frame. Short-circuiting and preferential flow paths would likely reduce the efficiency of ozone treatment, and ozone may need to be supplied in excess of stochiometric requirements.

Other applications of ozone at this scale have not been identified. The ozone may cause high temperatures or explosive reactions as it contacts the FPP that is present on the surface of the groundwater and may react with non-target compounds (e.g., metals). Because of the additional performance risks associated with these potential reactions (implementability) and the very large quantity of ozone generators and injection wells that would be required (reliability), ozone oxidation is rejected as neither implementable nor reliable for the treatment of the petroleum groundwater plumes and associated smear zone soil at the Facility.

Hydrogen Peroxide/Fenton's Reagent. Hydrogen peroxide in the presence of ferrous iron (Fe2+) reacts to form hydroxyl radicals (OH•), ferric iron (Fe3+), and hydroxyl ions (OH-). Hydroxyl free radicals are able to oxidize complex organic compounds (EPA 1998). The Fenton's reaction is a complex reaction with numerous reaction intermediates, competing reactions, and a variety of factors that affect the reaction (EPA 2006b).

Hydrogen peroxide and Fenton's reagent both have very short residence times in the subsurface, from several minutes to hours, which would limit the radius of influence of the reagent once injected into the subsurface (EPA 2006b). Hydrogen peroxide is unstable and readily dissociates into water and oxygen within 4 hours (EPA 2004b). The oxygen will persist in the subsurface and can stimulate biodegradation (ITRC 2005). High concentrations of hydrogen peroxide (greater than 200 mg/L) can make the subsurface environment toxic to microbes (EPA 2004b).

The porous nature of the smear zone limits the radius of influence of the oxidant to directly around the well under unsaturated conditions. In saturated conditions, groundwater would be able to transport the oxidant from the injection well but the rapid reactions would still limit the area of influence. Thus, the injection of hydrogen peroxide is expected to require a very close injection well spacing to provide adequate contact. The actual radius of influence would be determined by pilot-scale testing. For the purposes of this evaluation, a well spacing of 15 feet was selected. This spacing would require over 3,000 wells to cover the smear zone soil AOCs.

The Fenton's reaction is a complex reaction with multiple reaction intermediates. A site-specific stochiometric demand can be determined in a laboratory (ITRC 2005). Mass ratios of hydrogen peroxide mass to mass of TPH range from 5:1 to 50:1 (US Peroxide 2010). Iron catalysts generally are added at low concentrations (20 to 100 mg/L) (EPA 2006b). Fenton’s reagent can also be added using a volumetric pore volume approach. A significant amount of Fenton's reagent would be required based on the large mass of smear zone SVOCs.

Other applications of Fenton’s reagent at this scale have not been identified. Fenton’s reagent may cause high heat or explosive reactions as it contacts the FPP that is present on the surface of the groundwater and may react with non-target compounds (metals). The heat released may damage or melt PVC wells and well screens (EPA 2006b). Another potential risk associated with supplying Fenton's reagent or other oxidants to the subsurface includes the potential for high heat or explosive reactions that may release fugitive vapor emissions. Because of the large mass of SVOCs and VOCs in smear zone soil (approximately 1.7 million pounds) a large mass of hydrogen peroxide would be required, further increasing these risks.

As a result of the additional performance risk associated with these potential reactions (implementability), the very large quantity of Fenton’s reagent that must be added, and number of injection wells that would be required (reliability), Fenton’s reagent is rejected as neither implementable nor reliable for the treatment of smear zone soil associated with the petroleum hydrocarbon groundwater plumes at the Facility.

Hydrogen peroxide injection wells for groundwater treatment alone would be installed at a minimum on 10-foot centers perpendicular to groundwater flow downgradient of the smear zone soil for each petroleum groundwater plume. The actual radius of influence would be determined by pilot-scale testing. Hydrogen peroxide would need to be added continuously for the extent of the restoration time frame. Short-circuiting and preferential flow paths would likely reduce the efficiency of the hydrogen peroxide/SVOC contact. The risks for high heat and explosive reactions, fugitive vapors, and unknown reaction byproducts discussed above are also risks for the treatment of groundwater alone.

Chemical Oxidation Feasibility

Ozone and hydrogen peroxide are judged to be more implementable and reliable than persulfate or potassium permanganate as potential oxidants to treat the petroleum hydrocarbon groundwater plumes and associated smear zone soil.

The porous nature of the smear zone soil associated with the petroleum groundwater plumes would require the installation of more than six ozone generators and more than 3,000 injection wells on a 15-foot spacing if ozone were used as an oxidant. Similarly, a significant volume of Fenton's reagent would have to be added through the more than 3,000 injection wells. Other examples at this scale of application of oxidation technology have not been identified.

The ozone and Fenton's reagent may cause high heat or explosive reactions as it contacts the FPP on the surface of the groundwater, and may react with non-target compounds (metals). Because of the additional performance risk associated with these potential reactions (implementability) and the very large quantity of ozone generators and injection wells that would be required (reliability), ozone and Fenton's reagent are rejected as neither implementable nor reliable for the treatment of smear zone soil associated with the petroleum groundwater plumes at the Facility.

As discussed above, hydrogen peroxide concentrations above 200 mg/L can be toxic to microorganisms. Limiting peroxide concentrations to this concentration for the oxidation of groundwater would reduce the effectiveness of treatment and lengthen the restoration time frame for the hydrogen peroxide oxidation alternative. The addition of hydrogen peroxide, for the purpose of oxidizing

SVOCs in groundwater, could also reduce the effectiveness of the natural attenuation processes that are already underway in the petroleum groundwater plumes at the Facility (refer to Appendix F).

Similar to other oxidants, hydrogen peroxide (added at concentrations that would be effective for oxidation) may cause high heat or explosive reactions as it contacts the FPP on the surface of the groundwater and may react with non-target compounds (metals).

Another potential risk associated with hydrogen peroxide or other oxidants includes the potential for high heat or explosive reactions that may release fugitive vapor emissions. Because of the large mass of SVOCs and VOCs in the smear zone soil (approximately 1.7 million pounds), a large mass of hydrogen peroxide would be required, further increasing these risks.

As a result of the additional performance risk associated with these potential reactions (implementability), the very large quantity of hydrogen peroxide reagent that must be added, and number of injection wells that would be required (reliability), hydrogen peroxide is rejected as neither implementable nor reliable for the treatment of the petroleum groundwater plumes at the Facility.

As a result of the cumulative impact of the technical concerns and health and safety risks, *in situ* chemical oxidation was judged not to be an implementable or reliable alternative for the treatment of smear zone soil and petroleum groundwater plume AOCs at the Facility.

4.1.3.3 Description of *In Situ* Enhanced Bioremediation

The purpose of Alternative C3 is to biologically reduce the concentrations of SVOCs in smear zone soil *in situ*. Bioremediation is a process by which microorganisms degrade contaminants through the consumption or transformation of the target substances. Enhanced bioremediation involves the addition of substrates and/or nutrients to the subsurface to increase bacterial growth and the degradation rates of SVOCs and VOCs. These compounds readily degrade under aerobic conditions, where microorganisms use oxygen as an electron acceptor. Biological reduction of SVOCs is expected to occur only in the dissolved phase. *In situ* enhanced bioremediation indirectly reduces the mass in the smear zone soil as the SVOCs leach from the smear zone soil into groundwater.

An assessment of natural attenuation in groundwater at the Facility indicates that the majority of the petroleum hydrocarbon plumes are shrinking (Appendix F). This assessment also indicates that PCBs that are comingled with SVOCs in the petroleum plumes and associated smear zone soil may also be subject to biodegradation as the PCBs are released by the SVOCs or otherwise enter the aqueous phase, where biodegradation under anaerobic or aerobic conditions can occur.

Considerable evidence is available to support the assertion that biodegradation of the heavy oil and diesel fuels present in the petroleum plumes and associated smear zone soil has occurred in the past and is expected to continue in the future (refer to Appendix F). While there is considerable indication that the degradation of PCBs that are associated with the petroleum hydrocarbons in the Oil House and Wastewater Treatment areas is likely to have occurred and continues to occur, evidence to support this assertion must still be collected and assessed.

In Situ Enhanced Bioremediation System Description

System components for the *in situ* enhanced bioremediation system include aboveground tanks for mixing and storing amendments, a series of injection wells, and the pumping equipment and piping necessary to inject amendments into the subsurface. Piping will be located underground to minimize operational disturbances at the Facility. A typical treatment design schematic for *in situ* treatment is presented on Figure 4-10. Injection wells were chosen over horizontal infiltration systems (similar to the existing system in the Wastewater Treatment area) to deliver amendments closer to the targeted location and to provide better contact and control of the injected amendments.

Injection wells will be installed perpendicular to groundwater flow direction and spaced 20 feet apart. The system design relies on an "inject and carry" mechanism, where the amendments will be injected upgradient and carried through the impacted zone by groundwater flow. For the smaller petroleum hydrocarbon groundwater plumes (e.g., Cold Mill areas), one line of injection wells will be installed at the upgradient side of the groundwater plume and smear zone soil AOC. For the larger areas (e.g., Oil House and Wastewater Treatment areas), a second line of injection wells will be installed approximately mid-plume to replenish depleted oxygen and nutrients. Wells will span the maximum width of the area where the smear zone and groundwater plume overlap. Wells will not be located within building footprints or other operating areas. The injection wells for the ORB smear zone soil AOC were placed along the edge of the AOC to minimize the distance the amendments travel before reaching the AOC. See Figure 4-11 and 4-12 for conceptual well locations.

Based on seasonal fluctuations and mixing, it is assumed that the top 20 feet of groundwater is impacted by petroleum. Injection wells will be installed to a depth of 20 feet below the groundwater table during high water conditions, or approximately 90 feet bgs in the AOCs except in the Wastewater Treatment area, where the wells will extend to approximately 75 feet bgs because of shallower groundwater. The wells will have a 20-foot screen extending from the top of the smear zone to the bottom of the boring.

Amendments will be added monthly as slug injections (discussed below). Injection wells located within the groundwater plume will operate throughout the year. Because of the porous soil at the Facility, adequate coverage of the entire smear zone soil is not expected to happen during the dry season. Injection flow rates and amendment concentrations will vary over the course of the year to provide more amendments during periods of high water. Biological treatment is expected to occur only in the dissolved phase. Amendment requirements are based on the initial predicted groundwater concentrations (Table 4-2).

Potential water sources for injections include non-impacted deep groundwater that is currently being extracted as part of the groundwater IRM, or from extraction wells that are not currently in use. It is assumed that a sufficient supply of water will be available and that additional extraction wells will not be constructed as part of this alternative.

Pilot-scale testing would be required to determine design parameters such as radius of influence per well (well spacing) and appropriate dosing of amendments, as well as the overall treatment performance of the alternative. Dosing rates would be adjusted over time based on the results of performance monitoring.

Oxygen Requirement

The theoretical amount of oxygen required to aerobically biodegrade petroleum hydrocarbons is approximately 3 pounds of oxygen for one pound of petroleum hydrocarbons (Wong et al. 1997). The saturated dissolved oxygen (DO) concentration in water is 9 mg/L at 20°C at standard pressure when it is aerated with ambient air. Water aerated with pure oxygen can have saturated DO concentrations at approximately 45 mg/L at standard pressure (Kuo 1999).

Hydrogen peroxide can also be used as an oxygen source. Two moles (6.02×10^{23} molecules/mole) of hydrogen peroxide dissociate into two moles of water and one mole of oxygen. It should be noted that hydrogen peroxide can be toxic to bacteria at high concentrations. The maximum recommended concentration of hydrogen peroxide to avoid toxicity is 200 mg/L (EPA 2004b). Hydrogen peroxide at 200 mg/L can produce DO concentrations of approximately 90 mg/L. Hydrogen peroxide provides the additional benefit of reducing SVOC concentration by direct chemical oxidation.

Hydrogen peroxide was selected as the source of oxygen for the conceptual design, because it provides a significantly higher oxygen concentration than using ambient air or pure oxygen. Hydrogen peroxide will be delivered to the Facility in bulk solution at concentrations of 50 percent by weight. The bulk solution will be diluted to 200 mg/L in a tank prior to injection.

DO concentrations in the petroleum groundwater plumes are generally elevated and only appear depleted in a few areas within the plumes (see Figure F-1). Because of the high groundwater velocity through the Facility (33 feet/day), it is likely that DO is being replenished at a greater rate than it is being depleted under current site conditions. Assuming a DO concentration of 9 mg/L in the upgradient groundwater, there is sufficient DO in the groundwater entering the petroleum groundwater plumes to degrade the SVOCs present, based on the predicted concentrations of SVOCs for each plume (Table 4-2). However, the DO concentration would decline as groundwater travels along the length of the plume, as the DO is consumed by microbiological processes. The DO concentration in the larger plumes (i.e., Oil House North and Wastewater Treatment North areas) may require replenishment of DO at their midpoints to promote biodegradation of SVOCs at the downgradient end of the plumes. The SVOC concentration in groundwater, and associated oxygen demand, would decrease over time as SVOCs are destroyed.

Dilute hydrogen peroxide would be injected once per month to maintain aerobic conditions in the North plume in the Oil House and Wastewater Treatment areas. Approximately 16,000 and 23,000 gallons per month of dilute hydrogen peroxide will be added to the Oil House and Wastewater Treatment area plumes, respectively, through wells located along the midpoint of each plume (see Figures 4-11 and 4-12). This equates to approximately 16 gallons of 50 percent (by weight) hydrogen peroxide per month.

Nutrient Requirements

Successful microbial growth and contaminant degradation requires both macro- and micronutrients. Nutrients may be present in the subsurface but concentrations may be insufficient for adequate biodegradation. The suggested ratio of carbon, nitrogen, and phosphorus (C:N:P) for bacterial growth is 100:10:1(EPA 2004b). Water amended with the appropriate mass of nutrients to meet the suggested ratio will be injected in wells located upgradient of the petroleum groundwater plumes (see Figures 4-11 and 4-12). Nutrients will also be added through the wells located at the midpoints of the North plumes in the

Oil House and Wastewater Treatment areas. Nutrients will be added to mixing tanks aboveground and thoroughly mixed prior to being injected under pressure into groundwater. Nutrients will be injected on a monthly basis for the entire year. The mass of nutrients added will be based on the expected monthly mass loading of SVOCs.

Additional Requirements

FPP removal will continue in downgradient wells as described in Section 4.1.3.4. The addition of amendments upgradient is not expected to limit the effectiveness of the FFP removal.

Bacteria can degrade contaminants in only the dissolved phase. Over time, diffusion will cause additional SVOC mass from residual light non-aqueous phase liquid (LNAPL) and sorbed phases to move into the dissolved phase. A surfactant would be needed to remove the heavy-end petroleum from the LNAPL and sorbed phase into solution to make these SVOCs more bioavailable. This alternative assumes that a surfactant will be required. A light surfactant will be added monthly for 6 months of the year during high water table conditions.

Hydraulic Containment

Capture and hydraulic containment of the petroleum hydrocarbon plumes will be implemented in this alternative, as described in Section 4.1.2. Plume capture and hydraulic containment will eliminate the risk that nutrients that are not consumed or that desorbed contaminants could reach the Spokane River.

Expected Performance of In Situ Treatment

Bioremediation has successfully been demonstrated for the treatment of SVOCs and VOCs at many sites (EPA 2006c). *In situ* enhanced bioremediation is expected to occur only in the dissolved phase. For the purposes of this FS and for evaluating restoration time frames (see Appendix I), the sole mechanism for reducing the mass of SVOCs in smear zone soil was assumed to be through leaching of SVOCs from smear zone soil into the groundwater.

An assessment of natural attenuation in groundwater at the Facility (see Appendix F) indicates that PCBs that are comingled with SVOCs in the petroleum plumes and associated smear zone soil may also be subject to biodegradation as the PCBs are released by the SVOCs or otherwise enter the aqueous phase. While there is considerable indication that the degradation of PCBs that are associated with the petroleum hydrocarbons in the Oil House and

Wastewater Treatment areas is likely to have occurred and continues to occur, evidence to support this assertion must still be collected and assessed.

Groundwater SVOC concentrations are predicted based on site-specific soil/water partitioning coefficients (Kaiser 2010b), assuming a linear equilibrium relationship between groundwater and soil concentrations.

Restoration time frames to meet the standard POC for the SVOC plumes are estimated based on reducing the existing average groundwater SVOC concentration in each AOC to the PCUL of 500 µg/L (see Appendix I). For the purposes of this FS, the primary mechanism for reducing the mass of TPH in smear zone soil is assumed to be through leaching of TPH from smear zone soils, and biodegradation of the TPH mass to a point where the resulting groundwater concentrations are less than the PCUL of 500 µg/L.

The restoration time frame calculations are based on the following assumptions:

- The SVOC concentrations in groundwater and soil reach equilibrium instantaneously;
- There is a linear equilibrium relationship (proportional to the K_d value) between the SVOC concentration in soil and SVOC concentration in groundwater;
- A K_d value of 2,250 L/kg for diesel and 1,987 L/kg for oil is representative of the K_d values associated with the distribution of SVOCs present in smear zone soil in each of the AOCs;
- The SVOC mass in soil and groundwater is destroyed through biological processes resulting in a shrinking plume;
- Groundwater is in contact with the smear zone 60 percent of the time; and
- Restoration of groundwater is considered complete once the concentration of TPH in smear zone soil declines to a concentration that would result in a groundwater concentration below the PCUL.

These assumptions may result in an estimated restoration time frame that is optimistic. Longer time frames would result if temporal changes were considered, such as the amount of time that is actually required for SVOCs in smear zone soil and groundwater to reach equilibrium. The restoration time frame would also be lengthened because the daily biological destruction of SVOCs will be less than 100 percent efficient. The estimated restoration time frame is also dependent on the quantity of COCs that are present in each AOC. If the quantity of COCs is overestimated, the predicted restoration time frame will be longer. The approach used to calculate restoration time frames is presented in more detail in Appendix I.

Additionally, as the water table fluctuates through the smear zone, the SVOCs at the top of the smear zone are in contact with groundwater for a very short time and may continue to act as an ongoing source long after the majority of the SVOC mass that is in contact with groundwater has been removed.

Assuming a groundwater PCUL of 500 μg/L for total petroleum hydrocarbons (TPH), target diesel- and oil-range hydrocarbon concentrations that are protective of groundwater in smear zone soil are 1,125 and 993 mg/kg, respectively, based on the average soil/water partitioning coefficients for diesel and heavy oil (Kaiser 2010b). Estimated restoration time frames range from approximately 4 years in the South plume in the Oil House area to approximately 30 years in the North plume in the Wastewater Treatment area (see Appendix I).

This alternative assumes an operating period of 30 years for comparison with the other alternatives in this section. Following the same assumptions as described above, an estimated 690,000 pounds of SVOCs will be destroyed in this operating period. This amounts to approximately 44 percent of the total mass of SVOCs in the smear zone soil treatment area.

Restoration time frames and removal efficiency are evaluated in Section 4.2.4.

4.1.3.4 FPP Recovery

Alternative C3a includes *in situ* bioremediation, containment, institutional controls, MNA, and monitoring with FPP recovery. Ideally, recoverable FPP would be removed from the subsurface prior to the operation of the *in situ* bioremediation system to mitigate a major source of COCs as well as to reduce the smearing or spreading of high concentrations of COCs (EPA 1992 and 2004b). However, based on the volume of FPP and the historical rate of recovery per well, recovery that would be necessary prior to *in situ* bioremediation treatment would not be practical because of the length of time to complete FPP recovery.

As described in Section 4.1.3.3, *in situ* bioremediation will be implemented by a series of injection well arrays located upgradient of the petroleum hydrocarbon groundwater plumes. Based on the location of the injection points, it is assumed that *in situ* bioremediation will not be disrupted by FPP skimming operations. It is recommended that belt skimmer operation continue if sufficient FPP is present during *in situ* bioremediation efforts.

Alternative C3b includes *in situ* chemical oxidation, containment, institutional controls, MNA, and monitoring with FPP recovery. As described in Section 4.1.3.2, *in situ* chemical oxidation is not determined to be an implementable and reliable treatment method for of smear zone soil or the petroleum groundwater plumes at the Facility. If *in situ* chemical oxidation were to be used, completion of FPP recovery would be necessary prior to the initiation of the *in situ* chemical oxidation process to reduce the chance for high temperatures or explosive reactions between the oxidant and the FPP to occur.

4.1.3.5 Monitoring Requirements for Alternative C3

Long-term performance and protection groundwater monitoring will be conducted with the same objectives and scope described above for Alternative C1 (Section 3.1.1).

Protection monitoring for Alternative C3 will include the monitoring elements prescribed in the HASP, and includes dust monitoring during well installation.

Additional performance monitoring required as part of Alternative C3 includes semiannual groundwater monitoring within the petroleum groundwater plume for nutrient and oxygen concentrations. Monthly monitoring will also include system parameter checks of injection flow rates and pressures and amendment quantities. Monitoring requirements will be detailed in the O&M Plan.

Hydrogen peroxide may react with metals in the subsurface and oxidize them to their highest oxidative state. This may increase the toxicity and mobility of arsenic, iron, and manganese. Annual groundwater sampling and performance soil sampling will include metals analysis to monitor for changes in oxidative states. See Table 4-8 for a summary of monitoring requirements unique to Alternative C3.

4.1.3.6 Alternative C3 Estimated Costs

The NPV of implementing Alternatives C3 over a 30-year time period is estimated to be $28.1 million (-35 to +50 percent). The incremental cost of the *in situ* enhance bioremediation elements for Alternative C3 over Alternative C2 is estimated to total approximately $5.2 million.

A summary of the cost estimate is presented in Appendix C, Table C-6. Backup to this summary table are presented in other Appendix C tables as noted in Table C-14.

4.1.4 Alternative C4: Alternative C2 Plus Groundwater Extraction with Ex Situ Treatment

Alternative C4, which includes the elements of Alternative C2, employs groundwater extraction and *ex situ* treatment for remediation of the petroleum hydrocarbon groundwater plumes at the Facility. This section presents details of the groundwater extraction system proposed to remove contaminated groundwater from the petroleum groundwater plumes, the screening steps taken to select the unit operations of the *ex situ* system to treat this water, and the monitoring requirements and estimated costs associated with the groundwater extraction and *ex situ* treatment system.

4.1.4.1 Description of the Groundwater Extraction System

Alternative C4 involves the extraction of contaminated groundwater from the existing petroleum hydrocarbon groundwater plumes with subsequent aboveground treatment. A description of the petroleum plumes and the proposed groundwater extraction system is described below.

Petroleum Hydrocarbon Groundwater Plumes

As shown on Figures 4-1 through 4-3, six petroleum groundwater plumes are present at the Facility, which are located in the Cold Mill, Oil House, ORB, and Wastewater Treatment areas. The footprint and average SVOC concentrations associated with these plumes are discussed in Section 4.1.1.1. FPP and comingled PCB locations are shown relative to the petroleum hydrocarbon plumes on Figures 4-1 through 4-3. Comingled PCB locations are shown separately on Figures 4-4 and 4-5.

Extracted Groundwater Conditions

As described in Section 4.1.3.1, dissolved SVOC concentrations for each petroleum groundwater plume were calculated using site-specific soil/water partitioning coefficients. These coefficients were developed to assess the mobility of hydrocarbons in the subsurface of the Facility (Kaiser 2010b). The concentration of SVOCs in smear zone soil is used as the source for the soil/water partitioning calculations.

Contaminant leaching from smear zone soil into groundwater is expected to occur only within the 10-foot-thick smear zone in most AOCs. (Note that in the FSTM, thicknesses of 10 and 12 feet were used but to obtain conservative mass values, a thickness of 10 feet is used in the FS.) Leached COCs in addition to SVOCs may include comingled PCBs and potentially metals.

The mass available for treatment is based on the groundwater flux into the smear zone AOCs. The groundwater flow rate through the petroleum groundwater plumes was calculated by multiplying the groundwater flux (gpd/square feet) (refer to Appendix E) by the widest portion of the plume (perpendicular to groundwater flow) and by the thickness of the contaminated groundwater zone (20 feet). An estimated maximum of approximately 2.6 MGD of groundwater passes through the top 20 feet of the petroleum groundwater plumes each day. This groundwater initially contains an estimated weighted average concentration of approximately 1.2 mg/L (see Table 4-9). As described in Section 4.1.3.1, the SVOC concentration in groundwater is expected to decrease over time as the SVOC mass is extracted by the groundwater flowing through the area. The mass removal rate was estimated based on the assumption that the equilibrium relationship between SVOCs in the smear zone soil and groundwater is linear. The design of the *ex situ* system is based on the initial, or maximum, SVOC concentration. Plume-specific flow rates and initial concentrations in the petroleum groundwater plumes are summarized in Table 4-9.

Details of the groundwater extraction wells and the *ex situ* treatment system are presented below.

Groundwater Extraction System

As mentioned above, one groundwater extraction well will be located within each petroleum groundwater plume. This interior placement serves to minimize the proportion of non-impacted groundwater extracted with the impacted groundwater and thus increases extraction efficiency. The exception to this placement methodology is extraction well ORB-FEW-1, which will be located at the downgradient edge of the ORB petroleum groundwater plume, since this well will also provide containment of the ORB plume. Extraction well locations are shown on Figures 4-13 and 4-14.

Modeled extraction flow rates for each new extraction well are presented in Table E-3 of Appendix E. The modeling resulted in a combined total extraction flow rate of approximately 4.1 MGD. The modeled flow rate is based on extracting groundwater from the top 30 feet of the saturated zone, whereas the flow rate used for Alternative C4 assumed that nearly all COC mass and groundwater flux would be limited to the top 20 feet of the saturated zone (as was assumed for Alternative C3). The total extraction rate for Alternative C4 was based on reducing the modeled flow rate by 33 percent to 2.6 MGD to account for the reduction in the thickness of the saturated zone.

Each well will be 12 inches in diameter and screened at the highest elevation of the water table (55 feet in Wastewater Treatment area and 68 feet in other parts of the Facility) to 20 feet below this point.

The extracted groundwater, containing SVOCs and potentially other COCs such as comingled PCBs and metals, will be conveyed to an aboveground system for *ex situ* treatment as described below.

4.1.4.2 Description of *Ex Situ* Treatment Options

Section 5 of the FSTM introduced various *ex situ* treatment options for contaminated groundwater extracted from the petroleum hydrocarbon groundwater plumes. These treatment options are summarized below and presented in more detail in Tables 4-10 through 4-31. The technologies presented in the FSTM are evaluated further in this section of the FS and in Tables 4-10 through 4-31. This evaluation follows the same methodology that was employed in the FSTM (refer to FSTM Section 2.4).

Some of the technologies presented in this section are presumptive remedies for *ex situ* treatment of SVOCs in groundwater. They include the use of aerobic biological reactors, chemical/UV oxidation, and granular activated carbon (EPA 1996c). This section also discusses solids separation technologies that will be necessary in pre- and/or post-treatment of SVOC-impacted groundwater.

Aerobic Biological Reactors

Biological reactors (bioreactors) use microorganisms to degrade organic contaminants in groundwater using *ex situ* treatment processes. There are two basic types of *ex situ* biological treatment processes: aerobic and anaerobic. Anaerobic treatment processes are not widely used for groundwater treatment. Aerobic process reactors are a presumptive technology for *ex situ* treatment of dissolved contaminants in extracted groundwater (EPA 1996c). There are two general design types for aerobic biological reactors: suspended growth and attached growth.

In suspended growth reactors, microbes are kept suspended in water using mechanical aerators or diffused air systems. These aeration systems also keep the solution well mixed, improving contact between microbes and dissolved contaminants and supplying oxygen to the system. Suspended growth reactors considered for the FS include aeration basins, aerated ponds or lagoons, stabilization ponds (using both algae and bacteria), constructed wetlands, and sequencing batch reactors (SBRs).

In attached growth reactors, biomass is attached to a solid substrate, such as sand, rock, plastic, activated carbon, or resin. Reactor design is dependent on the surface area of the substrate media available for biomass growth. Design types considered for the FS include trickling filter, rotating biological contactor, fluidized bed, fixed bed, and roughing filter.

Chemical/UV Oxidation

Chemical oxidation is applicable to both VOCs and SVOCs. Chemical/UV oxidation is a presumptive technology for the *ex situ* treatment of SVOCs dissolved in contaminated groundwater (EPA 1996c). Chemical oxidation is potentially applicable to PCBs, dioxins/furans, and metals (oxidation can be used to precipitate metals under certain conditions). Ultraviolet (UV) light can enhance the oxidation of compounds such as PCBs that can be resistant to chemical oxidation alone.

Ozone and hydrogen peroxide are generally preferred for removing organics. UV light is often used in conjunction with ozone and/or hydrogen peroxide to promote faster and more complete destruction of organic compounds (reaction rates may be increased by factors of 100 to 1,000). Oxidants are generally added to contaminated groundwater in a mixing tank prior to introduction into the reaction vessel (reactor). There is a variety of chemical oxidation reactor configurations available for *ex situ* treatment from different manufacturers (e.g., Cavox®, Ultrox™, perox-pure™). The perox-pure™ technology is available as a preassembled, turnkey, skid-mounted unit (EPA 1996c, EPA 1993a, GWTRAC 1996).

Complete oxidation decomposes hydrocarbons into carbon dioxide and water, although chlorinated organic compounds also yield chloride ions. If oxidation is incomplete, toxic constituents may remain, or intermediate degradation products can be formed that may be toxic. These toxic substances may be removed using granular activated carbon (GAC) as a secondary or polishing treatment step.

Granular Activated Carbon

Activated carbon removes contaminants from groundwater by adsorption. The principal form of activated carbon used for groundwater treatment is granular activated carbon (GAC). GAC is an excellent sorbent because of its large surface area, which generally ranges from 500 to 2,000 m^2/g. GAC is applicable to a wide variety of contaminants that are soluble in groundwater including halogenated volatile and semivolatile organics, non-halogenated volatile and semivolatile organics, PCBs, pesticides, dioxins/furans, most organic corrosives, metals, radioactive materials, inorganic cyanides, and certain oxidizers. Activated carbon is a well-developed, widely used technology, with many successful groundwater treatment applications, especially for secondary polishing of effluents from other treatment technologies.

In a GAC treatment system, contaminated groundwater is contacted with a fixed GAC bed in a vessel. Flow direction is generally vertically downward, although an upward flow configuration is also possible. GAC adsorption is a presumptive technology for the *ex situ* treatment of dissolved SVOCs in groundwater (EPA 1996c).

Suspended Solids Removal

Solids removal technologies are used to remove solids from groundwater after extraction. Sedimentation, precipitation, and filtration are processes that can be used to remove solids from water.

Sedimentation is used to separate suspended solids from water by the gravitational settling of particles that are denser than water. A sedimentation tank can be used to remove particles that settle as a result of gravity. Flocculants and precipitants are chemicals that can be added to hasten the settling rate. They alter the physical or chemical state of dissolved and suspended solids and facilitate their removal by sedimentation (Metcalf & Eddy 2003).

Filters physically separate suspended solid materials from groundwater. Filter types applicable to this alternative fall under two general categories: depth filters and surface filters. The difference between depth filters and surface filters lies in where the solids removal occurs relative to the filter. A depth filter removes suspended solids from water as the water travels through the interior of the filter medium, whereas a surface filter removes suspended solids as the water enters the filter.

Depth filters typically consist of a bed of granular material, which can be composed of one or more material layers such as sand and anthracite. Typical mechanisms that facilitate removal of suspended particulates within a depth filter include straining, sedimentation or inertial impaction, interception, adhesion, or flocculation. Depth filters typically are used to remove particles approximately 1 µm in diameter or greater. Depth filters can be regenerated as they near their solids removal capacity and reused (Metcalf & Eddy 2003).

Surface filters use a sieving mechanism for solid-liquid separation and typically remove particulate matter greater than approximately 10 to 30 µm in diameter. These filters come in different forms such as bags, cartridges, and disks; can be made of various materials such as metal, cloth, or synthetics; and are replaced once they are exhausted (Metcalf & Eddy 2003).

4.1.4.3 Technology Screening for Remediation of Groundwater Containing SVOCs

Technologies and their associated process options for remediating groundwater containing SVOCs are evaluated based on physical and chemical criteria in Table 4-10. Technologies retained through this assessment are then evaluated based on implementability in Tables 4-11 through 4-21. The technologies and associated process options judged to be potentially implementable are evaluated for reliability in Tables 4-22 through 4-31.

Each table provides information to justify why each process option should be accepted or rejected for the Facility. These tables indicate that the following process options for remediating groundwater containing SVOCs are judged potentially implementable at the Kaiser Facility.

***Ex Situ* Treatment Technologies**	**Process Options Accepted**
Suspended Growth Reactor	Sequencing Batch Reactor (SBR)
Attached Growth Reactor	Rotating Bed Contactor (RBC), Trickling Filter, Fixed Bed, Fluidized Bed
Chemical Oxidation	UV with Hydrogen Peroxide or Ozone
Suspended Solids Removal	Sedimentation Tank, Depth Filter, Surface Filter
Adsorption	Granular Activated Carbon (GAC)

The potentially implementable technologies and associated process options that are judged to be reliable and were retained for this alternative include the following:

- Oil/water separation using an API oil/water separator (see Appendix H);
- Depth filtration;

- Surface filtration; and

- Carbon adsorption using GAC.

Biological treatment technologies (suspended and attached growth) that were retained after implementability screening were rejected based on reliability (refer to Tables 4-22 through 4-26). These technologies were rejected generally because available design data indicate that the estimated influent SVOC concentrations (1.2 mg/L) in the extracted groundwater would not be sufficient to sustain biomass growth during the course of treatment.

Chemical oxidation was rejected based on reliability based on the complexity of the system as compared to GAC adsorption (refer to Table 4-27) and the potential for oxidation to create reaction products that might require further treatment. Both technologies are expected to be able to effectively treat SVOCs to the required PCULs, but chemical oxidation requires additional O&M because of hydrogen peroxide addition and the additional system components of the perox-pure™ system. Chemical oxidation may also form toxic compounds that will require a GAC polishing step for removal (GWTRAC 1996).

Sedimentation tanks were also rejected based on reliability (refer to Table 4-29). To effectively implement GAC adsorption as the treatment technology for SVOCs (and comingled PCBs) in extracted groundwater, suspended solids would need to be removed upstream of the GAC adsorption process step. Sedimentation tanks were rejected for reliability based on the relatively low total suspended solids (TSS) concentrations in groundwater at the Facility. (Average TSS values were less than 100 mg/L based on TSS values from spring and fall 2009 groundwater sampling events at the Facility.) Depth and surface filters were judged to be implementable and reliable for use in the *ex situ* treatment process.

4.1.4.4 *Ex Situ* Treatment System Description

Description of the Treatment Process

Extracted groundwater will be conveyed to an *ex situ* treatment system. A process flow diagram (PFD) of the treatment system is presented on Figure 4-15. Extracted groundwater first will be treated in an API oil/water separator where FPP extracted with the groundwater will be recovered. Alternative C4 includes belt skimmer operation since the alternative includes Alternative C1 and C2; however, it is assumed some FPP will be extracted with groundwater. From there, the extracted groundwater will flow through the depth filtration process step (e.g., sand/anthracite gravity filter), followed by surface filtration (e.g., pressure filter) to remove suspended solids. Depth filtration is expected to remove a significant portion of suspended solids, and surface filtration is expected to remove smaller residual particulates. Removal of suspended solids prevents fouling of the GAC beds and extends the life of the carbon.

To remove SVOCs and comingled PCBs, adsorption using GAC will be employed as the final step in the treatment process. The GAC adsorption units will be installed in series of two to prevent potential discharge of contaminants in the effluent once the upstream adsorption unit has reached its adsorption capacity. From the second GAC bed, effluent water will be used as plant process water, or for some other permitted use.

Treatment System Equipment and Location

Based on the estimated extraction flow rate (approximately 2.6 MGD), the influent SVOC concentration (approximately 1.2 mg/L), and design criteria (Metcalf & Eddy 2003), the *ex situ* treatment system consists of the following capital equipment items (presented in the order shown in the PFD (Figure 4-15):

- One 100,000-gallon API oil/water separator. This vessel will provide enough hydraulic retention time to allow the separation of product from water where FPP can be separated, accumulated, and removed from the API unit. Collected FPP will be disposed of appropriately.

- Five 500,000-gallon depth filtration units in parallel. Shallow vessels filled with sand and anthracite with a rotating groundwater distribution arm at the top of each vessel.

- Eight 1,000-gallon surface filtration units. A metal vessel that holds surface filter elements. It is assumed that Discfilter® elements will be used.

- Six 10,000-gallon GAC adsorption units. Metal vessels that hold GAC. Based on design flow rate, three units in parallel will be placed in series with a second set of three parallel units.

A summary of design criteria for the unit processes is presented in Table 4-33.

The system equipment will be connected by large-diameter piping to convey extracted groundwater to the treatment system. It is assumed the treatment system will be located in the West Landfill area of the Kaiser Facility (see Figure 4-13). It is assumed that most of the piping between wells and the treatment system will be underground to prevent interference with Facility operations.

Within the treatment system there will be piping and pumps to convey water from the oil/water separator through the filtration and GAC adsorption units.

Treatment System Operation and Maintenance

It is assumed that the *ex situ* treatment system will run continuously. Monitoring requirements will include daily monitoring of pressures and flow rates. Equipment and infrastructure will be inspected on a regular basis and maintained, repaired, or replaced as required. Minor maintenance items will include regularly removing (skimming) recovered product from the oil/water separator, backflushing the depth filters and GAC vessels to remove accumulated solids, and changing surface filter elements when differential pressures indicate excessive solids accumulation (Metcalf & Eddy 2003). Based on the size of the treatment system, it is assumed that two full-time employees will monitor system operation and perform system maintenance.

Treatment Time Frame and Effectiveness

In the *ex situ* treatment system, the majority of SVOCs and comingled PCBs will be treated by GAC adsorption. GAC adsorbers have demonstrated high removal efficiencies, for SVOCs (and for PCBs that are co-mingled with SVOCs), and it is assumed that *ex situ* treatment will result in effluent concentrations below SLs.

As discussed in Section 4.1.3.1, for the FS it is assumed that the mass of SVOCs in smear zone soil is reduced through leaching of SVOCs from smear zone soil into groundwater. Using site-specific soil/water partitioning coefficients and assuming a groundwater PCUL of 500 µg/L for TPH, target diesel- and oil-range hydrocarbon concentrations that are protective of groundwater in smear zone soil are expected to total approximately 1,125 and 993 mg/kg, respectively (Kaiser 2010b). Estimated restoration time frames range from approximately 3 years in the South plume in the Oil House area to approximately 24 years in the North plume of the Wastewater Treatment area (see Appendix I).

This alternative assumes an operating period of 30 years for comparison with the other alternatives in this section. Following the same assumptions as described above, an estimated 690,000 pounds of SVOCs will be extracted and are expected to be destroyed by *ex situ* treatment in this operating period. This amounts to approximately 44 percent of the total mass of SVOCs in the smear zone treatment area.

4.1.4.5 FPP Recovery

Alternative C4 includes *ex situ* groundwater treatment, containment, institutional controls, MNA, and monitoring. In this alternative, the FPP will be recovered by belt skimmers (part of Alternative C2) and through extraction of contaminated groundwater, followed by treatment in an aboveground system. The purpose of this system is to recover FPP from the extracted groundwater and to treat dissolved COCs. As discussed previously in this section, the API oil/water separator will be used upstream of the unit operations used to treat dissolved contaminants. Details of the treatment system are presented in Section 4.1.4.4.

4.1.4.6 Monitoring Requirements for Alternative C4

In addition to the treatment system monitoring requirements described above, sampling and chemical analysis of the treatment system effluent will be required to assess whether discharge requirements are met. To monitor system performance, sampling between treatment units (e.g., between carbon beds) and at extraction wells will take place. Alternative C4 also includes the monitoring elements associated with Alternative C2. Monitoring elements unique to the groundwater extraction and *ex situ* treatment system are summarized in Table 4-34.

4.1.4.7 Alternative C4 Estimated Costs

Capital costs will include installation of extraction wells, piping, and construction of the *ex situ* treatment system. Annual costs associated with Alternative C4 include electricity costs for running extraction and treatment system pumps, carbon and surface filter changeouts, and labor costs related to system operation, maintenance, and monitoring.

The estimated periodic costs for Alternative C4 assume that every 10 years significant system modifications would be completed. It is assumed that these modifications will cost approximately 10 percent of the capital cost of Alternative C4. These periodic costs include items such as changeout of the media in the depth filters, repairing or replacing equipment items (such as pumps), and professional services (such as completing Ecology five-year reviews and reporting).

The NPV of implementing Alternative C4 over a 30-year time period is estimated to total approximately $41.0 million (-35 to +50 percent). The portion of this cost that is directly applicable to the operation of the groundwater extraction wells and the *ex situ* treatment system is estimated to total approximately $18.1 million (refer to Table C-7).

4.2 EVALUATION OF REMEDIAL ALTERNATIVES FOR PETROLEUM HYDROCARBON GROUNDWATER PLUMES AND ASSOCIATED SMEAR ZONE SOIL

Ecology has identified criteria that are used to evaluate remedial technologies and remedial alternatives (WAC 173-340-360). These evaluation criteria are described in Section 2.2.1. Remedial action objectives (RAOs) for the petroleum hydrocarbon groundwater plumes and associated smear zone soil are defined in Section 4.2.1. The criteria are applied to Alternatives C1 through C4 in Sections 4.2.2 through 4.2.5, respectively. A comparative analysis of alternatives is conducted in Section 4.3 to identify the most appropriate remedial alternative for each COC group (i.e., SVOCs, PCBs that are comingled with SVOCs, and metals). The comparative analysis assesses the relative capability of each alternative to meet threshold requirements, to use permanent solutions to the maximum extent practicable, and to achieve a reasonable restoration time frame.

4.2.1 Remedial Action Objectives for Smear Zone Soil and Petroleum Hydrocarbon Groundwater Plumes

Remedial action objectives (RAOs) are broad, administrative goals for a cleanup action that address the overall MTCA cleanup process, as summarized in Section 2.2.2. The RAOs for smear zone soil and petroleum hydrocarbon groundwater plumes at the Facility must address the identified COCs for these areas, and the pathways by which these COCs can reach receptors on and off the Facility. The following COCs were identified for smear zone soil in the FSTM:

- Free phase product (FPP);
- SVOCs (diesel, heavy oil, Kensol, and carcinogenic polycyclic aromatic hydrocarbons [cPAHs]);
- PCBs (total); and
- Metals (arsenic, iron, and manganese) causing potential human (e.g., drinking water) or ecological health risk to the Spokane River.

VOCs are not included as COCs for smear zone soil and the petroleum hydrocarbon groundwater plumes, as discussed in the introduction to Section 4. The following COCs were identified for the petroleum groundwater plumes:

- FPP;
- SVOCs (diesel, heavy oil, and cPAHs);
- PCBs (total); and
- Metals (arsenic, iron, and manganese) causing potential human (e.g., drinking water) or ecological health risk to the river.

For the purposes of this section, only PCBs that are comingled with SVOCs in smear zone soil or in the petroleum hydrocarbon groundwater plumes are addressed. PCBs that occur alone in smear zone soil or alone in groundwater are addressed in Section 5.

The pathways by which COCs in smear zone soil and the petroleum hydrocarbon groundwater plumes can potentially reach receptors are, respectively, the soil to groundwater and the groundwater to surface water pathways. The soil to groundwater pathway assumes that COCs in smear zone soil could be mobilized into groundwater at concentrations that cause an exceedance of groundwater SLs. Smear zone SLs for this pathway for saturated soil were derived using the Fixed Parameter 3-Phase Partitioning Model (WAC 173-340-747[4] and MTCA Method B CULs, or MCLs established by the CWA or the SDWA, whichever is lower for groundwater). This pathway was determined to have the most impact on the SLs established for soil at the Kaiser Facility.

The RAOs for smear zone soil and petroleum hydrocarbon plume AOCs at the Facility are guided by specific MTCA requirements defined in WAC 173-340-720 and WAC 173-340-740. Specifically, soil and groundwater that are contained as a part of the remedy will be deemed to meet CULs if certain requirements set out in WAC 173-340-740(6)(f) (for soil) and WAC 173-340-720(9)(c)(vi) (for groundwater) are met, which are defined in Section 2.2.2.

The following RAOs are judged to apply to smear zone soil and petroleum hydrocarbon plume AOCs at the Facility:

- Meet the overall MTCA threshold requirements under WAC 173-340-360(2)(a);

- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent practicable (WAC 173-340-360[3]);

- Provide for a reasonable restoration time frame (WAC 173-340-360[2][b][ii]);

- Consider public concerns (WAC 173-340-360[2][b][iii]); and

- Meet threshold requirements for groundwater cleanup actions (WAC 173-340-360[2][c]).

The ways in which each remedial alternative will meet these RAOs for smear zone soil and the petroleum hydrocarbon groundwater plumes are discussed in Sections 4.2.2 through 4.2.5.

4.2.2 Evaluation of Remedial Alternative C1: Institutional Controls, Monitoring, MNA, and Groundwater IRM System Operation

Alternative C1 applies the institutional control, monitoring, MNA, and groundwater IRM actions described in Section 4.1.1. The institutional controls include physical measures (e.g., fences and controlled access to the Facility), best management practices (BMPs) (e.g., operating practices designed to prevent spills and leaks of chemicals and lubricants and SPCC Plans), and administrative measures (e.g., a restrictive covenant). An extensive groundwater monitoring program at the Facility has been in place for many years. This program contains a wide range of protection and performance monitoring for groundwater at the Facility, and is included as an element of Alternatives C2 through C4 to allow for evaluation of whether soil and groundwater concentrations are protective of the soil to groundwater and groundwater to surface water pathways.

Alternative C1 employs the operation of the existing groundwater Interim Remedial Measure (IRM) system, which hydraulically contains the groundwater plumes at the Facility, recovers FPP from the surface of the water table, and promotes biodegradation of petroleum hydrocarbon COCs in localized areas of the shallow depths of the aquifer by introducing oxygenated groundwater from the deep depths of the aquifer. An assessment of natural attenuation in groundwater at the Facility indicates that the majority of the petroleum hydrocarbon plumes are shrinking (Appendix F). This assessment also indicates that PCBs that are comingled with SVOCs in the petroleum plumes and associated smear zone soil may also be subject to biodegradation as the PCBs are released by the SVOCs or otherwise enter the aqueous phase, where biodegradation under anaerobic or aerobic conditions can occur.

The capability of Alternative C1 to meet the cleanup requirements established by MTCA is summarized below.

4.2.2.1 Threshold Requirements

Protect Human Health and the Environment

The smear zone soil and petroleum hydrocarbon groundwater plume AOCs are located at depths that prevent Facility workers and visitors from direct contact with COCs in these areas. Institutional controls in place at the Facility include physical and administrative controls and BMPs that are currently being used to reduce the potential for worker exposure to COCs. Institutional controls also include measures to prevent the potential release of COCs to the environment during industrial activities at the Facility.

Smear zone soil and pools of FPP are in contact with groundwater, which allows for the transport of COCs from soil and FPP in these AOCs into groundwater, which can potentially migrate to the Spokane River. Current operation of the groundwater IRM system provides hydraulic containment of the Wastewater Treatment area groundwater plumes and capture of the Oil House and Cold Mill area plumes. The IRM system also provides for recovery of FPP from the surface of the water table. The petroleum hydrocarbon plume in the ORB area is beyond the northern boundary of the capture zone produced by the current IRM system, which indicates that groundwater COCs in this area of the Facility may not be completely contained.

However, an assessment of natural attenuation processes in groundwater at the Facility (Appendix F) indicates that the plume in the ORB area is likely shrinking. Thus, the probability is low that petroleum hydrocarbon COCs above SLs from this plume are reaching the Spokane River. Ecology has agreed with this assessment and concluded that expanded hydraulic containment to capture this plume is not necessary (Ecology 2011). This assessment is supported by ongoing groundwater monitoring that documents that petroleum constituents are not migrating beyond the downgradient Kaiser Facility line (Hart Crowser 2012a). The need for additional containment of the ORB petroleum hydrocarbon plume is discussed further in Section 6.

Biodegradation of petroleum hydrocarbon COCs in groundwater in the Wastewater Treatment area is being promoted by introducing oxygenated groundwater at the downgradient edge of the plume. The PCBs that are comingled with SVOCs can be biodegraded by anaerobic and aerobic microbes once the PCBs partition from the SVOCs and enter the aqueous phase (refer to Appendix F). Anaerobic conditions are generally present in areas where FPP is present (refer to Figure F-2), with aerobic conditions present in other areas where petroleum plumes are present. Groundwater monitoring indicates that the COCs associated with the plume in the Wastewater Treatment area are not traveling beyond the groundwater infiltration zone of the IRM system.

COC source control under Alternative C1 relies on physical measures (existing floor slabs and paved surfaces) for smear zone soil, and on natural attenuation processes and FPP removal through skimming wells, for both smear zone soil and the petroleum groundwater plumes.

Source reduction measures will be implemented at the Facility (refer to Section 4.1.1.2). The source areas in the near-surface, vadose zone, and smear zone soil are likely to be present for some time. The transfer of COCs from the smear zone and FPP into groundwater will be ongoing as groundwater flows through these impacted areas. The concentrations of these COCs in groundwater are expected to reach the SLs and PCULs listed in Table 4-1 in approximately 4 years (South plume in the Oil House area) to 34 years (North plume in the Wastewater Treatment area) (refer to Appendix I).

The physical measures associated with existing floor slabs and paved surfaces do not cover the entire smear zone AOCs (refer to Figure 4-12 of the FSTM). Thus, the potential currently exists for rainwater to mobilize COCs from smear zone soil (and from near-surface and vadose zone soil to smear zone soil) to the petroleum groundwater plumes.

If contaminated near-surface and vadose zone soil were contained (as indicated in Sections 2 and 3), the rainwater to soil to groundwater pathway for smear zone soil would be active only in those areas where surface containment was not in place above a smear zone soil AOC. Rainfall reaching the smear zone, in this case, could potentially carry COCs in the smear zone to groundwater during periods when groundwater is at a low elevation. Thus, Alternative C1 does not directly cut the rainfall to soil to groundwater pathway.

However, COCs present in the smear zone would potentially reach the groundwater in any case, as the level of groundwater fluctuates approximately 10 to 12 feet per year (Hart Crowser 2012a, Section 4.2). This groundwater fluctuation redistributes COCs throughout the smear zone, creating a secondary source area of COCs that can mobilize into groundwater. Thus, the rainfall to soil to groundwater pathway is not considered to be a significant potential pathway for smear zone soil, since the COCs mobilized by this pathway will be mobilized to a much greater extent by groundwater than by infiltrating rainwater, as the groundwater rises and falls throughout smear zone soil during the year.

Alternative C1 does not provide additional actions beyond operation of the current IRM and ongoing natural attenuation to reduce the concentration of COCs in smear zone soil or the amount of petroleum in the groundwater plumes. COC concentrations are likely to exceed SLs and PCULs from about 4 years for the South plume in the Oil House area to 34 years for the North plume in the Wastewater Treatment area (refer to Appendix I). Potential risks to the environment remain at the Facility, in that the soil to groundwater exposure pathway persists in the smear zone soil AOCs. The risk to receptors in the Spokane River is controlled under Alternative C1 through the plume capture and hydraulic containment of groundwater COCs provided by the IRM system, and through natural attenuation processes causing the petroleum hydrocarbon plumes to shrink.

The risk to humans who may extract and drink petroleum-contaminated groundwater is controlled by the current on-site practice that prohibits this activity, and by a restrictive covenant that will prohibit this activity in the future. The human direct contact or ingestion pathway to Facility workers and visitors is mitigated because of the depth (greater than 20 feet) of the smear zone soil and groundwater plume AOCs, through implementation of institutional controls, and because the groundwater plumes do not appear to be reaching surface water, based on analytical results from the ongoing groundwater monitoring network. The soil to groundwater exposure pathway remains between smear zone soil and groundwater, but this impact to groundwater is controlled through the plume capture and hydraulic containment provided through operation of the IRM system, and through the natural attenuation processes occurring in groundwater at the Facility.

Implementation of institutional controls protects Facility workers and visitors from exposure to COCs, and prevents release of COCs to the environment, where Facility workers and visitors could subsequently contact media containing released COCs. Because the groundwater plumes do not appear to be reaching surface water, exposure to COCs contained in the petroleum hydrocarbon groundwater plume and associated smear zone soil through contact with water in the Spokane River does not appear to pose a risk to human health or the environment.

Comply with MTCA Cleanup Standard

The implementation of Alternative C1 may result in compliance with MTCA cleanup requirements if the point of compliance is established throughout Facility soil and groundwater. The SLs developed for the Kaiser Facility were based on the requirements of MTCA plus state and federal contaminant-specific ARARs. These SLs are currently exceeded in the smear zone soil and petroleum groundwater plume AOCs identified on Figures 4-1 through 4-3. The SLs for groundwater established in the FSTM and the PCULs established for groundwater by Ecology (Ecology 2010a and 2010b) for a standard POC and for a conditional POC are summarized in Table 4-1. The SL and PCUL established for diesel and heavy oil are both 500 μg/L. The PCUL for total petroleum hydrocarbons for a conditional POC is also 500 μg/L. Alternative C1 is expected to reduce petroleum hydrocarbon concentrations to below 500 μg/L within approximately 4 to 34 years (refer to Appendix I). Thus, Alternative C1 is expected to meet MTCA standards for petroleum hydrocarbons regardless of whether or not a conditional POC is established by Ecology for the petroleum plumes. The concentration of PCBs in the petroleum plume FPP areas may exceed the PCUL for a standard point of compliance until the FPP is no longer present. A more thorough discussion of the anticipated restoration time frame for PCBs that are comingled with SVOCs is provided in Appendix I.

Compliance with SLs and the PCULs established by Ecology will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of cleanup actions that are implemented. Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternative C1, compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in Alternative C1 (WAC 173-340-720[9][c][vi]).

MTCA provides additional requirements for permanent groundwater cleanup actions (WAC 173-340-360[2][c]):

(i) Permanent groundwater cleanup actions are:

> *"A permanent groundwater cleanup action shall be used to achieve the CULs for ground water in WAC 173-340-720 at the standard point(s) of compliance (see WAC 173-340-720[8])..."*

Alternative C1 is expected to meet PCULs for SVOCs, PCBs, and metals at the standard POC (refer to Tables 2-1 and 4-1) in a time frame ranging from approximately 4 years for the South plume in the Oil House area to approximately 34 years for the North plume in the Wastewater Treatment area (refer to Appendix I). If a conditional POC is established by Ecology for the petroleum groundwater plumes, the time required for the concentration of PCBs and PAHs in groundwater and associated smear zone soil in the operating areas of the Facility to reach the PCULs associated with this conditional POC will be shorter than the time frames needed to meet the PCULs established by Ecology for a standard POC (refer to Table 4-1). Ecology has determined that the PCULs for COCs in smear zone soil will be met when the concentration of the COC in groundwater has achieved its PCUL (Ecology 2010a and 2010b). The cleanup of groundwater at the Kaiser Facility is judged to be a permanent groundwater cleanup action.

(ii) Nonpermanent groundwater cleanups require:

(A) Treatment or removal of the source of release shall be conducted for liquid wastes, areas contaminated with high concentrations of hazardous substances, highly mobile hazardous substances, or hazardous substances that cannot be reliably contained. This includes removal [of] free product consisting of petroleum and other light nonaqueous phase

liquid (LNAPL) from the ground water using normally accepted engineering practices.

Alternative C1 does not consider the active treatment of smear zone soil but does allow for the continued natural attenuation of the SVOCs that are present in groundwater and of the PCBs that partition from the SVOCs and enter the aqueous phase in smear zone soil and groundwater. Alternative C1 also includes the continued removal of FPP from wells that are currently operating. Thus, Alternative C1 does prevent COCs in smear zone soil from reaching human or ecological receptors. There are areas of the Facility where LNAPL currently collects and where existing FPP recovery systems are not operating.

(B) Ground water containment, including barriers or hydraulic control through ground water pumping, or both, shall be implemented to the maximum extent practicable...

Alternative C1 implements a hydraulic containment system that, together with the ongoing natural attenuation at the Facility, is judged to be an effective containment system for the COCs present in the petroleum groundwater plumes and the smear zone soil associated with them.

MTCA identifies several expectations for cleanup action alternatives (WAC 173-340-370). These expectations represent the types of cleanup actions Ecology considers likely results of the remedy selection process described in WAC 173-340-350 through WAC 173-340-360; however, Ecology recognizes that there may be some sites where cleanup actions conforming to these expectations are not appropriate. Per WAC 173-340-370(7), Ecology expects that natural attenuation of hazardous substances may be appropriate at sites where:

(a) Source control has been conducted to the maximum extent practicable;

As discussed in Section 4.1.1, source control is an important component of Alternative C1. However, Alternative C1 does not recover FPP to the maximum practicable extent.

(b) Leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health and the environment;

As discussed above, Alternative C1 is judged to be protective of human health and the environment.

(c) There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and

Considerable evidence is available to support the assertion that biodegradation of the heavy oil and diesel fuels present in the petroleum plumes and associated smear zone soil has occurred in the past and is expected to continue in the future (refer to Appendix F). While there is considerable indication that the degradation of PCBs associated with the petroleum hydrocarbons in the Oil House and Wastewater Treatment areas is likely to have occurred and continues to occur, evidence to support this assertion must still be collected and assessed.

(d) Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

Monitoring is a component of Alternative C1 and is described in Section 4.1.1. As discussed above, Alternative C1 is judged to be protective of human health and the environment. The existing IRM, MNA, and institutional controls provided in Alternative C1 prevent COCs in the petroleum groundwater plumes and associated smear zone soil from reaching human or ecological receptors. Thus, the risk to these receptors from the petroleum groundwater plumes and associated smear zone soil is expected to be reduced to acceptable levels by Alternative C1.

However, there are five areas of the Facility where LNAPL collects in what appears to be recoverable amounts based on the most recent data from the Facility. Existing FPP recovery systems are not operating in three of these possible locations (refer to Sections 4.1.1.2 and 4.1.2.3). As a result, Alternative C1 does not meet a threshold requirement established by WAC 173-340-360(2)(c)(ii)(A), since FPP has not been removed by normal engineering practices to the degree that is judged to be practicable.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. Several action-specific ARARs were identified as being potentially applicable to the implementation of Alternative C1 (refer to Appendix G, Tables G-3 and G-4).

Alternative C1 uses the groundwater IRM system that was first installed beginning in 1993. This system includes (1) groundwater extraction wells that provided hydraulic containment and oxygenated groundwater for distribution to the shallow part of the aquifer; (2) horizontal and vertical distribution wells for delivery of oxygenated groundwater to shallow aquifer depths; (3) skimming wells and belt skimmers for recovery of FPP; and (4) deep observation wells to monitor for potential downward migration of petroleum hydrocarbons near groundwater extraction wells.

Groundwater extraction wells are now operating in the Oil House and Wastewater Treatment areas of the Kaiser Facility. The extraction wells draw groundwater from deep within the aquifer, from below zones of impacted groundwater.

Currently, extraction well OH-EW-1 is operating at a pumping rate of approximately 1.2 MGD. Extracted groundwater from OH-EW-1 is conveyed to plant processes for use as both contact process water and non-contact cooling water.

Extraction wells WW-EW-1, WW-EW-2, and WW-UVB-1 are currently operating in the Wastewater Treatment area at flow rates of approximately 4.5, 7.1, and 4.37 MGD, respectively. Groundwater extracted from WW-EW-1 is used in plant processes for contact and non-contact cooling. Groundwater from WW-EW-2, which is drawn from deep in the aquifer, is currently discharged to the Spokane River. Groundwater extracted from WW-EW-2 is not impacted by specific COCs (petroleum, PCBs, and arsenic) as verified by quarterly sample analytical results presented in the Final Groundwater Remedial Investigation Report (Hart Crowser 2012a, Appendix F) and is not treated prior to discharge to the river.

Groundwater from WW-UVB-1 is conveyed underground to a horizontal infiltration well (WW-UVB-1-HS) with a distribution system consisting of three screened intervals to deliver oxygenated groundwater to the upper part of the aquifer. The three horizontal screens receive extracted groundwater at flow rates of 1.78 MGD (WW-UVB-1-HSS), 0.97 MGD (WW-UVB-1-HSM), and 1.62 MGD (WW-UVB-1-HSN).

Three additional state regulations authorized by state statutes are potentially applicable, relevant, and appropriate to the operation of horizontal infiltration well WW-UVB-1-HS. The WAC citations for these potentially applicable, relevant, and appropriate state requirements are (1) the Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC); (2) the State Waste Discharge Permit Program (Chapter 173-216 WAC); and (3) the Underground Injection Control (UIC) Program (Chapter 173-218 WAC). The applicability, relevance, and appropriateness of these requirements to Alternative C1 is discussed below.

Groundwater Quality Standards (Chapter 173-200 WAC). This regulation does not apply, nor is it relevant and appropriate, to cleanup actions approved by

Ecology under MTCA (WAC 173-200-010[3][c]). Rather, Ecology has already determined that MTCA groundwater cleanup standards (WAC 173-340-720) apply to the implementation of Alternatives C1 through C4. The groundwater quality standards include an antidegradation policy (WAC 173-200-030[2][a]) which states that the existing and future beneficial uses of groundwater will be maintained and protected, and degradation of groundwater quality that would interfere with or become injurious to beneficial uses shall not be allowed. As noted above, however, MTCA specifically excludes the groundwater quality standards, including the antidegradation policy, so the policy does not apply to MTCA actions.

The groundwater quality standards, and the antidegradation policy, are not "relevant and appropriate" because MTCA expressly excludes them from MTCA actions; thus, they do not address problems or situations that are “sufficiently similar to those encountered at the site that their use is well suited to the particular site" (WAC 173-340-710[4]). In fact, if they were deemed relevant and appropriate, the express MTCA exclusion would be meaningless.

In addition, the groundwater extracted by the IRM comes from deep in the aquifer and sampling of this groundwater has shown it to not contain specific COCs at concentrations above detection limits, its redistribution to the shallow depths of the aquifer does not degrade the shallow depths of the aquifer or interfere with the beneficial uses of that portion of the aquifer.

State Waste Discharge Permit Program (Chapter 173-216 WAC). This program is not applicable, nor is it relevant and appropriate to Alternative C1. The purpose of this regulation is to implement a state permit program applicable to the discharge of waste materials from industrial, commercial, and municipal operations into groundwater and surface waters of the state and into municipal sewerage systems. The groundwater extracted from deep in the aquifer at the Facility does not contain any materials known to originate from industrial, commercial, or municipal operations, and is not a waste material (WAC 173-216-030[19]). Thus, the transfer of groundwater from deeper in the aquifer to shallower depths without piercing the surface of the ground at the Facility is not a regulated discharge. As a result, the State Waste Discharge Program is not applicable to Alternative C1. The program also is not relevant and appropriate to Alternative C1 because it does not address problems or situations that are “sufficiently similar to those encountered at the site that [its] use is well suited to the particular site" (WAC 173-340-710[4]).

State Underground Injection Control Program (Chapter 173-218 WAC). This program is not applicable, nor is it relevant and appropriate to Alternative C1. The purpose of this regulation is (1) to preserve and protect groundwater by preventing the discharge of fluids *into* UIC wells that will endanger groundwater (emphasis added); (2) to require the use of all known, available, and reasonable methods of prevention, control, and treatment (AKART) to the discharge of fluids and waste fluids *into* the waters of the state (emphasis added); and (3) to prohibit the injection of fluids through wells except as authorized by this regulation.

Moreover, groundwater from well WW-UVB-1 is conveyed underground to a horizontal infiltration well (WW-UVB-1-HS). A UIC well is a well that is used to discharge fluids *into* the subsurface (emphasis added). This means that the discharge of fluids must break the surface of the ground to constitute a discharge *into* the waters of the state. The water extracted by WW-UVB-1 does not pierce the surface of the earth on its journey from WW-UVB-1 to horizontal infiltration well WW-UVB-1-HS. Thus, well WW-UVB-1-HS is not a UIC well, and its registration as a UIC well is not required. As a result, the State Underground Injection Control Program is not applicable to Alternative C1. It is also not relevant and appropriate to Alternative C1, because it does not address problems or situations that are "sufficiently similar to those encountered at the site that [its] use is well suited to the particular site" (WAC 173-340-710[4]).

In addition, as noted above, the groundwater extracted as part of the IRM comes from deep in the aquifer, and sampling and analysis of this groundwater has shown it to not contain specific COCs at detectable concentrations (Hart Crowser 2012a). Thus, its redistribution to the shallow depths of the aquifer does not endanger the aquifer.

4.2.2.2 Other Requirements

Use of Permanent Solutions to the Maximum Extent Practicable

Protectiveness. COC concentrations in smear zone soil and petroleum hydrocarbon groundwater plume AOCs at the Facility are likely to exceed SLs and PCULs from approximately 4 years for the South plume in the Oil House area to 34 years for the North plume in the Wastewater Treatment area (refer to Appendix I). During this time, approximately 690,000 pounds of SVOCs are expected to be degraded and approximately 4 pounds of PCBs are expected to be removed with the FPP or degraded together with the SVOCs (refer to Appendix I).

Alternative C1 will not break the soil to groundwater exposure pathway. However, natural attenuation has caused the majority of the petroleum hydrocarbon plume AOCs to shrink significantly over time. This is expected to continue. Natural attenuation processes are also expected to reduce the concentration of PCBs that are comingled with SVOCs in these AOCs to acceptable levels over time. The risk that remains as the natural attenuation processes proceed is controlled through operation of the IRM system, which protects receptors in the Spokane River from off-site migration of COCs (refer to Section 4.1.1.2).

The direct contact exposure pathway to Facility workers and visitors is mitigated by nature of the depth of the smear zone and groundwater plume AOCs, by the fact that groundwater from these AOCs is not used as a current drinking water source and will not be used in the future as a drinking water source (via a restrictive covenant), and through plume capture and hydraulic containment, which prevents COCs from reaching the Spokane River.

Permanence. Alternative C1 will reduce the toxicity and volume of COC concentrations that can be biodegraded or reduced through natural attenuation processes. These processes are expected to take from 4 to 34 years to attain the SLs and PCULs established for smear zone soil and groundwater COCs (refer to Appendix I). During this time approximately 690,000 pounds of SVOCs and 4 pounds of PCBs are expected to be converted to degradation products (refer to Appendix I).

The mobility of the majority of groundwater COCs is reduced by the plume capture and hydraulic containment provided by the groundwater IRM system, which prevents COC migration to the Spokane River.

Natural attenuation will reduce COC source area mass in smear zone soil. FPP mass on the water table is currently being reduced through FPP recovery using skimming wells. For example, available FPP recovery recorded between 1994 and the end of 2008 document over 4,200 gallons of FPP removed from the skimming systems operated at the Facility (Hart Crowser 2012a, Table 5-4). As discussed in Section 4.1.1.2, based on the recovery rate over the last 7 years, it would take approximately 43 years to recover the approximately 3,700 gallons remaining in the Wastewater Treatment area, not taking into account diminishing returns that have been observed at the Facility and will continue in the future. For cost estimating purposes, a period of 50 years was conservatively assumed for the continued operation of skimmers at wells WW-SK-1 and WW-SK-4. Using similar assumptions, it would take approximately 12 years to recover the approximately 980 gallons remaining in the Oil House area, not accounting for diminishing returns. It was conservatively assumed that skimming wells OH-SK-2 and OH-SK-4 would run for 20 years.

Institutional controls in place at the Facility help to prevent the release of COCs into the environment through the Facility's industrial activities. Contact process wastewater and sanitary wastewater generated by the plant are treated at one of two treatment facilities (IWT plant and sanitary treatment plant), which are collectively known as the Facility's WWT plant, prior to discharge to the Spokane River.

Cost. The NPV of implementing Alternative C1 over a 30-year time period is estimated to total approximately $21.0 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 4.1.1 above and in the cost estimate tables provided in Appendix C.

Effectiveness over the Long Term. This alternative will not add additional activity, beyond the significant benefits provided by biodegradation, to reduce the concentration of COCs currently present in smear zone soil and in the petroleum hydrocarbon groundwater plumes to concentrations below SLs. The operation of the existing groundwater IRM system provides plume capture and hydraulic containment and partial LNAPL recovery, which helps to prevent the groundwater COCs from reaching the Spokane River, based on available groundwater monitoring data (Hart Crowser 2012a).

Management of Short-Term Risks. Alternative C1 uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create any new or additional risk to human health and the environment.

The short-term risks that are associated with implementation of existing and future institutional controls include:

- Potential exposure of Facility workers and visitors to hazardous materials (e.g., handling items containing hazardous waste as part of executing BMPs); and

- Hazards to workers associated with the industrial activities taking place at locations within the Facility where these institutional controls are being implemented.

Technical and Administrative Implementability. The actions associated with the implementation of Alternative C1 are already in place and successfully operating at the Kaiser Facility.

Restoration Time Frame

SVOCs. The approach used to estimate the restoration time frame for Alternative C1 is discussed in Appendix I. The estimated restoration time frames for SVOCs in Alternative C1 for each operating area of the Facility are summarized in Table 4-7, and range from approximately 4 years for the South plume in the Oil House area to approximately 34 years for the North plume in the Wastewater Treatment area.

The factors used to determine whether Alternative C1 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) are assessed below:

(i) *Potential risks posed by the site to human health and the environment;*

The direct contact and ingestion exposure pathways to Facility workers and visitors are mitigated by nature of the depth of the smear zone and groundwater plume AOCs; by the fact that groundwater from these AOCs is not used as a current drinking water source and will not be used in the future as a drinking water source (via a restrictive covenant); and through plume capture and hydraulic containment, which prevents COCs from reaching the Spokane River and potentially impacting receptors in the river.

(ii) *Practicability of achieving shorter restoration time frame;*

The restoration time frame that Alternative C1 provides for each COC group is compared to the other remedial alternatives for the petroleum groundwater plumes and associated smear zone soil in Section 4.3. These other alternatives have similar or shorter restoration time frames compared to Alternative C1 for the various COC groups (refer to Table 4-7). A comparative analysis of the restoration time frames of Alternatives C1 through C4 is presented in Section 4.3. Alternatives C2 through C4 remove FPP to a greater extent than Alternative C1 but cost more to implement.

(iii) *Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;*

Releases from the Facility may pose risks to human and ecological receptors, and may potentially affect groundwater and the Spokane River. Alternative C1 includes physical and administrative controls, BMPs, natural attenuation, and containment to reduce the potential for worker exposure to COCs and to reduce the potential for COCs in smear zone soil and groundwater to migrate to the Spokane River. These controls have effectively cut the pathways by which COCs could reach potential human and ecological receptors.

(iv) Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

A restrictive covenant will limit future uses of the Facility. The Spokane River is likely to continue to be a potential source of receptors for releases from the Facility. Currently, PCBs that are comingled with SVOCs are not reaching the river at concentrations above SLs based on available data.

(v) Availability of alternative water supplies;

Alternative water supplies are abundant. A considerable amount of groundwater exists at the Facility that is outside of the footprint of the existing AOCs at the Facility. Kaiser also has secured access to this groundwater for domestic and industrial use through a water right.

(vi) Likely effectiveness and reliability of institutional controls;

The institutional controls implemented in Alternative C1 (refer to Sections 4.1.1.1 and 4.1.1.2) have been shown to be effective and reliable at the Facility. Most of these measures have been successfully used at the Facility for many years.

(vii) Ability to control and monitor migration of hazardous substances from the site;

The groundwater monitoring program at the Facility is governed by a SAP (Hart Crowser 2007a), as amended (Kaiser 2010a), that has been approved by Ecology. A new monitoring plan will be developed to monitor the performance of this alternative if it is selected as the preferred alternative for petroleum groundwater and associated smear zone soil at the Facility.

(viii) Toxicity of hazardous substances at the site;

FPP, SVOCs, PCBs, PAHs, and select metals have been identified as COCs for the petroleum groundwater plumes and associated smear zone soil at the Facility. The toxicity of these COCs depends on their concentration and the duration of exposure to them. The implementation of Alternative C1 will prevent these COCs from reaching potential human or ecological receptors in the future.

(ix) Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar conditions.

> Natural attenuation processes have substantially reduced the extent of the petroleum groundwater plumes at the Facility over time (refer to Appendix F). These processes are expected to continue in the future and reduce the concentration of SVOCs to SLs and PCULs in approximately 4 to 34 years. PCBs that enter the aqueous phase are also expected to undergo biodegradation during this time. PCB concentrations have not been measured in wells that are directly downgradient from the petroleum plumes.

A comparative analysis of the restoration time frames associated with Alternatives C1 through C4 is presented in Section 4.3. These alternatives have similar or shorter restoration time frames than Alternative C1 for the various COC groups, but cost more to implement. The restoration time frame for Alternative C1 for SVOCs and FPP is judged to be reasonable, as defined by WAC 173-340-360(4).

PCBs Comingled with SVOCs. The hydrophobic behavior of PCBs has been observed at the Facility in the Oil House and Wastewater Treatment areas, where PCBs are comingled with FPP at the water table. The Oil House and Wastewater Treatment areas were designed and constructed for the management of petroleum hydrocarbons in the form of used product and in wastewater mixtures. As a result, the PCBs detected in the Oil House and Wastewater Treatment areas were in contact with petroleum before being released to the environment. It is logical to assume that, because of the presence of petroleum, the PCBs would have had ample opportunity to comingle with this carbon source.

PCBs present in groundwater samples from Oil House and Wastewater Treatment area wells are associated with FPP or dissolved petroleum products. When petroleum hydrocarbons are absent, PCBs have not been detected in groundwater from the Oil House and Wastewater Treatment areas. It is hypothesized that the lack of PCBs in groundwater in these two areas is a direct result of comingling effects of PCBs and SVOCs, and sorption to soil and/or degradation are also factors that reduce the mobility of PCBs into the aquifer.

It is anticipated that, over time, PCBs will remain associated with FPP, and that the removal rate of FPP from the smear zone would be a factor in the restoration time frame for comingled PCBs. Based on historical FPP recovery rates at the Facility, the approximate time to recover remaining FPP using belt skimmers in Alternative C1 is conservatively estimated to be approximately 20 years in the Oil House area and 50 years in the Wastewater Treatment area of the Facility (refer to Section 4.1.1.2).

The restoration time frame for PCBs comingled with SVOCs may be associated with these time frames for the removal of FPP, but may also be associated with the restoration time frame for SVOCs in the petroleum groundwater plumes and associated smear zone soil to attain SLs and PCULs by natural attenuation in Alternative C1. The SL and PCUL for SVOCs in smear zone soil is 2,000 mg/kg, which is the default residual saturation value for diesel and heavy oil in soil. Petroleum hydrocarbon concentrations in soil above the residual saturation value may indicate the presence of FPP. The concentration of SVOCs in smear zone soil is expected to be below 2,000 mg/kg for petroleum hydrocarbons at the end of the restoration time frames time for the petroleum groundwater plumes (see Table 4-2), which ranges from approximately 4 years (South plume in the Oil House area) to 34 years (North plume in the Wastewater Treatment area) (see Table 4-7 and Appendix I).

It can be assumed that comingled PCBs may still be present if the petroleum hydrocarbon concentration in the soil exceeds the residual saturation default value of 2,000 mg/kg, and that the estimated restoration time frame for comingled PCBs may be associated with the time needed for the concentration of petroleum hydrocarbons to decline to this value. However, considering the potential for non-recoverable product to remain in the subsurface (even if the concentration of SVOCs declines to below 2,000 mg/kg), the restoration time frame for comingled PCBs may be longer.

The available evidence indicates that the estimated restoration time frame for PCBs that are comingled with SVOCs for Alternative C1 will be approximately the same as the estimated restoration time frame for SVOCs alone. The restoration time frame for SVOCs and FPP is judged to be reasonable. The restoration time frame for PCBs that are comingled with SVOCs is also judged to be reasonable.

4.2.3 Evaluation of Remedial Alternative C2: Institutional Controls, Monitoring, MNA, Containment, and Expanded FPP Recovery

Alternative C2 includes the institutional control, monitoring, and MNA elements of Alternative C1, improves the capture and hydraulic containment of the petroleum hydrocarbon groundwater plumes and associated smear zone soil, and expands the FPP recovery measures provided in Alternative C1. Petroleum groundwater plume, smear zone soil, and FPP AOCs are shown on Figures 4-1 through 4-5.

The capability of Alternative C2 to meet the cleanup requirements established by MTCA is summarized below.

4.2.3.1 Threshold Requirements

Protect Human Health and the Environment

Alternative C2 provides capture and hydraulic containment of the petroleum hydrocarbon groundwater plumes at the Facility. An assessment of natural attenuation processes in groundwater at the Facility (Appendix F) indicates that the petroleum hydrocarbon groundwater plumes appear to be shrinking. The PCBs that are comingled with SVOCs can be biodegraded by anaerobic and aerobic microbes once the PCBs partition from the SVOCs and enter the aqueous phase (refer to Appendix F). Anaerobic conditions are generally present in areas where FPP is present (refer to Figure F-2), with aerobic conditions present in other areas where petroleum plumes are present.

The combined benefit of hydraulic containment and active natural attenuation is expected to prevent petroleum hydrocarbon COCs at concentrations above SLs or PCULs from reaching the Spokane River. Ongoing groundwater monitoring confirms that petroleum constituents and associated COCs are not migrating beyond the downgradient Facility property line (Hart Crowser 2012a).

Alternative C2 expands source control measures at the Facility by expanding FPP recovery through installation and operation of one additional skimming well and restarting operations at two existing idle skimming locations (see Section 4.1.2.3). In this alternative, FPP recovery will be implemented where historical FPP thickness measurement data indicate the ongoing presence of FPP. Because the source area in smear zone soil is likely to be present for a long time, transfer of COCs from the smear zone and FPP into groundwater will be ongoing as groundwater flows through these impacted areas. Similar to Alternative C1 (see Section 4.2.2), Alternative C2 does not directly cut the rainfall to soil to groundwater exposure pathway that could convey COCs from smear zone soil to groundwater. However, this exposure pathway is not considered to be a significant pathway relative to the extent of COC mobilization into groundwater caused by the seasonal fluctuation of the water table through smear zone soil.

Alternative C2 provides additional containment of the petroleum hydrocarbon groundwater plumes to the existing IRM, and adds additional FPP skimming locations to those contained in Alternative C1. COC concentrations are likely to exceed SLs and PCULs for some time in these AOCs. The concentrations of these COCs in groundwater are expected to reach the SLs and PCULs listed in Table 4-1 in approximately 4 years (South plume in the Oil House area) to 34 years (North plume in the Wastewater Treatment area) (refer to Appendix I).

Because the soil to groundwater exposure pathway persists in the smear zone soil AOCs, potential risks to the environment remain at the Facility. Alternative C2 controls the risk to receptors in the Spokane River through the plume capture and hydraulic containment of groundwater COCs, and through natural attenuation causing the petroleum hydrocarbon plumes to shrink, as discussed in Appendix F. The risk to receptors that may extract and drink petroleum-contaminated groundwater is controlled by the current practice that prohibits this activity at the Facility, and by a restrictive covenant that will prohibit this activity in the future.

The human direct contact or ingestion pathway to Facility workers and visitors is mitigated by the depth (greater than 20 feet) of the smear zone soil and groundwater plume AOCs, through implementation of institutional controls, and because the groundwater plumes do not appear to be reaching surface water based on the results of ongoing groundwater monitoring. The soil to groundwater exposure pathway remains between smear zone soil and groundwater, but this impact to groundwater is controlled through the plume capture and hydraulic containment provided in Alternative C2, and through the groundwater natural attenuation processes occurring in groundwater at the Facility. Removal of FPP as a source control measure will be implemented in Alternative C2 in locations where historical monitoring data indicate the ongoing presence of FPP. Because of the risk control provided by Alternative C2, it is concluded that Alternative C2 is protective of human health and the environment.

Comply with MTCA Cleanup Standards

The implementation of Alternative C2 may result in compliance with MTCA cleanup requirements if the point of compliance is established throughout Facility soil and groundwater. SLs are currently exceeded in the smear zone soil and petroleum groundwater AOCs identified on Figures 4-1 through 4-5.

The SLs for groundwater established in the FSTM and the PCULs established for groundwater by Ecology (Ecology 2010a and 2010b) for a standard POC and for a conditional POC are summarized in Table 4-1. The SL and PCUL established for diesel and heavy oil are both 500 µg/L. The PCUL for total petroleum hydrocarbons for a conditional POC is also 500 µg/L. Alternative C2 is expected to reduce petroleum hydrocarbon concentrations to below 500 µg/L within approximately 4 to 34 years (refer to Appendix I). Thus, Alternative C2 is expected to meet MTCA standards for petroleum hydrocarbons regardless of whether a conditional POC is established by Ecology for the petroleum plumes. The concentration of PCBs in the petroleum plume FPP areas may exceed the PCUL for a standard point of compliance until the FPP is no longer present. A more thorough discussion of the anticipated restoration time frame for PCBs that are comingled with SVOCs is provided in Appendix I.

Compliance with SLs and the PCULs established by Ecology will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of cleanup actions that are implemented. Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternative C2, compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in Alternative C2 (WAC 173-340-720[9][c][vi]).

MTCA provides additional requirements for permanent groundwater cleanup actions under WAC 173-340-360(2)(c)(i) and for nonpermanent groundwater cleanup actions under WAC 173-340-360(2)(c)(ii). These requirements are presented in detail for Alternative C1 in Section 4.2.2.1 and are summarized for Alternative C2 below:

- **WAC 173-340-360(2)(c)(i).** Alternative C2 is expected to meet PCULs for SVOCs, PCBs, and metals at the standard POC in approximately 4 years for the South plume in the Oil House area to approximately 34 years for the North plume in the Wastewater Treatment area (refer to Appendix I). If a conditional POC is established by Ecology for the petroleum groundwater plumes, the time required for the concentration of PCBs and PAHs in groundwater and associated smear zone soil to reach the PCULs associated with this conditional POC will be shorter than the time frames needed to meet the PCULs established by Ecology for a standard POC (refer to Table 4-1). The cleanup of groundwater at the Facility is judged to be a permanent groundwater cleanup action.

- **WAC 173-340-360(2)(c)(ii).** Alternative C2 does not consider the active treatment of smear zone soil, but does allow for the continued natural attenuation of the SVOCs that are present in groundwater and of the PCBs that partition from the SVOCs and enter the aqueous phase in smear zone soil and groundwater. There are five locations at the Facility where LNAPL collects. In Alternative C2, two existing skimming locations will resume operation, and one new FPP recovery systems will be installed and operated, in addition to two locations where FPP recovery is currently active (refer to Section 4.1.2.3). Alternative C2 implements plume capture and hydraulic containment that, together with the ongoing natural attenuation at the Facility, is judged to be an effective containment system for the COCs present in the petroleum groundwater plumes and the associated smear zone soil.

MTCA identifies several expectations for cleanup action alternatives (WAC 173-340-370). These expectations represent the types of cleanup actions Ecology considers likely results of the remedy selection process described in WAC 173-340-350 through WAC 173-340-360; however, Ecology recognizes that there may be some sites where cleanup actions conforming to these expectations are not appropriate. Per WAC 173-340-370(7), Ecology expects that natural attenuation of hazardous substances may be appropriate at sites where:

(a) Source control has been conducted to the maximum extent practicable;

As discussed in Section 4.1.2, source control is an important component of Alternative C2, which recovers FPP to the maximum extent practicable.

(b) Leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health and the environment;

As discussed above, Alternative C2 is judged to be protective of human health and the environment.

(c) There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and

Considerable evidence is available to support the assertion that biodegradation of the heavy oil and diesel fuels present in the petroleum plumes and associated smear zone soil has occurred in the past and is expected to continue in the future (refer to Appendix F). While there is considerable indication that the degradation of PCBs that are associated with the petroleum hydrocarbons in the Oil House and Wastewater Treatment areas is likely to have occurred and continues to occur, evidence to support this assertion must still be collected and assessed.

(d) Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

Monitoring is a component of Alternative C2 and is described in Section 4.1.2. As discussed above, Alternative C2 is judged to be protective of human health and the environment. The existing IRM, MNA, and institutional controls provided in Alternative C2 prevent COCs in the petroleum groundwater plumes and associated smear zone soil from reaching human or ecological receptors. Thus, the risk to these receptors from the petroleum groundwater plumes and associated smear zone soil has been reduced to acceptable levels by Alternative

C2. As a result, Alternative C2 meets the threshold requirement established by WAC 173-340-360(2)(c)(ii)(A), with which Alternative C1 is not compliant.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. Several action-specific ARARs were identified as being potentially relevant and appropriate, and applicable to the implementation of Alternative C2 (refer to Appendix G, Tables G-3 and G-4).

Alternative C2 uses the groundwater IRM system that was first installed in 1993. This system includes the components that were described in Section 4.2.2.1 for Alternative C1: (1) groundwater extraction wells that provided hydraulic containment and oxygenated groundwater for distribution to the shallow part of the aquifer; (2) horizontal and vertical distribution wells for delivery of oxygenated groundwater to shallow depths of the aquifer; (3) skimming wells and belt skimmers for recovery of FPP; and (4) deep observation wells to monitor for potential downward migration of petroleum hydrocarbons near groundwater extraction wells. In addition to these components, Alternative C2 includes the installation of a new extraction well (ORB-FEW-1) in the ORB area. This well would extract groundwater from the deeper depths of the aquifer, which would be either used in plant processes or discharged to the Spokane River. The need for additional groundwater containment in the ORB area is discussed further in Section 6 of this FS.

The groundwater extraction wells that are now operating in the Oil House and Wastewater Treatment areas of the Facility are summarized in Section 4.2.2.1 for Alternative C1, which are assumed to be operating as part of Alternative C2. Groundwater extracted from these wells is either conveyed to plant processes, discharged to the Spokane River, or is conveyed underground to a horizontal infiltration well (WW-UVB-1-HS) to deliver oxygenated groundwater to the shallow depths of the aquifer to promote aerobic biodegradation of COCs.

Three additional regulations authorized by state statutes are judged to be potentially applicable, relevant, and appropriate to the operation of horizontal infiltration well WW-UVB-1-HS. The WAC citations for these potentially applicable, relevant, and appropriate state requirements are (1) the Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC); (2) the State Waste Discharge Permit Program (Chapter 173-216 WAC); and (3) the Underground Injection Control Program (Chapter 173-218 WAC). The applicability, relevance, and appropriateness of these requirements to Alternative C2 is the same as described for Alternative C1, as discussed in Section 4.2.2.1 and briefly summarized below.

Groundwater Quality Standards (Chapter 173-200 WAC). This regulation does not apply, nor is it relevant and appropriate, to cleanup actions approved by Ecology under MTCA (WAC 173-200-010[3][c]). Rather, Ecology has already determined that MTCA groundwater cleanup standards (WAC 173-340-720) apply to the implementation of Alternatives C1 through C4.

In addition, the groundwater extracted by the IRM comes from deep in the aquifer and sampling and analysis of this groundwater has shown it to not contain specific COCs above detection limits. Its redistribution to the shallow depths of the aquifer does not degrade the shallow depths of the aquifer or interfere with the beneficial uses of that portion of the aquifer. Thus, for this separate reason, the Groundwater Quality Standards are not applicable, nor are they relevant and appropriate, to Alternative C2.

State Waste Discharge Permit Program (Chapter 173-216 WAC). This program also is not applicable, nor is it relevant and appropriate to Alternative C2 for the reasons described for Alternative C1, above. The groundwater extracted from deep in the aquifer at the Facility does not contain any materials known to originate from industrial, commercial, or municipal operations, and is not a waste material (WAC 173-216-030[19]). The transfer of groundwater from deep in the aquifer to shallower depths does not degrade but improves the water quality of the shallower depths of the aquifer. Thus, the placement of groundwater extracted from deeper in the aquifer into shallower depths of the aquifer at the Facility is not a regulated discharge. As a result, the State Waste Discharge Program is not applicable, nor is it relevant and appropriate, to Alternative C2.

State Underground Injection Control Program (Chapter 173-218 WAC). This program also is not applicable, nor is it relevant and appropriate to Alternative C2 for the reasons described for Alternative C1, above. Groundwater from well WW-UVB-1 is conveyed entirely underground to a horizontal infiltration well (WW-UVB-1-HS). A UIC well is a well that is used to discharge fluids *into* the subsurface (emphasis added). This means that the discharge of fluids must break the surface of the ground to constitute a discharge *into* the waters of the state. The water extracted by WW-UVB-1 does not pierce the surface of the earth on its journey from WW-UVB-1 to horizontal infiltration well WW-UVB-1-HS, and well WW-UVB-1-HS is not a UIC well. As a result, the State Underground Injection Control Program is not applicable to Alternative C2. It is also not relevant and appropriate to Alternative C2 because it does not address problems or situations that are "sufficiently similar to those encountered at the site that [its] use is well suited to the particular site" (WAC 173-340-710[4]).

In addition, as noted above, the groundwater extracted as part of the IRM comes from deep in the aquifer and sampling and analysis of this groundwater has shown it to not contain COCs above detection limits. Thus, its redistribution to the shallow depths of the aquifer does not endanger the aquifer.

4.2.3.2 Other Requirements

Use of Permanent Solutions to the Maximum Extent Practicable

Protectiveness. COC concentrations in smear zone soil and petroleum hydrocarbon groundwater plume AOCs at the Facility are likely to exceed SLs and PCULs from approximately 4 years for the South plume in the Oil House area to 34 years for the North plume in the Wastewater Treatment area (refer to Appendix I) in Alternative C2. During this time approximately 690,000 pounds of SVOCs are expected to be degraded and 4 pounds of PCBs are expected to be removed with the FPP or degraded (refer to Appendix I).

Alternative C2 reduces COCs in the smear zone and groundwater plume through FPP recovery and oxygen enhancement to stimulate natural biological processes. Natural attenuation has been shown to be occurring at the Facility (Appendix F), and is expected to continue. Natural attenuation processes are also expected to reduce the concentration of PCBs that are comingled with SVOCs in these AOCs to acceptable levels over time. The soil to groundwater exposure pathway remains between smear zone soil and groundwater, but this impact to groundwater is controlled through the plume capture and hydraulic containment provided in Alternative C2, and through the natural attenuation processes occurring in groundwater at the Facility.

The human direct contact or ingestion pathway to Facility workers and visitors is mitigated because of the depth of the smear zone soil and groundwater plume AOCs, through implementation of institutional controls, and because the groundwater plumes do not appear to be reaching surface water.

Source control will be implemented by continuing to operate the four existing skimming wells currently operating; starting operation of two existing skimming wells that are not currently operating; and installation of one new skimming well (seven skimming locations in total) to remove FPP from the surface of the water table in locations where historical monitoring data indicate the ongoing presence of FPP.

It can be concluded that Alternative C2 is protective of human health and the environment because of the risk control that it provides.

Permanence. Alternative C2 will reduce the toxicity and volume of COCs through natural attenuation processes. These processes are expected to take from 4 to 34 years to attain the SLs and PCULs established for smear zone soil and groundwater COCs (see Appendix I). During this time approximately 690,000 pounds of SVOCs and 4 pounds of PCBs are expected to be converted to degradation products (refer to Appendix I). The mobility of the groundwater COCs is reduced by the plume capture and hydraulic containment provided in this alternative, which prevents COC migration to the Spokane River. FPP mass on the water table will be reduced through operation of seven skimming well locations for FPP recovery.

Institutional controls in place at the Facility help to prevent the release of COCs into the environment through the Facility's industrial activities. Contact process wastewater and sanitary wastewater generated by the plant are treated at the Facility's WWT plant prior to discharge to the Spokane River.

Cost. The NPV of implementing Alternative C2 (Scenario C2b) over a 30-year time period is estimated to total approximately $22.9 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 4.1.2 and in the cost tables contained in Appendix C.

Effectiveness over the Long Term. This alternative will reduce the concentration of COCs present in the petroleum hydrocarbon groundwater plumes and associated smear zone soil to concentrations below SLs and PCULs from approximately 4 years for the South plume in the Oil House area to 34 years for the North plume in the Wastewater Treatment area (refer to Appendix I). The depth of the petroleum groundwater plume and smear zone soil AOCs prevents Facility workers and visitors from directly contacting or ingesting COCs in these locations. The plume capture and hydraulic containment provided in Alternative C2 is expected to prevent the petroleum hydrocarbon groundwater COCs from reaching the Spokane River.

Management of Short-Term Risks. This alternative will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks associated with construction activities in Alternative C2 (for example, groundwater well installation) will be mitigated by adherence to the HASP prepared to guide health and safety practices during the construction work.

The short-term risks associated with Alternative C2 include the following:

- Potential exposure of Facility workers and visitors to hazardous materials (e.g., handling items containing hazardous waste as part of executing BMPs); and

- Hazards to workers associated with the industrial activities taking place at locations within the Facility where these institutional controls are being implemented.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place and successfully operating at the Facility. The installation of groundwater extraction wells and FPP skimming wells has been employed successfully at the Facility in the past and is a practice with which Kaiser is familiar.

Restoration Time Frame

SVOCs. The restoration time frame needed in Alternative C2 for remediation to occur through natural attenuation processes, FPP removal, and through operation of a groundwater hydraulic containment system ranges from approximately 4 years for the South plume in the Oil House area to approximately 34 years for the North plume in the Wastewater Treatment area. The approach used to estimate the restoration time frame for Alternative C2 is discussed in Appendix I.

This time frame is considered to be reasonable as defined by WAC 173-340-360(4). Alternative C2 meets the minimum requirements for cleanup actions under WAC 173-340-360(2). An assessment of the factors used to determine whether Alternative C2 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) follows:

(i) Potential risks posed by the site to human health and the environment;

Alternative C2 is judged to be protective of human health and the environment (see discussion above). The direct contact and ingestion exposure pathways to Facility workers and visitors is mitigated by nature of the depth of the smear zone and groundwater plume AOCs; by the fact that groundwater from these AOCs is not used as a current drinking water source and will not be used in the future as a drinking water source (via a restrictive covenant); and through plume capture and hydraulic containment, which prevents COCs from reaching the Spokane River and potentially impacting receptors there.

(ii) Practicability of achieving shorter restoration time frame;

The restoration time frame that Alternative C2 provides for each COC group is compared to Alternatives C1, C3, and C4 in Section 4.3. *In situ* and *ex situ* treatment of petroleum-contaminated groundwater provide no additional protection of potential human or ecological receptors than Alternative C2 but will generally require less time and incur substantially greater costs to achieve CULs (see Appendices C and I).

(iii) Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

Releases from the Facility may pose risks to human and ecological receptors, and may potentially affect groundwater and the Spokane River. Alternative C2 includes enhanced containment, physical and administrative controls, BMPs, additional FPP removal, and natural attenuation to reduce the potential for worker exposure to COCs and are expected to prevent COCs in smear zone soil and groundwater from migrating to the Spokane River. These controls are expected to cut the pathways by which COCs could reach potential human and ecological receptors.

(iv) Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

A restrictive covenant will limit future uses of the Facility. The Spokane River is likely to continue to be a potential source of receptors for releases from the Facility. Currently, SVOCs and PCBs that are comingled with SVOCs are not reaching the river at concentrations above SLs.

(v) Availability of alternative water supplies;

Alternative water supplies are abundant at the Facility. A considerable amount of groundwater exists at the Facility that is outside of the footprint of the petroleum hydrocarbon groundwater plumes at the Facility. Kaiser also has secured access to this groundwater for domestic and industrial use through a water right.

(vi) Likely effectiveness and reliability of institutional controls;

The institutional controls implemented in Alternative C2 (refer to Sections 2.1.1.1 and 2.1.1.2 and Tables 2-2 and 2-3) have been shown to be effective and reliable at the Facility. Most of these measures have been successfully used at the Facility for many years.

(vii) Ability to control and monitor migration of hazardous substances from the site;

The groundwater monitoring program at the Facility is governed by a SAP (Hart Crowser 2007a), as amended (Kaiser 2010a), that has been approved by Ecology. A new monitoring plan will be developed to monitor the performance of this alternative if it is selected as the preferred alternative for petroleum groundwater and associated smear zone soil at the Facility.

(viii) Toxicity of hazardous substances at the site; and

FPP, SVOCs, PCBs, PAHs, and metals have been identified as COCs for the petroleum groundwater plumes and associated smear zone soil at the Facility. The toxicity of these COCs will depend on their concentration and the duration of exposure to them. None of these COCs is now reaching potential receptors in the Spokane River. The implementation of Alternative C2 is expected to prevent these COCs from reaching potential receptors in the Spokane River in the future.

(ix) Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar conditions.

Natural attenuation of SVOCs and of PCBs that are comingled with SVOCs in the petroleum groundwater plumes has been under way for many years (refer to Appendix F). Several of the plumes have shrunk significantly during this time. These processes are expected to continue in the future and reduce the concentration of SVOCs to SLs and PCULs in approximately 4 to 34 years. PCBs that enter the aqueous phase are also expected to undergo biodegradation during that time. PCB concentrations have not been measured in wells that are directly downgradient from the petroleum plumes.

A comparative analysis of the restoration time frames associated with Alternatives C1 through C4 is presented in Section 4.3. These alternatives have similar or shorter restoration time frames than Alternative C2 for the various COC groups, but some cost more to implement. The restoration time frame for Alternative C2 for SVOCs is judged to be reasonable, as defined by WAC 173-340-360(4).

PCBs Comingled with SVOCs. PCBs present in groundwater samples from Oil House and Wastewater Treatment area wells are associated with FPP or dissolved petroleum products. When petroleum hydrocarbons are absent, PCBs have not been detected in groundwater from the Oil House and Wastewater Treatment areas. It is hypothesized that the lack of PCBs in groundwater in these two areas is a direct result of comingling effects of PCBs with SVOCs, and petroleum sorption to soil and/or degradation are also factors that reduce the mobility of PCBs into the aquifer.

It is anticipated that, over time, PCBs will remain associated with FPP, and that the removal rate of FPP from the smear zone would be a factor in the restoration time frame for comingled PCBs. Based on historical FPP recovery rates at the Facility, the estimated time to recover remaining FPP using belt skimmers in Alternative C2 is estimated to be approximately 10 years in the Oil House area and 25 years in the Wastewater Treatment area of the Facility (refer to Section 4.1.2.3).

The restoration time frame for PCBs comingled with SVOCs may be associated with these time frames for the removal of FPP, but may also be associated with the restoration time frame for SVOCs in the petroleum groundwater plumes and associated smear zone soil to attain SLs and PCULs by natural attenuation in Alternative C2. The SL and PCUL for SVOCs in smear zone soil is 2,000 mg/kg, which is the default residual saturation value for diesel and heavy oil in soil. Petroleum hydrocarbon concentrations in soil above the residual saturation value may indicate the presence of FPP. The concentration of SVOCs in smear zone soil is expected to be below 2,000 mg/kg for petroleum hydrocarbons at the end of the restoration time frames time for the petroleum groundwater plumes (see Table 4-2), which ranges from approximately 4 years (South plume in the Oil House area) to 34 years (North plume in the Wastewater Treatment area) (see Table 4-7 and Appendix I).

It can be assumed that comingled PCBs may still be present if the petroleum hydrocarbon concentration in the soil exceeds the residual saturation default value of 2,000 mg/kg, and that the estimated restoration time frame for comingled PCBs may be associated with the time needed for the concentration of petroleum hydrocarbons to decline to this value. However, considering the potential for non-recoverable product to remain in the subsurface (even if the concentration of SVOCs declines to below 2,000 mg/kg), the restoration time frame for comingled PCBs may be longer.

The available evidence indicates that the estimated restoration time frame for PCBs comingled with SVOCs for Alternative C2 will be approximately the same as the estimated restoration time frame for SVOCs alone. As a result of this assessment, Alternative C2 is judged to have reasonable restoration time frames for SVOCs and PCBs comingled with SVOCs.

4.2.4 Evaluation of Remedial Alternative C3: Alternative C2 Plus In Situ Treatment

Alternative C3 adds *in situ* enhanced bioremediation of the petroleum hydrocarbon groundwater plumes and associated smear zone soil to Alternative C2. Alternative C3 includes institutional controls, MNA, monitoring, hydraulic containment, FPP recovery, and *in situ* treatment. The purpose of Alternative C3 is to hydraulically contain the petroleum groundwater plumes at the Facility, to recover FPP from the surface of the water table, and to enhance biodegradation in the petroleum hydrocarbon groundwater plumes and associated smear zone soil.

The capability of Alternative C3 to meet the cleanup requirements established by MTCA is summarized below.

4.2.4.1 Threshold Requirements

Protect Human Health and the Environment

The smear zone soil and petroleum hydrocarbon groundwater plume AOCs are located at depths that prevent Facility workers and visitors from direct contact with COCs in these areas. Institutional controls in place at the Facility include physical and administrative controls and BMPs that are currently being used to reduce the potential for worker exposure to COCs. Institutional controls also include measures to prevent the potential release of COCs to the environment through the industrial activities taking place at the Facility.

Operation of a hydraulic containment system, as described in Section 4.1.2, captures and contains the groundwater plumes present at the Facility and prevents COCs present in the petroleum hydrocarbon groundwater plumes and associated smear zone soil from reaching the Spokane River. FPP recovery described in Section 4.1.3.4 removes FPP from the surface of the water table, effectively reducing a potential source of COCs to the groundwater.

An assessment of natural attenuation processes in groundwater at the Facility (refer to Appendix F) indicates that natural attenuation of the SVOCs present in the petroleum hydrocarbon groundwater plumes is occurring and that the plumes are shrinking. The PCBs that are comingled with SVOCs can be biodegraded by anaerobic and aerobic microbes once the PCBs partition from the SVOCs and enter the aqueous phase (refer to Appendix F). Anaerobic conditions are generally present in areas where FPP is present (refer to Figure F-2), with aerobic conditions present in other areas where petroleum plumes are present.

Alternative C3 actively reduces the concentrations of SVOCs in the smear zone soil and petroleum groundwater plume AOCs. Approximately 44 percent of the SVOCs (estimated at 690,000 pounds) present in smear zone soil are expected to be destroyed by *in situ* enhanced bioremediation during the operating period of Alternative C3. Additional biodegradation will continue to occur at the leading edge of the Wastewater Treatment area plume through the introduction of oxygenated groundwater through the IRM system distribution wells.

Alternative C3 does not directly cut the rainfall to soil to groundwater exposure pathway that could convey COCs from smear zone soil to groundwater. However, this exposure pathway is not considered to be a significant pathway relative to the extent of COC mobilization into groundwater caused by the seasonal fluctuation of the water table through smear zone soil.

Risk to human health is mitigated under Alternative C3 because of the depth of the impacted smear zone soil and groundwater AOCs (greater than 20 feet), the implementation of institutional controls (e.g., BMPs, restrictive covenant), the capture and containment of the petroleum groundwater plumes, and the reduction in the smear zone soil SVOC and comingled PCB mass, that results from *in situ* treatment. Alternative C3 is expected to reduce the concentration of SVOCs in groundwater to below SLs and PCULs in approximately 4 years for the South plume in the Oil House area to approximately 30 years for the North plume in the Wastewater Treatment area.

Alternative C3 is judged to be protective of human health and the environment.

Comply with MTCA Cleanup Standards

Alternative C3 is expected to reduce the quantity of SVOCs in the smear zone soil AOCs by approximately 44 percent during its operating period. Alternative C3 also removes the remaining FPP from the petroleum hydrocarbon groundwater plumes that can be removed by conventional engineering practices. Groundwater plume capture and containment will eliminate the possibility that the SVOCs in the petroleum groundwater plumes could reach the Spokane River. Alternative C3 is expected to reduce the concentration of SVOCs in groundwater to below SLs and PCULs in approximately 4 years for the South plume in the Oil House area to approximately 30 years for the North plume in the Wastewater Treatment area.

The SLs for groundwater established in the FSTM and the PCULs established for groundwater by Ecology (Ecology 2010a and 2010b) for a standard POC and for a conditional POC are summarized in Table 4-1. Alternative C3 is expected to meet MTCA standards for petroleum hydrocarbons regardless of whether a conditional POC is established by Ecology for the petroleum plumes. The concentration of PCBs in the petroleum plume FPP areas may exceed the PCUL for a standard point of compliance until the FPP is no longer present. A more thorough discussion of the anticipated restoration time frame for PCBs comingled with SVOCs is provided in Appendix I.

Compliance with SLs and the PCULs established by Ecology will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of cleanup actions that are implemented. Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternative C3, compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in Alternative C3 (WAC 173-340-720[9][c][vi]).

As discussed in the evaluation of Alternative C2 (Section 4.2.3), hydraulic containment and LNAPL removal (provided by Alternative C2) are compliant with the requirements for nonpermanent groundwater cleanup actions under WAC 173-340-360(2)(c)(ii). The removal of an estimated 690,000 pounds of SVOCs from the smear zone soil secondary source area in Alternative C3 provides additional compliance with this MTCA threshold requirement.

Alternative C3 is judged to meet the threshold requirements established by WAC 173-340-360(2) for smear zone soil.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. Several action-specific requirements were identified as being potentially applicable to the implementation of Alternative C3 (refer to Appendix G, Tables G-3 and G-4).

Alternative C3 involves the injection of compounds into the subsurface to stimulate *in situ* biodegradation of SVOCs in the petroleum groundwater plumes and associated smear zone soil. Alternative C3 also uses the groundwater IRM system that was first installed in 1993 plus expansion of FPP recovery and the installation of a new extraction well in the ORB area, as described for Alternatives C1 and C2 (see Sections 4.2.2.1 and 4.2.3.1). The groundwater extraction wells that are now operating in the Oil House and Wastewater Treatment areas are assumed to be operating as part of Alternative C3. Groundwater extracted from these wells is either conveyed to plant processes, discharged to the Spokane River, or conveyed underground to a horizontal infiltration well (WW-UVB-1-HS) to deliver oxygenated groundwater to the shallow depths of the aquifer to promote aerobic biodegradation of COCs.

Three additional state regulations authorized by state law are judged to be potentially applicable or relevant and appropriate to the injection of compounds into the subsurface and to the operation of horizontal infiltration well WW-UVB-1-HS. The WAC citations for these potentially applicable, or relevant and appropriate state requirements are (1) the Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC); (2) the State Waste Discharge Permit Program (Chapter 173-216 WAC); and (3) the Underground Injection Control Program (Chapter 173-218 WAC). The applicability, relevance, and appropriateness of these requirements to Alternative C3 is summarized below.

Groundwater Quality Standards (Chapter 173-200 WAC). This regulation does not apply, nor is it relevant and appropriate, to cleanup actions approved by Ecology under MTCA (WAC 173-200-010[3][c]). Rather, Ecology has already determined that MTCA groundwater cleanup standards (WAC 173-340-720) apply to the implementation of Alternatives C1 through C4. The Groundwater Quality Standards include an antidegradation policy (WAC 173-200-030[2][a]) which states that the existing and future beneficial uses of groundwater will be maintained and protected, and degradation of groundwater quality that would interfere with or become injurious to beneficial uses shall not be allowed. As noted above, however, MTCA specifically excludes the groundwater quality regulations, including the antidegradation policy, so the policy does not apply to MTCA actions.

The groundwater quality standards and the antidegradation policy also are not "relevant and appropriate" because MTCA expressly excludes them from MTCA actions; thus, they do not address problems or situations that are "sufficiently similar to those encountered at the site that their use is well suited to the particular site" (WAC 173-340-710[4]). In fact, if they were deemed "relevant and appropriate," the express MTCA exclusion would be meaningless.

In addition, as determined for Alternatives C1 and C2, since the groundwater extracted by the IRM comes from deep in the aquifer and sampling and analysis of this groundwater has shown it to not contain specific COCs above detection limits, its redistribution to the shallow depths of the aquifer does not degrade the shallow depths of the aquifer or interfere with the beneficial uses of that portion of the aquifer. Thus, for this separate reason, the Groundwater Quality Standards are not applicable nor are they relevant and appropriate, to Alternative C3 for operation of the containment system.

Even if the antidegradation policy were deemed to be an ARAR, the addition of a compound that provides oxygen for the stimulation of biodegradation is intended to improve the condition of the groundwater and generally is not considered detrimental to the beneficial uses of groundwater. However, there is a potential risk of changing the valence state of naturally occurring metals (arsenic, chromium) through reactions with hydrogen peroxide, potentially increasing their toxicity and mobility. This potential issue will be addressed under MTCA if Alternative C3 is judged to be the most appropriate alternative for the petroleum hydrocarbon plumes and associated smear zone soil.

State Waste Discharge Permit Program (Chapter 173-216 WAC). This program is not applicable, nor is it relevant and appropriate, to Alternative C3. The groundwater extracted from deep in the aquifer at the Facility does not contain any materials known to originate from industrial, commercial, or municipal operations, and is not a waste material (WAC 173-216-030[19]). Thus, the placement of groundwater extracted from deeper in the aquifer into shallower depths at the Facility is not a regulated discharge and does not trigger the waste discharge program regulations. Similarly, the material injected to stimulate *in situ* bioremediation does not fall under any of these material categories and does not trigger the waste discharge program regulations. The program is not relevant and appropriate because it does not address problems or situations that are "sufficiently similar to those encountered at the site that [its] use is well suited to the particular site" (WAC 173-340-710[4]).

State Underground Injection Control Program (Chapter 173-218 WAC). Again, as described for Alternatives C1 and C2 (see Sections 4.2.2.1 and 4.2.3.1), the groundwater extracted as part of the IRM comes from deep in the aquifer and sampling and analysis of this groundwater has shown it to not contain COCs above detection limits. Thus, its redistribution to the shallow depths of the aquifer does not endanger the aquifer. Moreover, as described above, well WW-UVB-1-HS is not a UIC well, and its registration as a UIC well is not required.

However, the injection of materials into the subsurface from aboveground locations to stimulate *in situ* biodegradation of COCs may require registration with the UIC Program if the injection points are classified as UIC wells.

4.2.4.2 Other Requirements

Use of Permanent Solutions to the Maximum Extent Practicable

Protectiveness. Alternative C3 actively destroys SVOC and comingled PCB mass in the petroleum groundwater plumes and associated smear zone soil at the Facility. COC concentrations in the smear zone and groundwater plume AOCs are likely to exceed SLs and PCULs from approximately 4 years for the South plume in the Oil House area to approximately 30 years for the North plume in the Wastewater Treatment area (refer to Appendix I) in Alternative C3. This restoration time frame is shorter than the time frame expected with Alternative C1, C2, or C4. During this time, approximately 690,000 pounds of SVOCs are expected to be degraded, and 4 pounds of PCBs are expected to be removed with the FPP or degraded (refer to Appendix I).

The direct contact exposure pathway to Facility workers and visitors is mitigated by the depth of the smear zone and groundwater plume AOCs and by the fact that impacted groundwater from these AOCs will not be used as drinking water. Implementation of institutional controls protects Facility workers and visitors from exposure to COCs and prevents future releases of COCs to the environment. COCs in groundwater are prevented from reaching the Spokane River through plume capture and hydraulic containment (i.e., Alternative C2).

The soil to groundwater exposure pathway remains between smear zone soil and groundwater, but this impact to groundwater is controlled through plume capture and hydraulic containment. Source control will be implemented by operating new and existing skimming wells and by biologically destroying SVOCs in the petroleum hydrocarbon groundwater plumes and associated smear zone soil.

Natural attenuation has caused the majority of the petroleum hydrocarbon groundwater plume AOCs to shrink (refer to Appendix F). Natural attenuation processes are also expected to reduce the concentration of PCBs comingled with SVOCs in these AOCs to acceptable levels over time.

Hydrogen peroxide added as a source of oxygen during the *in situ* bioremediation process may react with metals in the subsurface and will oxidize them to their highest oxidation state if reaction occurs. This may increase the toxicity and potential mobility of naturally occurring metals (arsenic, chromium) in the smear zone. Because hydrogen peroxide will be added at low concentration, and because the groundwater is hydraulically contained, the addition of hydrogen peroxide is not likely to cause increased risk to human health and the environment.

Permanence. Alternative C3 is expected to reduce the mass of SVOCs to SLs and PCULs in the petroleum groundwater plumes and the associated smear zone soil in approximately 4 years for the South plume in the Oil House area to about 30 years for the North plume in the Wastewater Treatment area (refer to Appendix I). Enhanced biological and natural attenuation processes are expected to continue to reduce SVOC and comingled PCB concentrations over time.

FPP mass on the water table will continue to be reduced through FPP recovery using skimming wells. Available FPP recovery records between 1994 and the end of 2008 document over 4,200 gallons of FPP removed from the water table by skimming systems at the Facility (Hart Crowser 2012a, Table 5-4).

There is a potential risk of changing the valence state of naturally occurring metals (arsenic, chromium) through reactions with hydrogen peroxide, potentially increasing their toxicity and mobility. Metal concentrations will be monitored during treatment.

Cost. The NPV of implementing Alternative C3 over a 30-year time period is estimated to total approximately $28.1 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 4.1.3 above and in the cost estimate tables provided in Appendix C. Table C-6 summarizes the cost estimate for Alternative C3.

Effectiveness over the Long Term. Alternative C3 is expected to actively reduce the concentration of SVOCs and comingled PCBs in the smear zone soil AOCs to SLs and PCULs in approximately 4 years for the South plume in the Oil House area to about 30 years for the North plume in the Wastewater Treatment area (refer to Appendix I). During this time, approximately 690,000 pounds of SVOCs are expected to be degraded, and 4 pounds of PCBs are expected to be removed with the FPP or degraded (refer to Appendix I).

The operation of the hydraulic containment system prevents groundwater COCs from being conveyed to the Spokane River by groundwater flow. Institutional controls will be put into place that prohibit or limit activities that could interfere with the long-term integrity of the hydraulic containment system as well as prevent groundwater in the AOCs from being used as a drinking water source.

Management of Short-Term Risks. Short-term risks associated with Alternative C3 include worker exposure to contaminants during the installation of wells and underground piping. Controls to protect workers will be defined in the HASP and implemented during construction and remediation activities. Short-term risks to construction workers during these activities will be mitigated by their adherence to the HASP that is prepared to guide the worker health and safety aspects of these activities.

Additional risks are associated with the storage and handling of nutrients and hydrogen peroxide. Hydrogen peroxide and some nutrients (ammonium nitrate) are strong oxidizers, which increase explosion risk. Short-term risks will be mitigated by minimizing the quantities stored on site and by adherence to the HASP.

Hydrogen peroxide may react with metals in the subsurface and oxidize them to their highest oxidative state, potentially increasing their mobility or toxicity. Hydrogen peroxide will be added at low concentrations to minimize this risk. The hydraulic containment system will prevent oxidized metals (if any are present) from reaching the river.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place and successfully operating at the Facility. Hydraulic containment is currently used at the Facility and has been empirically demonstrated to be effective.

Bioremediation techniques have been used to successfully remediate SVOCs at other similar sites (FRTR 2010). The injection of nutrients and hydrogen peroxide may require UIC Program registration.

On-site pilot-scale testing will be required for design and implementation of *in situ* enhanced bioremediation to confirm its technical implementability and its effectiveness in reducing SVOC and comingled PCB concentrations in the petroleum hydrocarbon groundwater plumes and associated smear zone soil.

Restoration Time Frame

SVOCs. The time frame needed for the concentration of SVOCs in smear zone soil and petroleum groundwater plumes to fall below SLs and PCULs is estimated to range from approximately 4 years for the South plume in the Oil House area to about 30 years for the North plume in the Wastewater Treatment area (see Appendix I). As discussed in Section 4.1.3.3, the mass of SVOCs in smear zone soil will be reduced through partitioning of SVOCs from smear zone soil into groundwater. The dissolved phase SVOCs will be biologically destroyed. As SVOCs are released from smear zone soil, transfer of comingled PCBs into the aqueous phase, where they will be available for biodegradation, will also occur.

The restoration time frame needed in Alternative C3 for remediation to occur through *in situ* bioremediation plus natural attenuation processes, FPP removal, and through operation of a groundwater hydraulic containment system is considered to be reasonable as defined by WAC 173-340-360(4). Alternative C3 meets the minimum requirements for cleanup actions under WAC 173-340-360(2). An assessment of the factors used to determine whether Alternative C3 provides for a reasonable restoration time frame is similar to the assessment conducted per WAC 173-340-360(4)(b) for Alternative C2 in Section 4.2.3.2. Aspects of this assessment that pertain to Alternative C3 in particular are summarized below.

The restoration time frame that Alternative C3 provides for each COC group is compared to Alternatives C1, C2, and C4 in Section 4.3. *In situ* and *ex situ* treatment of petroleum-contaminated groundwater provide no additional protection to potential human and ecological receptors than Alternative C2, requires less time to achieve CULs than Alternative C2 (see Appendix I), and will incur significantly greater additional cost than Alternative C2 (refer to Appendix C).

There is a potential risk of changing the valence state of naturally occurring metals (arsenic, chromium) through reactions with hydrogen peroxide, potentially increasing their toxicity and mobility. The toxicity of these metals will depend on their concentration and the duration of exposure to them. Hydrogen peroxide will be added at low concentrations to minimize this risk. The hydraulic containment system will prevent oxidized metals (if any are present) from reaching the river.

A comparative analysis of the restoration time frames associated with Alternatives C1 through C4 is presented in Section 4.3. These other alternatives have longer restoration time frames than Alternative C3 for the various COC groups; however, some cost significantly less to implement. The restoration time frame for Alternative C3 for SVOCs is judged to be reasonable, as defined by WAC 173-340-360(4).

PCBs Comingled with SVOCs. PCBs present in groundwater samples from Oil House and Wastewater Treatment area wells are associated with FPP or dissolved petroleum products. It is anticipated that, over time, PCBs will remain associated with FPP, and that the removal rate of FPP from the smear zone would be a factor in the restoration time frame for comingled PCBs. Based on historical FPP recovery rates at the Facility, the estimated time to recover remaining FPP using belt skimmers in Alternative C3 is the same as for Alternative C2, which is conservatively estimated to be approximately 10 years in the Oil House Area and 25 years in the Wastewater Treatment Area of the Facility (refer to Section 4.1.2.3).

The restoration time frame for PCBs comingled with SVOCs may also be associated with the restoration time frame for SVOCs in the petroleum groundwater plumes and associated smear zone soil to attain SLs and PCULs in Alternative C3 through *in situ* bioremediation and natural attenuation processes.

The SL and PCUL for SVOCs in smear zone soil is 2,000 mg/kg, which is the default residual saturation value for diesel and heavy oil in soil. Petroleum hydrocarbon concentrations in soil above the residual saturation value may indicate the presence of FPP. The concentration of SVOCs in smear zone soil is expected to be below 2,000 mg/kg for petroleum hydrocarbons at the end of the restoration time frames time for the petroleum groundwater plumes (see Table 4-2), which ranges from approximately 4 years (South plume in the Oil House area) to about 30 years (North plume in the Wastewater Treatment area) (see Table 4-7 and Appendix I).

It can be assumed that comingled PCBs may still be present if the petroleum hydrocarbon concentration in the soil exceeds the residual saturation default value of 2,000 mg/kg, and that the estimated restoration time frame for comingled PCBs may be associated with the time needed for the concentration of petroleum hydrocarbons to decline to this value. However, considering the potential for non-recoverable product to remain in the subsurface (even if the concentration of SVOCs declines to below 2,000 mg/kg), the restoration time frame for comingled PCBs may be longer.

4.2.5 Evaluation of Remedial Alternative C4: Alternative C2 Plus Groundwater Extraction with Ex Situ Treatment

Alternative C4 includes the elements of Alternative C2 (institutional controls, monitoring, MNA, improved capture and hydraulic containment of the petroleum hydrocarbon groundwater plumes and associated smear zone soil, and expanded FPP recovery measures) as well as extraction and *ex situ* treatment of contaminated groundwater from the petroleum hydrocarbon groundwater plume AOCs. The petroleum groundwater plume, associated smear zone soil, and FPP AOCs are shown on Figures 4-1 through 4-5.

The capability of Alternative C4 to meet the cleanup requirements established by MTCA is summarized below.

4.2.5.1 Threshold Requirements

Protect Human Health and the Environment

Alternative C4 actively reduces the concentrations of SVOCs in the petroleum groundwater plume AOCs. Alternative C4 will extract groundwater contaminated with SVOCs, PCBs comingled with SVOCs, and FPP. This water will be treated in an *ex situ* treatment system, where the majority of the SVOCs and PCBs in the extracted groundwater are expected to be adsorbed onto GAC, and FPP will be recovered by an oil/water separator (this is in addition to the expanded FPP recovery element of Alternative C2 that is included in Alternative C4). Extraction of contaminated groundwater is estimated to decrease groundwater COC concentrations to below SLs and PCULs in approximately 3 years for the South plume in the Oil House area to approximately 24 years for the North plume in the Wastewater Treatment area (see Appendix I). Alternative C4 includes operation of a hydraulic containment system, which is expected to prevent the potential migration of COCs during the course of treatment from reaching the Spokane River.

Natural attenuation processes are also expected to continue during this time. An assessment of natural attenuation processes in groundwater at the Facility (refer to Appendix F) indicates that natural attenuation of the SVOCs present in the petroleum hydrocarbon groundwater plumes is occurring and that the plumes are shrinking. The PCBs comingled with SVOCs can be biodegraded by anaerobic and aerobic microbes once the PCBs partition from the SVOCs and enter the aqueous phase (refer to Appendix F). Anaerobic conditions are generally present in areas where FPP is present (refer to Figure F-2), with aerobic conditions present in other areas where petroleum plumes are present.

The smear zone soil and petroleum hydrocarbon groundwater plume AOCs are located at depths that prevent Facility workers and visitors from direct contact with COCs in these areas. Institutional controls in place at the Facility include physical and administrative controls and BMPs that are currently being used to reduce the potential for worker exposure to COCs. Institutional controls also include measures to prevent the potential release of COCs to the environment during industrial activities taking place at the Facility.

Alternative C4 does not directly cut the rainfall to soil to groundwater exposure pathway that could convey COCs from smear zone soil to groundwater, as is discussed under Alternative C1 (see Section 4.2.2). However, this exposure pathway is not considered to be a significant pathway relative to the extent of COC mobilization into groundwater caused by the seasonal fluctuation of the water table through smear zone soil. Thus, the soil to groundwater exposure pathway remains between smear zone soil and groundwater.

Removal of FPP from the water table surface will be implemented in Alternative C4 by operation of belt skimmers (included as part of Alternative C2) and extraction of contaminated groundwater and recovery of FPP as a process step (oil/water separation) in the *ex situ* treatment system. Eventually, the concentrations of COCs in the petroleum groundwater plume AOCs are expected to decrease below SLs and PCULs as a result of the groundwater extraction and treatment provided in Alternative C4. Because of the risk control and reduction measures provided by Alternative C4, its ability to implement these measures in a reasonable time frame and the overall improvement in environmental quality that Alternative C4 provides, it is concluded that this alternative is protective of human health and the environment.

Comply with MTCA Cleanup Standards

Alternative C4 may attain compliance with MTCA cleanup requirements and with ARARs promulgated by state and federal law if the point of compliance is established throughout Facility soil and groundwater. Alternative C4 is expected to reduce petroleum hydrocarbon concentrations to below 500 μg/L within approximately 3 to 24 years (see Appendix I). The concentration of PCBs in the petroleum plume FPP areas may exceed the PCUL for a standard point of compliance until the FPP is no longer present. A more thorough discussion of the anticipated restoration time frame for PCBs comingled with SVOCs is provided in Appendix I.

Compliance with SLs and the PCULs established by Ecology will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of cleanup actions that are implemented. Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternative C4, compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in Alternative C4 (WAC 173-340-720[9][c][vi]).

The SLs developed for the Facility were based on the requirements of MTCA and state and federal ARARs. These SLs are currently exceeded in the petroleum groundwater AOCs identified on Figures 4-1 through 4-3. Alternative C4 actively works to reduce the concentration of COCs that are present in these AOCs.

MTCA provides additional requirements for permanent and nonpermanent groundwater cleanup actions under WAC 173-340-360(2)(c). These requirements are presented in detail for Alternative C1 in Section 4.2.2 and are summarized for Alternative C4 below:

- **WAC 173-340-360(2)(c)(i).** Alternative C4 is expected to meet PCULs for SVOCs, PCBs, and metals at the standard POC in approximately 3 years for the South plume in the Oil House area to approximately 24 years for the North plume in the Wastewater Treatment area (refer to Appendix I). If a conditional POC is established by Ecology for the petroleum groundwater plumes, the time required for the concentration of PCBs and PAHs in groundwater and associated smear zone soil to reach the PCULs associated with this conditional POC will be shorter than the time frames needed to meet the PCULs established by Ecology for a standard POC (refer to Table 4-1). The cleanup of groundwater at the Facility is judged to be a permanent groundwater cleanup action.

- **WAC 173-340-360(2)(c)(ii).** Alternative C4 prevents COCs in smear zone soil from reaching human or ecological receptors. Alternative C4 implements hydraulic containment and treatment of SVOCs and comingled PCBs that, together with the ongoing natural attenuation at the Facility (refer to Appendix F), is judged to be an effective containment system for the COCs present in the petroleum groundwater plumes and the associated smear zone soil. FPP plumes exist in the Oil House and Wastewater Treatment areas. For Alternative C4, FPP will be recovered using belt skimmers and through the oil/water separation process of the *ex situ* treatment system.

Alternative C4 does not directly treat smear zone soil, but groundwater extraction will promote the transfer of SVOCs and comingled PCBs from the smear zone soil to groundwater. During the restoration time frame, it is estimated that approximately 690,000 pounds of SVOCs will be extracted from smear zone soil (see Appendix I). Extracted SVOCs and comingled PCBs will be adsorbed onto GAC and eventually destroyed as spent carbon is regenerated via thermal treatment or incinerated. Thus, Alternative C4 is judged to be protective of human health and the environment and meet MTCA threshold requirements established by WAC 173-340-360(2).

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. Several action-specific ARARs were identified as being potentially applicable to the implementation of Alternative C4 (refer to Appendix G, Tables G-3 and G-4).

Alternative C4 uses the groundwater IRM system that was first installed in 1993. This system includes the remedial components that were described in Section 4.2.3.1 for Alternative C2 plus *ex situ* treatment of extracted groundwater. The groundwater extraction wells that are operating as part of Alternative C2 are assumed to be operating as part of Alternative C4. Groundwater extracted from these wells either is conveyed to plant processes, discharged to the Spokane River, or conveyed underground to a horizontal infiltration well (WW-UVB-1-HS) to deliver oxygenated groundwater to the shallow depths of the aquifer to promote aerobic biodegradation of COCs as part of the IRM system.

Three additional state laws are judged to be potentially applicable, or relevant and appropriate, to the operation of horizontal infiltration well WW-UVB-1-HS. These potentially applicable or relevant and appropriate state laws are (1) the Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC); (2) the State Waste Discharge Permit Program (Chapter 173-216 WAC); and (3) the Underground Injection Control Program (Chapter 173-218 WAC). The applicability, relevance, and appropriateness of these statutes to Alternative C4 are summarized below.

Groundwater Quality Standards (Chapter 173-200 WAC). The groundwater standards do not apply, nor are they relevant and appropriate, to MTCA actions approved by Ecology (see WAC 173-200-010[3][c]). Moreover, the groundwater extracted by the IRM comes from deep in the aquifer and sampling and analysis of this groundwater has shown it not to contain COCs above detection limits, its redistribution to the shallow depths of the aquifer does not degrade the shallow depths of the aquifer or interfere with the beneficial uses of that portion of the aquifer. Thus, for this separate reason, the Groundwater Quality Standards are not applicable or relevant and appropriate to Alternative C4.

In any event, extracted groundwater that is treated in the *ex situ* treatment system will be used as plant process water, or for some other permitted use. This water will be treated to meet discharge requirements and, if discharged to the waters of the state, does not pose potential risk to its beneficial use. Again, however, the regulation does not apply, nor is it relevant and appropriate, to cleanup actions approved by Ecology under MTCA (WAC 173-200[010][3][c]).

State Waste Discharge Permit Program (Chapter 173-216 WAC). The groundwater extracted from the petroleum plumes contains COCs identified for groundwater at the Facility. However, the *ex situ* treatment system is intended to treat extracted groundwater to meet discharge requirements. The effluent of the *ex situ* treatment may be considered a waste material in some situations (WAC 173-216-030[19]), thus potentially triggering the waste discharge program requirements.

The existing IRM, on the other hand, is different relative to the State Waste Discharge permit program. The groundwater extracted by the IRM system from deep in the aquifer does not contain any materials known to originate from industrial, commercial, or municipal operations, and is not a waste material per regulatory definition. Thus, the placement of clean groundwater extracted from deeper in the aquifer into shallower aquifer depths at the Facility is not a regulated discharge. The operation of the IRM containment system does not trigger the waste discharge program regulations.

State Underground Injection Control Program (Chapter 173-218 WAC). Again, the clean groundwater extracted as part of the IRM comes from deep in the aquifer and sampling and analysis of this groundwater has shown it to not contain COCs above detection limits. Thus, its redistribution to the shallow depths of the aquifer does not endanger the aquifer. Moreover, for the reasons described for Alternative C2 in Section 4.2.3.1, the distribution well WW-UVB-1-HS is not a UIC well, and its registration as a UIC well is not required.

Effluent discharged from the *ex situ* treatment system will be used in plant processes or for other permitted purposes. In the event that the treated effluent is discharged into the subsurface from an aboveground location, UIC Program registration may be required if the well receiving the effluent is classified as a UIC well per Chapter 173-218 WAC. In addition, as discussed above, the treated effluent may need to meet AKART prior to discharge to groundwater if selected as the ultimate discharge location.

4.2.5.2 Other Requirements

Use of Permanent Solutions to the Maximum Extent Practicable

Protectiveness. Alternative C4 is expected to reduce the concentration of COCs to below SLs and PCULs in the petroleum hydrocarbon groundwater plume AOCs in approximately 3 years for the South plume in the Oil House area to about 24 years for the North plume in the Wastewater Treatment area (see Appendix I). Extracted groundwater will be treated in an *ex situ* treatment system, and source control will be implemented by operating the expanded FPP recovery system. On- and off-site risks resulting from the implementation of the alternative are manageable, and overall environmental quality is improved.

During implementation of Alternative C4, the potential migration of SVOCs to the Spokane River will be controlled through the capture and hydraulic containment provided by the groundwater extraction system and IRM system, and via natural attenuation processes (see Appendix F). Natural attenuation processes are also expected to reduce the concentration of PCBs comingled with SVOCs in these AOCs to acceptable levels over time.

The direct contact exposure pathway to Facility workers and visitors is mitigated by the depth of the smear zone and petroleum hydrocarbon groundwater plume AOCs and by the fact that groundwater from these AOCs is not used as a current drinking water source. A restrictive covenant will prevent the extraction of groundwater at the Facility for use as drinking water. This exposure pathway is also mitigated through operation of a hydraulic containment system that prevents SVOCs from reaching the Spokane River. The soil to groundwater exposure pathway remains active in the smear zone soil AOCs, where seasonal groundwater fluctuation allows for transport of COCs from smear zone soil to groundwater.

It is concluded that Alternative C4 is protective of human health and the environment.

Permanence. Alternative C4 will permanently reduce the toxicity and volume of COCs in groundwater through extraction and treatment of impacted groundwater. SVOCs and comingled PCBs in extracted groundwater will be adsorbed onto GAC and will be subsequently destroyed as part of the spent carbon regeneration process or through incineration. During *ex situ* treatment, capture and hydraulic containment will prevent the potential migration of COCs to the Spokane River, and natural attenuation processes will continue to occur. FPP mass on the water table will be removed during groundwater extraction by belt skimming or recovered as part of the *ex situ* treatment process. Recovered FPP will be disposed of properly.

Institutional controls in place at the Facility help to prevent the release of COCs into the environment by the Facility's industrial activities. Prior to discharge to the Spokane River, contact process wastewater and sanitary wastewater generated by the plant are treated at the WWT facility.

As discussed above, Alternative C4 does not directly treat smear zone soil, but groundwater extraction will cause the mass transfer of SVOCs from smear zone soil to groundwater. As discussed in Section 4.1.4, during the restoration time frame, it is estimated that approximately 690,000 pounds of SVOCs will be extracted from smear zone soil and adsorbed onto GAC as part of the *ex situ* treatment process.

Cost. The NPV of implementing Alternative C4 over 30 years is estimated to total approximately $41.0 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 4.1.4 above and listed in the cost tables contained in Appendix C. The portion of the total cost of Alternative C4 that represents groundwater extraction and *ex situ* treatment is approximately $18.1 million.

Effectiveness over the Long Term. Operation of a hydraulic containment system, as described in Section 4.1.2, contains the petroleum hydrocarbon groundwater plumes that are present at the Facility and prevents the COCs in these plumes and in associated smear zone soil from reaching receptors in the Spokane River.

An assessment of natural attenuation processes in groundwater at the Facility (Appendix F) indicates that natural attenuation of the SVOCs present in the petroleum hydrocarbon groundwater plumes is occurring and that the plumes are shrinking. Natural attenuation processes are also expected to reduce the concentration of PCBs comingled with SVOCs in these AOCs to acceptable levels over time.

Alternative C4 actively destroys the SVOCs and comingled PCBs in the petroleum groundwater plume AOCs. Alternative C4 is expected to reduce the concentration of COCs to below SLs and PCULs in the petroleum hydrocarbon groundwater plume AOCs in approximately 3 years for the South plume in the Oil House area to about 24 years for the North plume in the Wastewater Treatment area (see Appendix I). Alternative C4 uses treatment technologies that are presumptive remedies for SVOCs and PCBs in groundwater. There is a high degree of certainty that the alternative will be successful.

Management of Short-Term Risks. Short-term risks are associated with the installation of extraction wells, extraction pumps, and the *ex situ* treatment system. Short-term risks to construction workers during installation will be mitigated by adherence to the HASP that is prepared to guide the health and safety aspects of these activities.

Short-term risks to workers operating the *ex situ* treatment system will be mitigated by adherence to the HASP and O&M Plan specific to the *ex situ* treatment system. An experienced contractor will manage the removal, transportation, and regeneration/incineration of spent carbon.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place and successfully operating at the Facility. The installation and operation of a hydraulic containment system, new groundwater extraction wells, and FPP skimming wells are routine activities, with which Kaiser has historical experience. Technical and administrative implementability of the *ex situ* groundwater treatment system is complex. Technical and administrative staff will be needed for the design, construction, and operation of the treatment system. Staff will be needed to complete permitting, O&M manuals, and other documentation. Operating staff will need to be properly trained.

Restoration Time Frame

The time frame needed for recovery to occur through groundwater extraction, *ex situ* treatment, and natural attenuation processes is estimated to range from approximately 3 years for the South plume in the Oil House area to 24 years for the North plume in the Wastewater Treatment area (see Appendix I). As discussed in Section 4.1.3.1, it is assumed for the FS that the mass of SVOCs in smear zone soil is reduced through partitioning of SVOCs from smear zone soil into groundwater. Approximately 690,000 pounds of SVOCs will be extracted from the petroleum groundwater plumes during the restoration time frame via the groundwater extraction wells. SVOCs will be adsorbed onto GAC in the *ex situ* treatment process and eventually destroyed during the thermal treatment process employed in activated carbon regeneration or during incineration of the GAC.

The time frame needed to reduce the concentration of COCs to SLs and PCULs is considered to be reasonable as defined by WAC 173-340-360(4). Alternative C4 meets the minimum requirements for cleanup actions under WAC 173-340-360(2). An assessment of the factors used to determine whether Alternative C4 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) is the same as for Alternative C2 (see Section 4.2.3.2).

The restoration time frame that Alternative C4 provides for each COC group is compared to Alternatives C1, C2, and C3 in Section 4.3. *In situ* and *ex situ* treatment of petroleum-contaminated groundwater provide no additional protection of human and ecological receptors than in Alternative C2, but will require less time to achieve CULs than Alternative C2 (see Appendix I), and will be significantly more costly to implement than Alternative C2.

A comparative analysis of the restoration time frames associated with Alternatives C1 through C4 is presented in Section 4.3. These alternatives have similar or shorter restoration time frames than Alternative C2 for the various COC groups, but some cost more to implement. The restoration time frame for Alternative C4 for SVOCs is judged to be reasonable, as defined by WAC 173-340-360(4).

PCBs Comingled with SVOCs. It is anticipated that, over time, PCBs will remain associated with SVOCs and FPP, and that the removal rate of FPP from the smear zone would be a factor in the restoration time frame for comingled PCBs. Based on historical FPP recovery rates at the Facility, the estimated time to recover FPP using belt skimmers in Alternative C4 is the same as for Alternative C2, which is conservatively estimated to be approximately 10 years in the Oil House area and 25 years in the Wastewater Treatment area of the Facility (refer to Section 4.1.2.3).

The restoration time frame for PCBs comingled with SVOCs may also be associated with the restoration time frame for SVOCs in the petroleum groundwater plumes to attain SLs and PCULs in Alternative C4 through groundwater extraction and *ex situ* treatment, which range from approximately 3 years (South plume in the Oil House area) to about 24 years (North plume in the Wastewater Treatment area) (see Table 4-7 and Appendix I). However, considering the potential for non-recoverable product to remain in the subsurface, the restoration time frame for comingled PCBs may be longer.

The available evidence indicates that the estimated restoration time frame for PCBs comingled with SVOCs for Alternative C4 will be approximately the same as the estimated restoration time frame for SVOCs alone. As a result of this assessment, Alternative C4 is judged to have reasonable restoration time frames for SVOCs and comingled PCBs.

4.3 COMPARATIVE ANALYSIS OF ALTERNATIVES FOR PETROLEUM HYDROCARBON GROUNDWATER PLUMES AND ASSOCIATED SMEAR ZONE SOIL

Alternatives C1 through C4 are evaluated individually in Sections 4.2.2 through 4.2.5 using the evaluation criteria that are established by Ecology (WAC 173-340-360). The evaluation of remedial alternatives for the petroleum hydrocarbon groundwater plumes and associated smear zone soil continues in this section through comparative analysis of these alternatives.

The comparative analysis assesses the relative capability of the alternatives (as applicable to the COC groups identified for the petroleum hydrocarbon groundwater plumes and associated smear zone soil) to meet threshold requirements, to use permanent solutions to the maximum extent practicable, and to provide a reasonable restoration time frame. A disproportionate cost analysis is used to determine whether a cleanup action uses permanent solutions to the maximum practicable extent. The disproportionate cost analysis procedure is summarized in Section 2.3.1. The factors assessed to determine whether restoration time frame is reasonable are summarized in Section 2.2.1.2.

The technology-based remedial alternatives judged to be potentially applicable to the COC groups in the petroleum hydrocarbon groundwater plumes and associated smear zone soil at the Facility were identified, respectively, in Section 4.6.1 (Table 4-22) and Section 5.5.1 (Tables 5-17) of the FSTM (Hart Crowser 2012c). These remedial alternatives are combined for the purposes of this FS, resulting in the alternatives that are presented in Section 4.1 and summarized below:

- Alternative C1: Institutional Controls, Monitoring, MNA, and Existing Groundwater IRM System Operation;

- Alternative C2: Alternative C1 and Additional Containment and FPP Removal;

- Alternative C3: Alternative C2 Plus *In Situ* Treatment; and

- Alternative C4: Alternative C2 Plus Groundwater Extraction and *Ex Situ* Treatment

Appendix H provides an evaluation of the FPP recovery technologies that were carried forward from the FSTM as potentially implementable and reliable, and identifies the FPP technology judged appropriate for each alternative. Revised restoration time frame calculations are provided in Appendix I.

The comparative analysis of alternatives is applied to the COC groups present in the petroleum groundwater plumes and associated smear zone soil in the following sections:

- Section 4.3.1 – SVOCs, FPP, and comingled PCBs (Alternatives C1, C2, C3, and C4); and

- Section 4.3.2 – Metals (Alternatives C1 and C2).

4.3.1 Comparative Analysis of Alternatives Applicable to SVOCs and to PCBs Comingled with SVOCs

Alternatives C1 (institutional controls, monitoring, and MNA, and the operation of the existing groundwater IRM), C2 (Alternative C1 and additional containment and FPP removal), C3 (Alternative C2 and *in situ* treatment), and C4 (Alternative C2 and *ex situ* treatment) are applicable to remediation of SVOC and comingled PCB AOCs and are evaluated in Section 4.2. Alternatives C1, C2, and C3 are applicable to SVOCs in the petroleum groundwater plumes and associated smear zone soil. Alternative C4, which involves extraction of impacted groundwater and *ex situ* treatment, is typically applied to groundwater treatment only; however, the extraction of groundwater from the SVOC AOCs causes mass transport of SVOCs from smear zone soil to groundwater, effectively reducing the mass of SVOCs in smear zone soil. The outcome of this assessment is summarized in Table 4-35 for the petroleum hydrocarbon groundwater plumes and in Table 4-36 for smear zone soil.

In some of the AOCs that contain SVOCs, PCBs are comingled with the SVOCs in groundwater (in the Oil House and Wastewater Treatment areas) and in smear zone soil (in the Oil House and Cold Mill areas). The alternatives applicable to SVOCs are considered applicable to the PCBs in the areas where PCBs are co-located with SVOCs, as discussed in Section 4.2.

4.3.1.1 Threshold Requirements

The capability of Alternatives C2, C3, and C4 to meet threshold requirements is discussed below and in Section 4.3.1.2. MTCA threshold requirements are defined in Section 2.2.1.1 of this FS. As described below, Alternative C1 does not meet the threshold criteria and will not be compared to other alternatives applicable to SVOCs and to PCBs comingled with SVOCs.

Protect Human Health and the Environment

The depth of the petroleum hydrocarbon groundwater plumes and associated smear zone soil AOCs (greater than 20 feet) eliminates the risk of direct exposure to these AOCs for Facility workers and visitors. Alternatives C1 through C4 each include physical and administrative controls and BMPs that will reduce worker exposure and potential future releases of SVOCs into the environment.

Alternative C2 expands the plume capture and hydraulic containment of the petroleum hydrocarbon groundwater plumes provided in Alternative C1 by including containment of the ORB petroleum groundwater plume. The hydraulic containment element of Alternative C2 is also included in Alternatives C3 and C4. The benefits of expanded hydraulic containment (Alternative C2) and increased active treatment in Alternatives C3 and C4 are expected to prevent groundwater COCs at concentrations above SLs and PCULs from reaching the Spokane River.

An assessment of natural attenuation processes in groundwater at the Facility (refer to Appendix F) indicates that natural attenuation of the SVOCs present in the petroleum hydrocarbon groundwater plumes is occurring and that the plumes are shrinking. Biodegradation of SVOCs will continue to occur at the leading edge of the Wastewater Treatment area plume through the introduction of oxygenated groundwater through the IRM system distribution wells. The PCBs comingled with SVOCs can be biodegraded by anaerobic and aerobic microbes once the PCBs partition from the SVOCs and enter the aqueous phase (refer to Appendix F). Anaerobic conditions are generally present in areas where FPP is present (refer to Figure F-2), with aerobic conditions present in other areas where petroleum plumes are present.

Alternative C2 expands the FPP recovery measures of Alternative C1 to include areas at the Facility where FPP has been recently observed in the subsurface but is not currently being recovered. The FPP recovery element of Alternative C2 is included in Alternatives C3 and C4. In addition to this FPP recovery element, Alternative C4 includes FPP recovery as a process step of the *ex situ* treatment system, which involves separation of FPP from extracted groundwater using an oil/water separator. FPP recovery removes FPP from the surface of the water table, effectively reducing a potential source of COCs to groundwater.

Potential risks to the environment remain at the Facility, in that the soil to groundwater exposure pathway persists in the smear zone soil AOCs. However, as described above, the hydraulic containment and natural attenuation processes active at the Facility prevent SVOCs and PCBs comingled with SVOCs from reaching the Spokane River. Alternatives C1 through C4 do not directly cut the rainfall to smear zone soil to groundwater exposure pathway that could convey SVOCs from smear zone soil to groundwater. However, this exposure pathway is not considered a significant pathway relative to the extent of SVOC mobilization into groundwater caused by the seasonal fluctuation of the water table through smear zone soil.

Alternatives C1 through C4 will significantly reduce the toxicity and volume of SVOCs in the petroleum hydrocarbon groundwater plumes and associated smear zone soil. These alternatives are expected to each destroy an estimated mass of about 690,000 pounds of SVOCs and 4 pounds of PCBs during the respective restoration time frames of these alternatives. For the purposes of this FS, mass reduction of comingled PCBs is considered to be incidental to the mass reduction of SVOCs.

Alternatives C1 through C4 are expected to reduce COC concentrations to below SLs and PCULs and provide the same degree of protection to human and ecological receptors in a reasonable restoration time frame (refer to Appendix I and Section 4.3.1.3). Alternative C3 provides this protection approximately 4 years to approximately 30 years, Alternative C4 in approximately 3 to 24 years, and Alternative C2 in approximately 4 to 34 years.

Comply with MTCA Cleanup Standards

In Alternatives C1 through C4, the concentration of SVOCs in smear zone soil is expected to attain SLs and PCULs within reasonable time frames and reduce the quantity of SVOCs in smear zone soil by an estimated mass of approximately 690,000 pounds and PCB mass by approximately 4 pounds during their respective restoration time frames. The expanded FPP recovery measures implemented under Alternatives C2, C3, and C4 will remove the remaining FPP from the petroleum hydrocarbon groundwater plumes, mitigating the SVOC source created by FPP floating on the water table.

The plume capture and hydraulic containment employed in Alternatives C2, C3, and C4 will prevent SVOCs and comingled PCBs present in the petroleum groundwater plume from reaching the Spokane River. Alternative C1 does not contain the petroleum groundwater plume associated with the ORB area of the Facility and does not recover FPP from some areas of the Facility where FPP has been documented to collect over time.

The implementation of Alternatives C1 through C4 is expected to result in compliance with MTCA cleanup requirements or with ARARs if the point of compliance is established throughout soil and groundwater at the Facility. Compliance will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of cleanup actions that are implemented. Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternatives C1 through C4, compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in these alternatives (WAC 173-340-720[9][c][vi]).

Alternative C1, which represents existing conditions at the Facility, does not meet the threshold requirement established in WAC 173-340-360(2)(c)(ii)(A). Alternative C1 is not compliant with this threshold requirement because there are presently areas at the Facility where FPP collects on the water table and where existing FPP recovery systems are not operating (see Section 4.1.1.2). Alternative C2 expands FPP recovery measures at the Facility to include these areas. As a result, Alternative C2 meets the threshold requirement established in WAC 173-340-360(2)(c)(ii)(A), with which Alternative C1 is not compliant. The elements of Alternative C2 are incorporated in Alternatives C3 and C4, and thus these alternatives are judged to comply with this threshold requirement.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these SLs is discussed above. Several action-specific requirements were identified as being potentially relevant and appropriate, or applicable to the implementation of Alternatives C1 through C4 (refer to Appendix G, Tables G-3 and G-4).

Alternative C1 through C4 use the groundwater IRM system, which was installed beginning in 1993. This system includes the components that were described in Section 4.2.2.1 for Alternative C1: groundwater extraction wells, horizontal and vertical distribution wells, skimming wells and belt skimmers for recovery of FPP, and deep observation wells to monitor for potential downward migration of petroleum hydrocarbons near groundwater extraction wells. In addition to these components, Alternative C2 adds additional containment and expanded FPP recovery, and Alternatives C3 and C4 further add *in situ* and *ex situ* treatment of groundwater, respectively.

Three additional regulations authorized by state law are judged to be potentially applicable or relevant and appropriate to the operation of horizontal infiltration well WW-UVB-1-HS in Alternatives C1 through C4, and to the *ex situ* treatment components of Alternative C4. The WAC citations for these potentially relevant and appropriate, and applicable state requirements are (1) the Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC); (2) the State Waste Discharge Permit Program (Chapter 173-216 WAC); and (3) the Underground Injection Control Program (Chapter 173-218 WAC).

Groundwater Quality Standards (Chapter 173-200 WAC). This regulation is not applicable, nor is it relevant and appropriate, to cleanup actions approved by Ecology under MTCA (WAC 173-200-010[3][c]). Rather, Ecology has already determined that MTCA groundwater cleanup standards (WAC 173-340-720) apply to the implementation of Alternatives C1 through C4. This regulation includes an antidegradation policy (WAC 173-200-030[2][a]), which states that the existing and future beneficial uses of groundwater will be maintained and protected and degradation of groundwater quality that would interfere with or become injurious to beneficial uses shall not be allowed. As noted above, however, MTCA specifically excludes the Groundwater Quality Standards, including the antidegradation policy, so the policy does not apply to MTCA actions.

The groundwater quality standards, and the antidegradation policy, are not "relevant and appropriate" either because MTCA expressly excludes them from MTCA actions; thus, they do not address problems or situations that are “sufficiently similar to those encountered at the site that their use is well suited to the particular site" (WAC 173-340-710[4]). In fact, if they were deemed "relevant and appropriate," the express MTCA exclusion would be meaningless.

Even if this regulation were to apply to cleanup at the Facility, the groundwater extracted by the IRM in Alternatives C1 through C4 comes from deep in the aquifer and sampling and analysis of this groundwater has shown it to not contain COCs at concentrations above detection limits. The redistribution of deep water of the aquifer to the shallow depths of the aquifer does not degrade the shallow depths of the aquifer or interfere with the beneficial uses of that portion of the aquifer.

In Alternative C3, the addition of a compound that provides oxygen for the stimulation of biodegradation is generally not considered detrimental to the beneficial uses of groundwater; rather, it is intended to improve the condition of this water. However, there is a potential risk of changing the valence state of naturally occurring metals (arsenic, chromium) through reactions with hydrogen peroxide, potentially increasing their toxicity and mobility. However, again, the Groundwater Quality Standards would not be applicable or relevant and appropriate to Alternative C3 because these components would be undertaken as part of a MTCA approved cleanup action.

In Alternative C4, extracted groundwater that is treated in the *ex situ* treatment system will be used as plant process water, or for some other permitted use. This water will be treated to meet discharge requirements and, if discharged to the waters of the state, does not pose potential risk to its beneficial use. However, again, as noted above, the Groundwater Quality Standards are not applicable or relevant and appropriate to Alternative C4 because these components would be undertaken as part of a MTCA approved cleanup action.

State Waste Discharge Permit Program (Chapter 173-216 WAC). The purpose of this regulation is to implement a state permit program applicable to the discharge of waste materials from industrial, commercial, and municipal operations into groundwater and surface waters of the state and into municipal sewerage systems. The groundwater extracted from deep in the aquifer in Alternatives C1 through C3 does not contain any materials known to originate from industrial, commercial, or municipal operations, and is not a waste material (WAC 173-216-030[19]). Thus, the placement of groundwater extracted from deeper in the aquifer into shallower depths at the Facility and the addition of nutrients to enhance biodegradation of COCs, as in Alternative C3, are not regulated discharges. Therefore, the program is not applicable, nor is it relevant and appropriate with respect to that component of the three alternatives.

In Alternative C4, the groundwater extracted from the petroleum plumes contains COCs identified for groundwater at the Facility. However, the *ex situ* treatment system is intended to treat extracted groundwater to meet discharge requirements. The effluent of the *ex situ* treatment system may be considered a waste material in some situations (WAC 173-216-030[19]). In those situations, the waste discharge program regulations may be triggered.

State Underground Injection Control Program (Chapter 173-218 WAC). The purpose of this regulation is (1) to preserve and protect groundwater by preventing the discharge of fluids *into* UIC wells that will endanger groundwater (emphasis added); (2) to require the use of all known, available, and reasonable methods of prevention, control, and treatment (AKART) to the discharge of fluids and waste fluids *into* the waters of the state (emphasis added); and (3) to prohibit the injection of fluids through wells except as authorized by this statute.

As determined for Alternatives C1 through C4, well WW-UVB-1-HS in the IRM system is not a UIC well, its registration as a UIC well is not required. In any event, as described above, the groundwater extracted as part of the IRM comes from deep in the aquifer and sampling and analysis of this groundwater has shown it to not contain COCs above detection limits. Thus, its redistribution to the shallow depths of the aquifer does not endanger the aquifer.

Effluent discharged from the *ex situ* treatment system will be used in plant processes or for other permitted purposes. Treatment to reduce the concentration of SVOCs and comingled PCBs in extracted groundwater will involve adsorption using GAC, which is AKART for these COCs. In the event that the treated effluent is discharged into the subsurface from an aboveground location, UIC Program registration may be required if the well receiving the effluent is classified as a UIC well per Chapter 173-218 WAC.

ARAR Summary. The Water Quality Standards, State Waste Discharge Permit Program, and UIC Program are not applicable or relevant and appropriate to Alternatives C1 and C2. However, Alternative C3 may be required to meet UIC Program requirements. Alternative C4 may have to meet State Waste Discharge Program requirements and potentially the UIC Program requirements.

4.3.1.2 Disproportionate Cost Analysis

This disproportionate cost analysis identifies which alternatives use permanent solutions to the maximum extent practicable. Alternatives C2, C3, and C4 meet the threshold requirements established by MTCA. Alternative C1 does not meet the threshold criteria and is not assessed in this disproportionate cost analysis.

Protectiveness

Alternatives C2 through C4 are expected to reduce COC concentrations to below SLs and PCULs and provide the same degree of protection to human and ecological receptors in a reasonable restoration time frame (refer to Appendix I and Section 4.3.1.3). Alternative C3 provides this protection in about 4 years to approximately 30 years, Alternative C4 in approximately 3 years to 24 years, and Alternative C2 in approximately 4 to 34 years.

Permanence

Alternative C2 will reduce the toxicity and volume of SVOC concentrations in the petroleum hydrocarbon groundwater plumes and associated smear zone soil through natural attenuation processes to attain the SLs and PCULs established for groundwater and smear zone soil SVOCs. Natural attenuation processes are also expected to reduce the concentration of PCBs comingled with SVOCs in these AOCs to acceptable levels over time. The mobility of SVOCs in groundwater is reduced by the plume capture and hydraulic containment provided in this alternative in combination with the natural attenuation process occurring at the Facility, which prevents SVOC migration to the Spokane River. FPP mass on the water table will be reduced through operation of new skimming wells for FPP recovery. Available FPP recovery records between 1994 and the end of 2008 document over 4,200 gallons of FPP removed from the water table through skimming systems operated at the Facility. The hydraulic containment, natural attenuation, and FPP recovery elements of Alternative C2 are also included in Alternatives C3 and C4.

Alternative C2 through C4 are expected to reduce SVOCs by an estimated mass of about 690,000 pounds and PCBs by 4 pounds in the petroleum groundwater plumes and the associated smear zone soil during their restoration time frames. Enhanced biological and natural attenuation processes are expected to continue to reduce SVOC and comingled PCB concentrations over time.

In Alternative C3, there is a potential risk of changing the valence state of naturally occurring metals (arsenic, chromium) present in the petroleum-contaminated groundwater and associated smear zone soil through reactions with hydrogen peroxide, potentially increasing their toxicity and mobility. Metal concentrations will be monitored during treatment.

Alternative C4 will reduce the toxicity and volume of SVOCs in groundwater through extraction and *ex situ* treatment. Alternative C4 does not directly treat smear zone soil, but groundwater extraction will cause the mass transfer of SVOCs from smear zone soil to groundwater. During the restoration time frame for Alternative C4, it is estimated that approximately 690,000 pounds of SVOCs and 4 pounds of PCBs will be extracted from smear zone soil, adsorbed onto GAC, and destroyed as the GAC is regenerated or incinerated as part of the *ex situ* treatment process. As SVOCs transfer from the smear zone into the aqueous phase during groundwater extraction, PCBs that are comingled with SVOCs will also be extracted and treated in the *ex situ* treatment process.

During *ex situ* treatment, hydraulic containment will prevent the potential migration of SVOCs to the Spokane River, and natural attenuation processes will continue to reduce the concentration of SVOCs and comingled PCBs. FPP mass on the water table will be removed during groundwater extraction by belt skimming and recovered as part of the *ex situ* groundwater treatment process. Recovered FPP will be disposed of properly.

Alternatives C2 through C4 employ the same source control measures and are expected to destroy the same quantities of SVOCs and PCBs during their respective restoration time frames in the petroleum groundwater plumes and associated smear zone soil. Alternative C3 is expected to treat the same mass of SVOCs as Alternative C4 but in a shorter time frame and thus provides greater permanence. While Alternatives C3 and C4 have shorter restoration time frames than Alternative C2, they generate treatment residuals (e.g., reaction products, spent GAC) that must be managed. Alternatives C2, C3, and C4 are judged to provide the same degree of permanence.

Cost

The NPV of implementing Alternative C2 (Scenario C2b) over a 30-year time period is estimated to total approximately $22.9 million (-35 to +50 percent). The mass of SVOCs that will be hydraulically contained in the petroleum hydrocarbon groundwater plumes in a 30-year period is about 690,000 pounds. Based on these values, the cost of Alternative C2 per pound of SVOC in the petroleum groundwater plumes is approximately $33.

The NPV of implementing Alternative C3 over a 30-year time period is estimated to total approximately $28.1 million (-35 to +50 percent). The mass of SVOCs that will be destroyed in groundwater and associated smear zone soil in this alternative is estimated at about 690,000 pounds. Alternative C3 costs approximately $41 per pound of SVOC destroyed.

The NPV of implementing Alternative C4 over a 30-year time period is estimated to total approximately $41.0 million (-35 to +50 percent). The mass of SVOCs that will be destroyed in groundwater and associated smear zone soil in this alternative is estimated to be approximately 690,000 pounds. Alternative C4 costs approximately $59 per pound of SVOC treated.

The assumptions used to prepare these estimates are described in Section 4.1 and listed in the cost tables contained in Appendix C. Restoration time frame assumptions and calculations are provided in Appendices E and I.

Effectiveness over the Long Term

Alternatives C2 through C4 will attain SLs and PCULs in the groundwater petroleum plume and associated smear zone soil AOCs within reasonable restoration time frames.

Alternative C3 will actively reduce the mass of SVOCs in the petroleum hydrocarbon groundwater plumes and associated smear zone soil through destruction of SVOC mass (approximately 690,000 pounds of SVOCs estimated over the restoration time frame). There is a potential risk of changing the valence state of metals in the treatment area of Alternative C3, which could increase the toxicity and mobility of the metals present (such as arsenic or chromium). The provision of plume capture and hydraulic containment will prevent the oxidized compounds (if they are present) from reaching the Spokane River.

Alternative C4 will actively reduce SVOC mass in the petroleum groundwater plumes by extraction of groundwater and treatment in an *ex situ* system. Approximately 690,000 pounds of the SVOCs that are estimated to be present in the smear zone secondary source area are expected to be destroyed by *ex situ* treatment during the restoration time frame of Alternative C4.

The remedial elements of Alternative C2 are incorporated in Alternatives C3 and C4, which include passive reduction of SVOC and PCB concentrations through natural attenuation processes, control of SVOC migration with groundwater flow through hydraulic containment, and SVOC and comingled PCB source control through FPP recovery from the water table. Bench- and/or pilot-scale tests will be needed to develop evidence to support the premise that PCBs that are comingled with SVOCs will be biodegraded once the PCBs enter the aqueous phase. Bench- and/or pilot-scale tests will also be required before Alternatives C3 and C4 could be implemented.

Alternative C2, C3, and C4 are judged to provide equivalent effectiveness over the long term.

Management of Short-Term Risks

Alternatives C2, C3, and C4 use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. The short-term risks associated with implementation of institutional controls include industrial hazards that are present in the locations where the institutional controls are being implemented.

Short-term risks are associated with the construction of the remedial alternatives. Alternative C2 involves installation of new groundwater extraction and skimming wells. Alternative C3 adds the additional short-term risk associated with the installation of injection wells (approximately 117) and poses additional risks associated with the storage and handling of the nutrients (ammonium nitrate) and hydrogen peroxide used in the enhanced *in situ* bioremediation process, which can increase explosion risk.

The installation of an aboveground treatment system in Alternative C4 presents short-term risks associated with construction of approximately six groundwater extraction wells. Additional short-term risks are presented by the construction and operation of the groundwater treatment system; and the handling, transportation, and regeneration or incineration of spent GAC. Short-term risks to construction workers during the installation and/or execution of the alternatives will be mitigated by adherence to the HASP prepared to guide the health and safety aspects of this work. An experienced contractor will manage the removal, transportation, and regeneration of spent GAC.

The hydrogen peroxide used in Alternative C3 may react with metals in the subsurface and oxidize them to their highest oxidative state, potentially increasing their mobility or toxicity. Hydrogen peroxide will be added at low concentrations to minimize this risk. The hydraulic containment system will prevent oxidized metals (if any are present) from reaching the river.

The biological activity associated with Alternative C3 takes place at least 55 feet below ground surface. The nutrients and other additives to the petroleum-contaminated groundwater and associated smear zone soil may not reach the entire targeted groundwater and smear zone soil because of short circuiting as the additives travel through the vadose zone. However, the delivery of reagents to the petroleum-contaminated groundwater in the *ex situ* treatment system used by Alternative C4 is readily controllable by the operators of the system.

Alternative C2 poses fewer short-term risks than Alternatives C3 and C4. Because Alternative C3 requires the installation of a greater number of wells than Alternative C4, requires the management of hazardous materials (hydrogen peroxide and ammonium nitrate), and is more difficult to control, Alternative C3 is judged to present more short-term risks than Alternative C4.

Technical and Administrative Implementability

Alternatives C2, C3, and C4 include BMPs, groundwater monitoring, and institutional controls, which are already in place and successfully operating at the Facility. The installation of groundwater extraction wells and FPP skimming wells has been employed at the Facility in the past and is a practice with which Kaiser is familiar. Hydraulic containment is currently being used at the Facility and has been empirically demonstrated to be effective. The expansion of hydraulic containment proposed in Alternative C2 (and included in Alternatives C3 and C4) will be similar to the installation of the existing IRM system.

The bioremediation techniques proposed in Alternative C3 have been successfully demonstrated at other similar sites (FRTR 2010). The assessment provided in Appendix F shows that biodegradation is also applicable to the PCBs comingled with the SVOCs present in the smear zone. Pilot-scale treatability testing will be a necessary part of the design process for Alternatives C2, C3, and C4.

The injection of nutrients and hydrogen peroxide in Alternative C3 may require compliance with the substantive requirements of Ecology's UIC Program.

Technical and administrative implementability of the *ex situ* groundwater treatment system in Alternative C4 and the *in situ* treatment system in Alternative C3 present greater complexity than Alternative C2. Technical and administrative staff will be needed for the design, construction, and operation of the *in situ* and *ex situ* treatment systems. Staff will be needed to complete the permitting process, prepare O&M manuals, and to provide proper training for the staff involved in these alternatives.

In general, the operation of the *ex situ* treatment system in Alternative C4 will be ongoing, requiring continuous technical and administrative attention, whereas implementing an *in situ* injection program (Alternative C3) requires only periodic attention as necessitated by the injection schedule (e.g., addition of nutrients once per month). However, the nutrients and other additives injected in Alternative C3 may not reach the entire petroleum-contaminated groundwater and associated smear zone soil because of short circuiting as the injected materials travel through the vadose zone.

Alternative C2 is judged to be more implementable than Alternatives C3 and C4. Alternatives C3 and C4 present about the same degree of administrative complexity. Alternative C3 is more difficult to control than Alternative C4, since reagents must be delivered 55 feet (or more) below ground surface. Alternative C4 requires more operator attention than does Alternative C3 since its operation is continuous, whereas the injections conducted in Alternative C3 are only periodic.

Alternatives C3 and C4 are judged to have the same degree of technical and administrative implementability.

Summary of Disproportionate Cost Analysis

Alternatives C2, C3, and C4 meet the threshold requirements established in WAC 173-340-360(2)(a) and are protective of human health and the environment. Alternative C1 does not satisfy threshold criteria and thus was not evaluated in the disproportionate cost analysis.

Alternatives C2, C3, and C4 each will provide physical and administrative controls, BMPs, hydraulic containment, and FPP recovery that will reduce the potential for SVOCs in the petroleum hydrocarbon groundwater plumes and associated smear zone soil to migrate to the Spokane River. This reduction in current risk will occur in a short time frame (approximately 1 year) through expansion of the plume capture and hydraulic containment provided by the groundwater IRM system and expansion of the FPP recovery system.

Alternatives C2, C3, and C4 exhibit equivalent degrees of protectiveness of human health and the environment and are expected to permanently reduce the toxicity and volume of SVOCs and PCBs in the petroleum groundwater plume and smear zone soil AOCs. These alternatives are estimated to destroy approximately 690,000 pounds of SVOCs and 4 pounds of PCBs during their respective restoration time frames. In Alternative C3, there is a potential risk of changing the valence state of metals present in the treatment area, which could increase the toxicity and mobility of these metals. The operation of a hydraulic containment system should prevent the oxidized compounds (if any are present) from reaching the Spokane River. Alternative C4 produces more treatment residuals than Alternatives C2 and C3. Alternatives C2, C3, and C4 are judged to provide the same degree of protection to human and ecological receptors.

Alternatives C2 through C4 are expected to reduce COC concentrations to below SLs and PCULs and provide the same degree of protection to human and ecological receptors in a reasonable restoration time frame (refer to Appendix I and Section 4.3.1.3). Alternative C3 provides this protection in approximately 4 to 30 years, Alternative C4 in approximately 3 years to 24 years, and Alternative C2 in approximately 4 to 34 years. Alternatives C2, C3, and C4 are judged to provide equivalent effectiveness over the long term. Each alternative uses biodegradation as the means to reduce the toxicity, mobility, and volume of the SVOCs and PCBs comingled with SVOCs in the petroleum plumes and associated smear zone soil.

Alternative C3 presents greater short-term risks than the other alternatives because of the expected construction of a greater number of injection wells and the need to manage a greater quantity of hazardous materials. Both Alternatives C3 and C4 are less implementable technically and administratively than

Alternative C2. Alternative C3 is judged to have similar overall technical and administrative implementability as Alternative C4.

The use of *in situ* and *ex situ* processes to destroy SVOCs and PCBs comingled with SVOCs in Alternatives C3 and C4 cost approximately $41 and $59 per pound of SVOC destroyed, respectively. Alternative C2 costs approximately $33 per pound to hydraulically contain and biodegrade the same mass of SVOCs and PCBs comingled with SVOCs treated in Alternatives C3 and C4. The use of *in situ* and *ex situ* treatment processes provided in Alternative C3 or C4 comes with an additional cost of $5.2 and $18.1 million, respectively.

Alternative C4 provides an equivalent amount of protection to human health and the environment, effectiveness over the long term, and degree of permanence, and would present similar technical implementability issues as Alternative C3. Alternative C3 is expected to provide these benefits in a shorter restoration time frame. Alternative C3 is expected to present more short-term risk than Alternative C4. The substantial additional cost of implementing Alternative C4 (approximately $18.1 million) rather than Alternative C3 is judged to be disproportionate, since Alternatives C3 and C4 provide equivalent benefits, and since the restoration time frames for Alternative C3 and C4 are both judged to be reasonable. Therefore, Alternative C4 is removed from consideration as a remedy for the petroleum groundwater plumes and associated smear zone soil.

Alternative C2 provides an equivalent amount of protection to human health and the environment, effectiveness over the long term, and degree of permanence as Alternative C3. Alternative C3 is expected to provide these benefits in a shorter restoration time frame than Alternative C2. Alternative C2 presents fewer technical implementability issues and short-term risk than Alternative C3, since its containment features have been used successfully at the Facility for many years. The additional cost of implementing Alternative C3 (approximately $5.2 million) rather than Alternative C2 is judged to be disproportionate, since Alternatives C2 and C3 provide equivalent benefits, and since the restoration time frames for Alternatives C2 and C3 are both judged to be reasonable.

Therefore, Alternative C2 is judged to be the alternative that uses permanent solutions to the maximum extent practicable for the petroleum hydrocarbon groundwater plumes and associated smear zone soil containing SVOCs and for PCBs comingled with SVOCs at concentrations above SLs and PCULs.

4.3.1.3 Restoration Time Frame for SVOCs and for PCBs Comingled with SVOCs

Remedial alternatives must provide for a reasonable restoration time frame per WAC 173-340-360(2)(b)(ii). A number of factors are considered to determine whether an alternative provides for a reasonable restoration time frame (WAC 173-340-360[4][b]), which are individually assessed for the remedial alternatives for the petroleum groundwater plumes and associated smear zone soil in Section 4.2. This section compares the restoration time frames potentially achieved by the alternatives for SVOCs and comingled PCBs in these AOCs. The approaches used to estimate the restoration time frames for Alternatives C1 through C4 are discussed in Appendix I.

SVOCs. The estimated restoration time frames for remediation to occur through natural attenuation processes and operation of hydraulic containment systems in Alternatives C1 and C2 are the same. These time frames range from approximately 4 years for the South plume in the Oil House area to approximately 34 years for the North plume in the Wastewater Treatment area.

Alternative C3 adds *in situ* bioremediation to the remedial elements of Alternative C2. In Alternative C3, the time frame needed for the concentration of SVOCs in smear zone soil and petroleum groundwater plumes to fall below SLs and PCULs is estimated to range from approximately 4 years for the South plume in the Oil House area to about 30 years for the North plume in the Wastewater Treatment area (see Appendix I).

Alternative C4 adds extraction of impacted groundwater and *ex situ* treatment components to Alternative C2. The time frame needed for recovery to occur through groundwater extraction, *ex situ* treatment, and natural attenuation processes is estimated to range from approximately 3 years for the South plume in the Oil House area to 24 years for the North plume in the Wastewater Treatment area (see Appendix I) for Alternative C4.

Of the four alternatives presented in this section, Alternative C4 provides for the shortest restoration time frame (ranging from approximately 3 to 24 years for the various AOCs) for treating SVOCs and comingled PCBs in the petroleum groundwater plumes and associated smear zone soil. The restoration time frames that Alternatives C1 and C2 provide are longer but similar (approximately 4 to 34 years for each). Alternative C3 provides a restoration time frame that is slightly shorter (4 to 30 years) than the restoration time frames of Alternatives C1 and C2.

PCBs Comingled with SVOCs. It is anticipated that, over time, PCBs will remain associated with FPP, and that the removal rate of FPP from the smear zone would be a factor in the restoration time frame for comingled PCBs. Based on historical FPP recovery rates at the Facility, the estimated time to recover FPP using belt skimmers in Alternative C1 is conservatively estimated to be approximately 20 years in the Oil House area and 50 years in the Wastewater Treatment area of the Facility (refer to Section 4.1.1.2). Alternative C2 provides expanded FPP recovery by belt skimming, which reduces the recovery time to approximately 10 years in the Oil House area and 25 years in the Wastewater Treatment area (refer to Section 4.1.2.3). Alternatives C3 and C4, which incorporate Alternative C2, provide the same FPP recovery times.

The restoration time frame for PCBs comingled with SVOCs may also be associated with the restoration time frames for SVOCs in the petroleum groundwater plumes to attain SLs and PCULs through natural attenuation (Alternatives C1 and C2), *in situ* treatment (Alternative C3), or *ex situ* treatment (Alternative C4), as described above and summarized in Table 4-7. However, considering the potential for non-recoverable product to remain in the subsurface (even if the concentration of SVOCs declines to below the default residual saturation value of 2,000 mg/kg), the restoration time frame for comingled PCBs may be longer.

The restoration time frames for Alternatives C1 through C4 are judged to be reasonable, as defined by WAC 173-340-360(4), for treating SVOCs and comingled PCBs in the petroleum hydrocarbon groundwater plumes and associated smear zone soil.

4.3.1.4 Summary of Comparative Analysis of Alternatives for SVOCs and PCBs Comingled with SVOCs

Alternative C1 does not contain the petroleum groundwater plume associated with the ORB area of the Facility and does not recover FPP from some areas of the Facility where FPP has been documented to collect over time. As a result, Alternative C1 does not meet MTCA threshold requirements. Alternatives C2 through C4 are all judged to meet MTCA threshold requirements.

The use of *in situ* and *ex situ* processes to destroy SVOCs and PCBs comingled with SVOCs in Alternatives C3 and C4 cost approximately $41 and $59 per pound of SVOC destroyed, respectively. Alternative C2 costs approximately $33 per pound to hydraulically contain and biodegrade the same mass of SVOCs and PCBs that are comingled with SVOCs treated in Alternatives C3 and C4. The use of *in situ* and *ex situ* treatment processes provided in Alternative C3 or C4 comes with an additional cost of $5.2 and $18.1 million, respectively.

Since this substantial additional cost does not provide any additional potential future risk reduction to current or potential future receptors on the Facility or to receptors in the Spokane River, the costs are judged to be disproportionate to the additional benefits provided by these alternatives. Thus, Alternative C2 is judged to be the alternative that uses permanent solutions to the maximum extent practicable for the petroleum hydrocarbon groundwater plumes and associated smear zone soil containing SVOCs and for PCBs comingled with SVOCs at concentrations above SLs and PCULs.

The restoration time frames for Alternatives C2 through C4 are considered to be reasonable under WAC 173-340-360(2)(b)(ii). Among Alternatives C2 through C4, Alternative C4 provides for the shortest restoration time frame (ranging from approximately 3 to 24 years for the various AOCs) for treating SVOCs and comingled PCBs in the petroleum groundwater plumes and associated smear zone soil. The range of restoration time frames that Alternative C2 provides is longer (approximately 4 to 34 years). Alternative C3 provides a restoration time frame range that is slightly shorter (4 to 30 years) than the restoration time frames of Alternative C2.

Since Alternative C2 is judged to meet threshold requirements, is judged to use permanent solutions to the maximum extent practicable, and provides for a reasonable restoration time frame, it is judged to be the appropriate remedial alternative for the petroleum hydrocarbon plumes and associated smear zone soil at the Kaiser Facility.

4.3.2 Comparative Analysis of Alternatives Applicable to Metals

The remedial technologies that are applicable to metal treatment include Alternative C1 (institutional controls, monitoring, and MNA) and Alternative C2 (institutional controls, monitoring, MNA, and containment). These alternatives are assessed in Sections 4.2.2 and 4.2.3, respectively.

Alternative C1 does not meet MTCA threshold requirements (see Section 4.2.2). Alternative C2 meets threshold and other requirements for metals and is judged to be the alternative that uses permanent solutions to the maximum extent practicable for metals present in the petroleum hydrocarbon groundwater plumes and associated smear zone soil at concentrations above SLs and PCULs. A comparative analysis of alternatives is not conducted for metals because only one applicable technology meets threshold criteria.

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Table 4-1 - Groundwater Screening Level and Preliminary Cleanup Level Concentrations

COCs	Screening Level [a] in µg/L	Preliminary Cleanup Level [b]: Standard Point of Compliance [c] in µg/L	Preliminary Cleanup Level [b]: Conditional Point of Compliance [d] in µg/L	Conditional Point of Compliance [d]: Point of Compliance
Metals				
Arsenic	0.018	5	5	Everywhere throughout the Facility
Iron	300	300	300	Point or points where groundwater flows into surface water
Manganese	50	50	50	Point or points where groundwater flows into surface water
PCBs				
Total PCBs	6.4×10^{-5}	6.4×10^{-5}, adjusted up to 0.0045 (the MDL based on Method 8082) [e]	6.4×10^{-5}, adjusted up to 0.0045 (the MDL based on Method 8082) [e]	Point or points where groundwater flows into surface water
			0.22	Everywhere else throughout the Facility
PAHs				
cPAH - TEQ	0.0028	0.0028, adjusted up to 0.02, based on MDL [e]	0.0028, adjusted up to 0.02, based on MDL [e]	Point or points where groundwater flows into surface water
			0.06	Everywhere else throughout the Facility
TPH				
Diesel	500	< 500	(f)	
Heavy Oil	500	< 500	(f)	
Total TPH [g]	(h)	500	500	Everywhere throughout the Facility

Notes:
TPH - total petroleum hydrocarbons.
(a) Groundwater screening level concentrations were developed in Table 1-3 of the FSTM.
(b) Preliminary cleanup levels (PCULs) were developed by Ecology (Ecology 2010a and 2010b).
(c) PCULs for PCBs and cPAHs for a standard point of compliance (POC) were developed to be protective of surface water. PCULs for a standard POC are presented in Table B of the Draft Cleanup Standards document (Ecology 2010a).
(d) PCULs for a conditional POC are presented in Table C of the Draft Cleanup Standards document (Ecology 2010a).
(e) Actual MDLs may be subject to modification based on further discussions (Ecology 2010a).
(f) Diesel- and heavy oil-range TPH concentrations are not defined individually for a conditional POC in the Draft Cleanup Standards document (Ecology 2010a).
(g) Total TPH concentration in groundwater is defined as the sum of diesel- and heavy oil-range TPH concentrations (Ecology 2010a and 2010b).
(h) Total TPH concentration not considered in development of SLs.

Table 4-2 - Estimated Petroleum Hydrocarbon Concentrations and Mass to Be Treated

Plume Name	Area in sq ft	Petroleum Hydrocarbon Range	Groundwater TPH Concentrations [a]		Soil TPH Concentrations Calculated from GW Concentrations [b]		TPH Mass Calculated from GW Concentrations [c]	
			GW PCUL Concentration in mg/L	Average GW Concentration in mg/L	Soil PCUL Concentration Protective of GW in mg/kg	Estimated Soil Concentration in mg/kg	Estimated TPH Mass to be Treated in GW in Pounds	Estimated TPH Mass to be Treated in Soil in Pounds
Oil House Area - North [d]	191,500	Diesel	0.50	1.32	1,125	2,970	29.4	272,054
Oil House Area - North		Heavy Oil	0.50	0.25	994	497	(e)	(e)
Oil House Area - South	33,900	Diesel	0.50	0.88	1,125	1,980	2.4	22,318
Oil House Area - South		Heavy Oil	0.50	0.25	994	497	(e)	(e)
Wastewater Treatment Area - North	309,000	Diesel	0.50	0.92	1,125	2,070	24.3	224,844
Wastewater Treatment Area - North		Heavy Oil	0.50	0.25	994	497	(e)	(e)
Wastewater Treatment Area - South [f]	40,900	Diesel/Oil	0.50	0.92	994	1,828	3.2	29,761
Cold Mill	81,000	Diesel	0.50	1.48	1,125	3,330	14.8	137,526
Cold Mill		Heavy Oil	0.50	0.53	994	1,053	0.5	3,718
ORB - Diesel	37,400	Diesel	0.50	0.25	1,125	563	(e)	(e)
ORB - Heavy Oil		Heavy Oil	0.50	0.25	994	497	(e)	(e)
Total	**693,700**						**75**	**690,221**

Notes:

(a) Average groundwater concentrations are based on the maximum concentration measured in 2009 and the first two quarters of 2010. One half the reporting limit was used in averaging calculation if non-detect samples were present in the AOC. Only data from 2009/2010 was used to calculate average.

(b) TPH soil concentrations calculated using partitioning coefficient (K_d) and the average groundwater TPH concentration.

(c) TPH mass to be treated calculated using partitioning coefficient (K_d) and the difference between the average groundwaer TPH concentration and the PCUL of 0.50 mg/L.

(d) The resulting average diesel-range TPH concentration in the Oil House area north plume was higher than the solubility limit for diesel. This average concentration was modified by using the estimated mass of diesel in smear zone soil in this AOC and the site-specific partitioning coefficient for diesel to estimate an approximate concentration of diesel in water, based on a chemical partitioning approach (see Appendix I).

(e) Mass to be treated not estimated because groundwater TPH concentration already below PCUL.

(f) No groundwater data available for Wastewater Treatment area South plume. For mass estimation purposes, assumed average groundwater TPH concentration same as Wastewater Treatment area North plume (0.92 mg/L).

TPH - total petroleum hydrocarbons; PCUL - preliminary cleanup level; GW - groundwater; ORB - Oil Reclamation Building

mg/L - milligrams per liter; mg/kg - milligrams per kilogram; lbs - pounds, L/kg - liters per kilogram

K_d - Diesel = 2,250 L/kg; Oil = 1,987 L/kg

See Appendix E, Table E-5, for groundwater flux and plume dimensions.

Table 4-3 - Groundwater IRM System Components and Operation Status

Well ID	Well Use	Diameter in Inches	Depth/Length in Feet	Screen Depth in Feet	Operation Status	Current Flow Rate [a] in MGD	Model Flow Rate [a, b] in MGD	Extracted Groundwater Destination	Notes
Baseline System - Oil House Area									
OH-EW-1	Extraction	20	133	100 - 130	On	-1.2	-1.28	Plant process (cooling water)	
OH-SK-1	Skimming	4	88	68 - 88	Seasonal				Skimming operated during periods of free phase product accumulation.
OH-SK-2	Skimming	12	95	65 - 90	Seasonal				Skimming operated during periods of free phase product accumulation.
OH-MW-26	Deep monitoring	2	98	94 - 96	Monitored				Early warning observation well for OH-EW-1.
Baseline System - Wastewater Treatment Area									
WW-EW-1	Extraction	24	190	115 - 179	On	-4.5	-4.42	Plant process (cooling water)	
WW-EW-2	Extraction	24	198	120 - 177	On	-7.1	-7.32	Spokane River	
WW-SK-1	Skimming	12	70	40 - 70	Seasonal				Skimming operated during periods of free phase product accumulation.
WW-MW-17	Deep monitoring	2	103	100 - 102	Monitored				Early warning observation well for WW-EW-1 and WW-EW-2.
Expanded System - Oil House Area									
OH-EW-2	Extraction	24	195	108 - 140; 166 - 186	Off			Upper aquifer (OH-EW-2-US)	
OH-EW-2-US	Distribution	7	60	23 - 59	Off				
TF-EW-1	Extraction	10	178	123 - 171	Off			Upper aquifer (TF-EW-1-US)	Originally drilled to 98 ft, 16-in diameter, screen 60 to 95 ft (April 1991).
TF-EW-1-US	Distribution	10	50	13 - 49	Off				
OH-SK-3	Skimming	12	95	70 - 95	Seasonal				Skimming operated during periods of free phase product accumulation.
OH-SK-4	Skimming	8	91	71 - 91	Seasonal				Skimming operated during periods of free phase product accumulation.
Expanded System - Wastewater Treatment Area									
WW-UVB-1 (lower screen)	Extraction	14	151	105 - 140	On	-4.37	-3.35	Upper aquifer (WW-UVB-1-HS)	
WW-UVB-1 (upper screen)	Distribution	14		20 - 55	Off				
WW-UVB-1-HSS	Distribution	8 (screen)	130	Horizontal	On	1.78	1.78		
WW-UVB-1-HSM	Distribution	8 (screen)	120	Horizontal	On	0.97	0.97		
WW-UVB-1-HSN	Distribution	8 (screen)	340	Horizontal	On	1.62	1.62		
WW-EW-3 (lower screen)	Extraction	20	196	152 - 186	Off			Upper aquifer (WW-EW-3-HS)	
WW-EW-3 (middle screen)	Extraction	20		95 - 145	Off				
WW-EW-3 (upper screen)	Distribution	24		10 - 30	Off				
WW-EW-3-HS	Distribution	8 (screen)	740	Horizontal	Off				
WW-SK-2	Skimming	8	68	48 - 68	Seasonal				Skimming operated during periods of free phase product accumulation.
WW-SK-3	Skimming	8	69	49 - 69	Seasonal				Skimming operated during periods of free phase product accumulation.
WW-SK-4	Skimming	8	69	49 - 69	Seasonal				Skimming operated during periods of free phase product accumulation.

Notes:
(a) Negative flow rate indicates extraction; positive flow rate indicates injection.
(b) Flow rate data shown are from the 2008 operating period and are consistent with the flow rates used in the Kaiser groundwater flow model for this FS (see Appendix E).
HS - Denotes horizontal screen.
MGD - Million gallons per day.
US - Denotes vertical screen.

Table 4-4 – Summary of Monitoring Requirements for Remedial Alternative C1: Institutional Controls, Monitoring, and MNA [a]

Locations and Quantity (N) [b]	Medium	Frequency	Parameters (methods)	Comment	Evaluation Criteria
Monitored Natural Attenuation Monitoring Plan					
Performance monitoring wells N = 36	Groundwater	Semi-annual	Nitrate and sulfate (EPA Method 300.0) Phosphate (EPA Method 365.3) Ammonia (EPA Method 350.1) Iron (filtered, EPA Method 200.7) Manganese (filtered, EPA Method 200.8) Potassium and magnesium (EPA Method 200.7)	Assessment of biological parameters associated with natural attenuation.	TBD

Notes:

This table presents an overview of monitoring requirements. Refer to the description of the remedial alternative for more details.

(a) These monitoring requirements are for elements unique to Alternative C1 only. In addition to these requirements, Alternative C1 includes the monitoring requirements of Alternative A1 (see Table 2-3).

(b) "N" does not include quality assurance/quality control (QA/QC) samples, which will also be analyzed.

TBD - To be determined.

Table 4-5 – Summary of Monitoring Requirements for Remedial Alternative C2: Institutional Controls, Monitoring, MNA, and Containment [a]

Monitoring Type and Location	Medium	Frequency	Parameters	Comment	Evaluation Criteria
Protection Monitoring					
Dust monitoring	Air	Daily, during extraction well and skimming well installation.	Visual inspection of dust generation.	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD in HASP
Performance Monitoring					
Hydraulic containment system	NA	Weekly	Flow rates, equipment condition (maintenance needs), plume boundaries [b].	As required by the O&M Plan.	TBD
Early warning monitoring wells	Groundwater	Quarterly	SVOCs, PCBs, metals.	Conducted to determine whether the operation of the extraction wells is drawing impacted groundwater from the shallow part of the aquifer into the deeper part of the aquifer.	TBD in SAP
FPP recovery system	FPP	Seasonal, when sufficient FPP thickness accumulates.	FPP thicknesses in skimming wells; total product recovery at skimming locations; belt skimmer electrical and mechanical component condition.	As required by the O&M Plan.	TBD

Notes:

(a) Monitoring requirements for elements unique to Alternative C2 only. In addition to these requirements, Alternative C2 includes the monitoring requirements of Alternative C1 (see Table 4-4) and Alternative A1 (see Table 2-3).

(b) Monitoring the performance of the hydraulic containment system (i.e., assessing the status of the petroleum hydrocarbon plume boundaries over time) will be included as part of the regular groundwater monitoring schedule at the Facility (see Table 2-3).

NA - Not applicable.

TBD - To be determined.

Table 4-6 - Estimated FPP Volumes Based on 2009 Groundwater Data

Area	Wells	Average Product Thickness in Feet	Approximate Area of Plume in Square Feet	Estimated Volume of FPP in Gallons
Oil House - Central	OH-MW-3, OH-MW-5, OH-MW-4, OH-SK-4, OH-MW-6, OH-SK-2, OH-MW-26, OH-SK-1	0.015	19,805	660
Oil House - Northeast	TF-MW-3, TF-MW-1, TF-MW-2	0.005	5,365	60
Oil House - Southwest	OH-MW-16, OH-SK-3	0.030	3,828	258
Wastewater - North	WW-SK-4, WW-MW-13, WW-SK-3, WW-MW-6, WW-MW-8, WW-MW-19, WW-MW-17, WW-SK-1	0.011	109,624	2,729
Wastewater - South	WW-SK-2, WW-MW-3, TL-MW-4	0.013	34,310	962
TOTAL				**4,669**

Table 4-7 - Restoration Time Frame for the Petroleum Hydrocarbon Groundwater Plumes [a]

Plume Name	Petroleum Hydrocarbon Range	Average GW Concentration [b] in mg/L	Estimated TPH Mass to be Treated in GW [c] in Pounds	Estimated TPH Mass to be Treated in Soil [c] in Pounds	Restoration Time Frame in Years					
					C1	C2a	C2b	C2c	C3	C4
Oil House Area - North [d]	Diesel	1.32	29.4	272,054	28	28	28	13	27	18
Oil House Area - South	Diesel	0.88	2.4	22,318	4	4	4	2	4	3
Wastewater Treatment Area - North	Diesel	0.92	24.3	224,844	34	34	34	17	30	24
Wastewater Treatment Area - South [e]	Diesel/Oil	0.92	3.2	29,761	11	11	11	7	11	8
Cold Mill Area	Diesel	1.48	14.8	137,526	19	19	19	7	19	12
	Heavy Oil	0.53	0.5	3,718						
ORB	Meets Cleanup Criteria - NFA									

Notes:

(a) See Appendix I for assumptions and methodology used to estimate restoration time frames.

(b) Average groundwater concentrations are based on the maximum concentration measured in 2009 and the first two quarters of 2010. One half the reporting limit was used in averaging calculation if non-detect samples were present in the AOC. Only data from 2009/2010 were used to calculate average.

(c) TPH mass to be treated calculated using partitioning coefficient (K_d) and the difference between the average groundwaer TPH concentration and the PCUL of 0.50 mg/L.

(d) The resulting average diesel-range TPH concentration in the Oil House area North plume was higher than the solubility limit for diesel. This average concentration was modified by using the estimated mass of diesel in smear zone soil in this AOC and the site-specific partitioning coefficient for diesel to estimate an approximate concentration of diesel in water, based on a chemical partitioning approach (see Appendix I).

(e) No groundwater data available for Wastewater Treatment area South plume. For mass estimation purposes, assumed average groundwater TPH concentration same as Wastewater Treatment area North plume (0.92 mg/L).

TPH - total petroleum hydrocarbons; PCUL - preliminary cleanup level; GW - groundwater; ORB - Oil Reclamation Building; NFA - no further action

mg/L - milligrams per liter; mg/kg - milligrams per kilogram; L/kg - liters per kilogram

K_d - Diesel = 2,250 L/kg; Oil = 1,987 L/kg

See Appendix E, Table E-5, for groundwater flux and plume dimensions.

Table 4-8 – Summary of Monitoring Requirements for Remedial Alternative C3: Alternative C2 Plus *In Situ* Treatment [a]

Monitoring Type and Location	Medium	Frequency	Parameters	Comment	Evaluation Criteria
Protection Monitoring					
Dust monitoring	Air	Daily, during well installation	Visual inspection of dust generation.	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD in HASP
Performance Monitoring					
Injection equipment	NA	Monthly	Pressures, flow rates	As required by the O&M Plan.	TBD
Plume footprint monitoring wells	Groundwater	Annual	Nutrients, dissolved oxygen, SVOCs, metals.	To access nutrient and oxygen demand and injection well radius of influence and to determine SVOC concentration trends. Monitor for changes in metal oxidative states.	TBD
AOC footprint	Soil	Every 5 years	SVOCs, VOCs, PCBs, metals	Soil sampling from borings within the AOC footprint that are being treated to assess the radius of influence and performance of the system.	TBD

Notes:

(a) Monitoring requirements for elements unique to Alternative C3 only; monitoring requirements for Alternatives C1 and C2 are presented in Tables 4-4 and 4-5.

NA - Not applicable.

TBD - To be determined.

Table 4-9 - Alternative C4 Extraction Flow Rates and Initial Concentrations for the Petroleum Hydrocarbon Groundwater Plumes

AOC	Extraction Well	COC	Initial Average Groundwater Concentration [a] in mg/L	Extraction Flow Rate to MGD	Initial Mass in Groundwater [b] in Pounds/Day
Oil Reclamation Building	ORB-FEW-1	Diesel	0.25	0.40	0.83
		Heavy Oil/TPH (418.1)	0.25		0.83
Cold Mill	CM-FEW-3	Diesel	1.48	0.37	4.6
		Residual Range Organics (Heavy Oil)	0.53		1.7
Oil House Area - North	OH-FEW-5	Kensol/TPH (418.1)	1.32	0.49	5.4
		Heavy Oil	0.25		1.0
Oil House Area - South	OH-FEW-6	Kensol/TPH (418.1)	0.88	0.29	2.1
		Heavy Oil	0.25		0.60
Wastewater Treatment Area - North	WW-FEW-5	Kensol/Diesel/TPH (418.1)	0.92	0.79	6.0
		Heavy Oil	0.25		1.6
Wastewater Treatment Area - South [c]	WW-FEW-6	Diesel/Oil	0.92	0.39	3.0
Total				**2.7**	**28**
Average Concentration			**1.2**		

Notes:
(a) See Section 4.1.4.1 for discussion of these values.
(b) Initial mass in groundwater estimate assumes top 20 feet of water table are contaminated (see Sections 4.1.3 and 4.1.4 for more detail).
(c) No groundwater data available for Wastewater Treatment area South plume. For mass estimation purposes, assumed average groundwater TPH concentration same as Wastewater Treatment area North plume (0.92 mg/L).

Table 4-10 – Physical and Chemical Screening of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

Remedial Technology	Process Options	Description	Screening Comments	Technology Retained
Suspended Growth Bioreactors (Aeration Basins)	Aeration Basins	Various aeration basin designs exist (e.g., complete mix, plug flow, extended aeration basin). For the Kaiser Facility, an extended aeration basin design was considered since this technology could treat the low biochemical oxygen demand (BOD) loading rates of the influent stream. The extended aeration basin design consists of three components: (1) reactor where microorganisms are kept in suspension; (2) liquid-solids separation; and (3) possibly a recycle stream for returning biomass to reactor. Reactor designs typically include large oxidation ditches or reactors which allow for long hydraulic retention time (Metcalf & Eddy 2003).	Technology may be able to treat flow rates and influent BOD concentration that are expected at the Facility. Estimated flow rates are approximately 2.6 MGD and 26 pounds SVOCs/day.	Yes
	Aerated Ponds or Lagoon	Relatively shallow earthen basins with mechanical aerators on floats or fixed platforms that can be operated on a flow-through basis or with solids recycle. Aerated ponds or lagoon without recycle can be treated as a complete mix reactor without recycle. An aerated pond or lagoon with solids recycle is a type of extended aeration basin – refer to discussion on aeration basins for more details on this technology (Metcalf & Eddy 2003).	Aerated pond or lagoons operated on a flow-through basis can be treated as a complete mix reactor without recycle. The required BOD loading rates (20 to 100 pounds BOD/1000 $ft^3 \cdot d$) for these types of reactors are higher than the expected extracted influent stream at Kaiser. Aerated ponds or lagoons with solids recycle can be treated as an extended aeration basin – refer to discussion on aeration basins for more details on this technology (Metcalf & Eddy 2003).	Yes – see screening comments
	Stabilization Ponds	Shallow basins that use algae and heterotrophic bacteria for the treatment of wastewater. Technology depends on natural development of algae and bacteria. Typically used in tropical and subtropical countries (IRC 2004).	This technology would not be applicable at the Kaiser Facility because of frequent cold climate conditions in the Spokane area.	No

Table 4-10 – Physical and Chemical Screening of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

Remedial Technology	Process Options	Description	Screening Comments	Technology Retained
	Sequencing Batch Reactors (SBRs)	Uses fill-and-draw reactor with complete mixing during a batch reaction step. Five steps: (1) fill; (2) react; (3) settle; (4) decant; and (5) idle. SBRs can treat flow rates up to 5 MGD and low BOD influent concentrations (EPA 1999).	Technology may be able to treat flow rates and influent BOD concentration that are expected at the Facility.	Yes
	Constructed wetlands	Consists of shallow ponds (<1 m deep) planted with aquatic plants that rely upon natural biological, physical, and chemical processes to treat wastewater (EPA 2000b).	Year-round treatment required by this technology will be difficult at the Facility because of cold weather conditions.	No
Attached Growth Bioreactor	Trickling Filter	Nonsubmerged fixed-film biological reactor using rock or plastic as fixed film media. Wastewater is distributed continuously over packing material. Trickling filters can be designed to handle low BOD loading rates and a range of influent flow rates (Metcalf & Eddy 2003).	Technology may be able to treat flow rates and influent BOD concentration that are expected at the Facility.	Yes
	Rotating Biological Contactors (RBCs)	Fixed-film biological reactor where biofilm is attached to shaft-mounted, closely spaced circular disks that are rotated through wastewater. The disks are partially or completely submerged. Reactor has small footprint. RBCs can treat influent streams with low BOD concentrations and a range of influent flowrates. (Metcalf & Eddy 2003).	Technology may be able to treat flow rates and influent BOD concentration that are expected at the Facility.	Yes
	Roughing Filter	A type of trickling filter that is capable of treating high organic loads at high hydraulic loading rates (Metcalf & Eddy 2003).	Technology cannot treat low influent BOD concentration that is expected at the Facility.	No
	Fixed Bed Reactors	Fixed film reactor where biofilm is attached to fixed packing materials that are submerged in wastewater. Water flows past packing material for treatment. Plastic is a common material for packing media. Oxygen is supplied by diffused aeration into the bed or predissolved into influent wastewater. Small space requirement and can treat dilute wastewaters (Metcalf & Eddy 2003).	Technology may be able to treat flow rates and influent BOD concentration that are expected at the Facility.	Yes

Table 4-10 – Physical and Chemical Screening of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

Remedial Technology	Process Options	Description	Screening Comments	Technology Retained
	Fluidized Bed Reactors (FBRs)	Biofilm is attached to a bed of sand or activated carbon (0.4 to 0.5 mm) that is fluidized by wastewater flowing upward through the bed. Recycle stream may be required for fluidization. Activated carbon allows for long solids retention time (SRT) since chemical are adsorbed onto carbon. Long SRTs allow for the degradation of toxic chemicals may not be readily biodegraded (Metcalf & Eddy 2003).	Technology was retained since long SRTs will allow for degradation of the low BOD loading of the influent stream at the Facility.	Yes
Chemical Oxidation	UV with Hydrogen Peroxide or Ozone	*Ex situ* chemical oxidation of groundwater uses hydrogen peroxide or ozone combined with UV light to produce hydroxyl radicals that degrade organic contaminants. Commonly used to treat residual organic compounds or compounds that are not readily degradable. Can treat a range of flow rates (EPA 1993, GWTRAC 1996, Suntherson 1997).	Technology retained since it can treat low contaminant concentrations and flow rates that are expected at the Facility.	Yes
Adsorption	Carbon Adsorption	Granulated activated carbon (GAC) beds can adsorb organics and PCBs. Commonly used in wastewater treatment as a final polishing step (Metcalf & Eddy 2003).	Technology retained since it can treat low contaminant concentrations and flow rates that are expected at the Facility.	Yes
Suspended Solids Removal	Sedimentation	Sedimentation tanks are used to settle suspended particles denser than water by gravity (Metcalf & Eddy 2003).	The expected TSS loading of extracted groundwater from the facility is low and sedimentation would not be effective; however, sedimentation tanks may be required downstream of biological treatment processes to allow settling of biomass (Metcalf & Eddy 2003).	Yes

Table 4-10 – Physical and Chemical Screening of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

Remedial Technology	Process Options	Description	Screening Comments	Technology Retained
	Precipitation	The addition of chemicals to alter the physical state of dissolved and suspended solids to facilitate their removal by sedimentation. Includes coagulation, flocculation, and pH adjustment. Typically, bench-scale studies are needed to determine whether chemical addition is needed for the treatment of wastewater (Metcalf & Eddy 2003).	The expected TSS loading of extracted groundwater is low. For purposes of this evaluation, it was assumed suspended solids removal by precipitation will not be needed, however in reality, bench-scale studies of wastewater will be needed to verify this assumption.	No
	Depth Filtration	Conventional technology to removal residual particles from groundwater. Filter made of granular or compressible filter material (e.g., sand). Typically used for the removal of particles approximately 10 µm or greater. Multimedia filters often used when particle size is in the 1 to 10 µm range. Depending on water quality, may require pre- and post-treatment (Metcalf & Eddy 2003).	Technology retained since commonly used for the removal of suspended solids.	Yes
	Surface Filtration	Conventional technology used for the removal of residual particles from groundwater. Depending on water quality, may require pre- and post-treatment. Cloth-medium filters have pore sizes of 10 to 30 µm (Metcalf & Eddy 2003).	Technology retained since commonly used for the removal of residual suspended solids.	Yes

Table 4-11 – Implementability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for *Ex Situ* Suspended Growth Reactors
Attribute	**Extended Aeration Basins**
Can it be constructed?	No. Extended aeration basins require long hydraulic retention times (20 to 30 hours) and with flow rates that are expected at the Facility (approximately 2.6 MGD) the total volume required for aeration basin(s) would be impracticable (> 1,000 acres) (Metcalf & Eddy 2003).
Will it work?	Uncertain. Technology is known to operate from 5 to 15 pounds BOD/1000 $ft^3 \cdot d$ (Metcalf & Eddy 2003). Initial concentrations of influent stream are expected below this range and decrease over time; therefore, it is uncertain whether the biomass can be sustained during course of cleanup. The large aeration basins that are required will make contact between contaminants, biomass, and oxygen difficult.
Will this be acceptable to regulatory agencies?	Uncertain.
Is technology available?	Uncertain. Unknown if technology has been used for large influent flow rates required for the Facility.
Is process option accepted?	No. Based on impracticable size required for reaction vessel and uncertainty of system performance during course of treatment.

Table 4-12 – Implementability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for *Ex Situ* Suspended Growth Reactors
Attribute	**Sequencing Batch Reactors (SBRs)**
Can it be constructed?	Yes. SBRs are an established technology that can handle required flow rates (less than 5 MGD) and low BOD loading (5 to 15 pounds BOD/1000 $ft^3 \cdot d$). Based on an estimated hydraulic retention time of 5 hours, approximately 200,000 gallons of reactor volume would be needed. This will likely require the installation of several large reactors (Metcalf & Eddy, EPA 1999).
Will it work?	Uncertain. Technology is known to operate from 5 to 15 pounds BOD/1000 ft^3 d (Metcalf and Eddy 2003). Initial concentrations of influent stream are expected to be below this range and decrease over time; therefore, it is uncertain if the biomass can be sustained during course of cleanup.
Will this be acceptable to regulatory agencies?	Uncertain.
Is technology available?	Yes
Is process option accepted?	Yes, since technology can be constructed and may be able to treat initial contaminant concentrations of extracted groundwater. System may require modification during the course of treatment to treat lower influent concentrations.

Table 4-13 – Implementability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for *Ex Situ* Attached Growth Reactors
Attribute	**Trickling Filter**
Can it be constructed?	Yes. Trickling filters can treat low BOD loading influent streams (0.07 to 0.22 kg BOD/$m^3 \cdot d$). Based on recommended design hydraulic loading rate for systems with low BOD loading (1 to 4 $m^3/m^2 \cdot d$), multiple trickling filters may be required in parallel that are estimated to be 30 to 50 feet diameter (Metcalf & Eddy 2003).
Will it work?	Uncertain. Technology is known to operate from 0.07 to 0.22 kg BOD/$m^3 \cdot d$ (Metcalf & Eddy 2003). Initial concentrations of influent stream are expected to be below this range and decrease over time; therefore, it is uncertain if the biomass can be sustained during the course of cleanup. Pilot-scale tests would be required to verify ability to treat the COCs present in the groundwater plumes.
Will this be acceptable to regulatory agencies?	Yes
Is technology available?	Yes
Is process option accepted?	Yes, since technology can be constructed and system may be able to treat initial contaminant concentrations of extracted groundwater. System may require modification during the course of treatment to treat lower influent concentrations.

Table 4-14 – Implementability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for *Ex Situ* Attached Growth Reactors
Attribute	**Rotating Biological Contactors (RBCs)**
Can it be constructed?	Yes. RBCs are an established technology with hundreds installed around the world. An RBC consists of a series of closely spaced circular disks of polystyrene or polyvinyl chlorine (PVC) that are submerged in wastewater and rotated through it. The cylindrical plastic disks are attached to a horizontal shaft and are provided at a standard unit size of approximately 12 feet in diameter and 25 feet in length. The surface area of disks for a standard unit is approximately 100,000 sq ft. Based on estimated hydraulic loading rates and influent BOD loading, approximately nine standard units would be required for Kaiser's influent stream (Metcalf & Eddy 2003).
Will it work?	Uncertain. Technology is known to operate from 8 to 20 g BOD/ $m^2 \cdot d$ (Metcalf & Eddy 2003). Initial concentrations of influent stream are expected to be below this range and decrease over time; therefore, it is uncertain if the biomass can be sustained during the course of clean up. Due to complexity of RBC design and the uncertainty of performance, pilot plant studies will be required.
Will this be acceptable to regulatory agencies?	Yes
Is technology available?	Yes
Is process option accepted?	Yes, since technology can be constructed and may be able to treat initial contaminant concentrations of extracted groundwater. System may require modification during the course of treatment to treat lower influent concentrations.

Table 4-15 – Implementability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for *Ex Situ* Attached Growth Reactors
Attribute	**Fixed Bed Reactor**
Can it be constructed?	Yes. Fixed bed reactors have small hydraulic retention times; therefore, it is likely that footprint will be small (Metcalf & Eddy 2003).
Will it work?	Uncertain. Currently there are many different types of reactor configurations available. Based on loading data found (3.5 to 4.5 kg $BOD/m^3 \cdot d$ or 10 to 12 kg $COD/m^3 \cdot d$) loading rates from the Facility (approximately 0.06 kg $BOD/m^3 \cdot d$) may be too low. Pilot plant or bench-scale studies will be required.
Will this be acceptable to regulatory agencies?	Yes
Is technology available?	Yes
Is process option accepted?	Yes

Table 4-16 – Implementability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for *Ex Situ* Attached Growth Reactors
Attribute	**Fluidized Bed Reactor (FBRs)**
Can it be constructed?	Yes. Fluidized bed reactors have low hydraulic retention times; therefore, it is likely that footprint will be small (Metcalf & Eddy 2003). Subcontractors would assemble units on site.
Will it work?	Yes. Aerobic FBRs are frequently used to treat groundwater contaminated with hazardous substances (Metcalf & Eddy 2003). Pilot-scale tests would be required to verify performance.
Will this be acceptable to regulatory agencies?	Yes
Is technology available?	Yes
Is process option accepted?	Yes

Table 4-17 – Implementability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for *Ex Situ* Chemical Oxidation
Attribute	**UV with Hydrogen Peroxide or Ozone**
Can it be constructed?	Yes. There are a variety of chemical oxidation reactor configurations available for *ex situ* treatment from different manufacturers (e.g., Cavox®, Ultrox™, perox-pure™). The perox-pure™ technology is available on skid-mounted units (EPA 1993, GWTRAC 1996).
Will it work?	Yes. *Ex situ* chemical oxidation technology perox-pure™ can treat SVOCs at concentrations less than 500 mg/L at flow rates expected at the Facility (based on information provided by vendor). Perox-pure™ technology relies on the destruction of organic compounds by hydroxyl radicals formed from UV photocatalysis of hydrogen peroxide. Over the course of *ex situ* treatment, influent concentrations are expected to decrease, which may require adjustments to hydrogen peroxide rates (EPA 1993). Pilot-scale tests will be required to verify performance at the Kaiser Facility.
Will this be acceptable to regulatory agencies?	Yes. Perox-pure™ technology was part of EPA's Superfund Innovative Technology Evaluation (SITE) program (EPA 1993). UV oxidation is a presumptive remedy for the treatment of SVOCs in groundwater (EPA 1996b).
Is technology available?	Yes.
Is process option accepted?	Yes, it is expected that perox-pure™ technology will be able to treat extracted groundwater stream at the Kaiser Facility over the course of treatment.

Table 4-18 – Implementability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for Carbon Adsorption
Attribute	**Granular Activated Carbon (GAC)**
Can it be constructed?	Yes, established technology for wastewater treatment and can be designed and constructed in <1 year.
Will it work?	Yes. Based on the potential for carbon bed fouling, pretreatment will be required. GAC bed typically used as final polishing step for treatment of residual organics (e.g., PCBs that are comingled with SVOCs). GAC has been used at CERCLA sites to remove low concentrations of PCBs from groundwater.
Will this be acceptable to regulatory agencies?	Yes
Is technology available?	Yes
Is process option accepted?	Yes

Table 4-19 – Implementability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for Sedimentation
Attribute	**Sedimentation Tanks**
Can it be constructed?	Yes, can be designed and constructed in <1 year. Established wastewater technology. Size and number of tanks will depend on the concentration, specific gravity, and surface properties of the suspended solids (Metcalf & Eddy 2003).
Will it work?	Uncertain. Bench-scale and pilot-scale tests will be required to determine appropriate design for the *ex situ* treatment system. May be used as a pre-treatment step associated with another biological treatment technology.
Will this be acceptable to regulatory agencies?	Yes
Is technology available?	Yes
Is process option accepted?	Yes, however, only as a pre- or post-treatment step for other SVOC treatment technologies.

Table 4-20 – Implementability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for Depth Filtration
Attribute	**Single Medium, Dual Media, Multimedia**
Can it be constructed?	Yes, can be designed and constructed in <1 year. Established wastewater technology.
Will it work?	Yes. Conventional technology. Depth filters currently in use at the Kaiser IWT plant are sand bed filters and a black walnut shell filter. Size of filter media particles, depth of filter media, type of filter media, and the number of filter units necessary depends on parameters such as water quality, influent flow rate, and how well TSS adheres to filter media. Bench-scale/pilot-scale tests will identify the appropriate media for the petroleum hydrocarbon groundwater plumes.
Will this be acceptable to regulatory agencies?	Yes
Is technology available?	Yes
Is process option accepted?	Yes, however, as a pre- or post-treatment step for extracted groundwater prior to the treatment of SVOCs by biological or oxidation processes.

Table 4-21 – Implementability of *Ex Situ* Groundwater Treatment Technologies for The Petroleum Hydrocarbon Groundwater Plumes

	Process Options for Surface Filtration
Attribute	**Bag, Cartridge, or Disk Filter**
Can it be constructed?	Yes, can be designed and constructed in <1 year. Established technology.
Will it work?	Yes. Conventional technology. The type and number of filters used depends on the influent water quality. Bench scale/pilot-scale tests are required. Frequently used as final pretreatment step before technologies very sensitive to fouling such as GAC adsorption and membrane technologies.
Will this be acceptable to regulatory agencies?	Yes
Is technology available?	Yes
Is process option accepted?	Yes, however, as a pre- or post-treatment step for groundwater that is treated by biological or oxidation processes to destroy SVOCs.

Table 4-22 – Reliability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for Suspended Growth Reactors
Attribute	**Sequential Batch Reactors (SBRs)**
Has this process option been used at the scale required for Kaiser?	Yes, SBRs can be used for flow rates up to 5 MGD (EPA 1999).
Are operation and maintenance requirements infrequent and straightforward?	No. SBR systems involve complex controls, automatic valves, and automatic switches. The level of sophistication may be very advanced in larger SBR wastewater treatment plants requiring a higher level of maintenance of the automatic valves and switches (EPA 1999) than other suspended growth reactors.
Has this process option been proven effective under COC and site conditions similar to those at Kaiser?	Uncertain. SBRs have been used for flow rates up to 5 MGD. Technology is known to operate from 5 to 15 pounds BOD/1000 $ft^3 \cdot d$ (EPA 1999, Metcalf & Eddy 2003). Initial concentrations of influent stream are expected to be below this range and decrease over time; therefore, it is uncertain whether the biomass can be sustained during course of cleanup. Pilot-scale tests would be required to verify performance at Kaiser.
Is process option accepted?	No. Based on complex O&M systems and uncertainty of performance during course of cleanup.

Table 4-23 – Reliability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for Trickling Filter
Attribute	**Trickling Filter**
Has this process option been used at the scale required for Kaiser?	Yes, trickling filters have been used to provide biological wastewater treatment of municipal and industrial wastewaters for nearly 100 years. BOD removal efficiency is 80% to 90% (Metcalf & Eddy 2003).
Are operation and maintenance requirements infrequent and straightforward?	Yes. A trickling filter is a nonsubmerged fixed-film biological reactor that uses rock or plastic packing over which wastewater is distributed continuously. Influent wastewater normally piped at top of packing trough distributor arms that extend across the filter and rotate. Trickling filters show a high degree of reliability if operating conditions remain steady and the wastewater temperature does not fall below 55 ^{o}F. Based on temperature fluctuations at the Facility, the technology will run more effectively if it is in an enclosed, temperature-controlled facility. Backflushing and cleaning of underdrains will periodically be required. Effluent stream may need filtering to removed suspend solids before final GAC polishing (Metcalf & Eddy 2003, Pipeline 2004).
Has this process option been proven effective under COC and site conditions similar to those at Kaiser?	Uncertain. Technology is known to operate from 0.07 to 0.22 kg BOD/$m^3 \cdot$ d (Metcalf & Eddy 2003). Initial concentrations of influent stream are expected to be below this range (approximately 3 x 10^{-3} kg BOD/$m^3 \cdot$ d) and decrease over time; therefore, it is uncertain if the biomass can be sustained during course of cleanup. Pilot-scale tests will be required to verify performance at Kaiser (SVOC destruction efficiency).
Is process option accepted?	No. Because of uncertainty of performance during course of cleanup and difficulty in maintaining a viable facultative bacterial culture at the low SVOC concentrations expected in groundwater extracted from the petroleum hydrocarbon groundwater plumes.

Table 4-24 – Reliability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for Attached Growth Reactors
Attribute	**Rotating Biological Contactors (RBCs)**
Has this process option been used at the scale required for Kaiser?	Yes, based on hydraulic loading rates a number of RBC units can be used to treat the required influent flow rate at the Facility (see Table 4-13 for more detail).
Are operation and maintenance requirements infrequent and straightforward?	No. RBCs are complex in design. The major elements of an RBC system design are the shaft, disk materials and configuration, drive system, enclosures, and settling tanks. RBC units are rotated by directed mechanical- or air-drive units attached to a central shaft. RBC units have to be enclosed to protect plastic disks from deterioration caused by UV light, protect the process from low temperatures, protect disks and equipment from damage, and control algae buildup (Metcalf & Eddy 2003). Maintenance, repair, and replacement may be required to maintain the integrity of plastic disks and drive systems. As discussed above and in Table 4-14, due to high flow rates, multiple RBC units will be required, which will multiply O&M needs.
Has this process option been proven effective under COC and site conditions similar to those at Kaiser?	Uncertain. Technology is known to operate from 8 to 20 g BOD/ $m^2 \cdot d$ (Metcalf & Eddy 2003). Initial concentrations of influent stream are expected to be at the lower end of this range and decrease over time; therefore, it is uncertain whether the biomass can be sustained during course of cleanup. Based on complexity of RBC design, pilot-scale studies may be required.
Is process option accepted?	No. Based on uncertainty of system performance during course of cleanup and increase level of O&M.

Table 4-25 – Reliability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for Attached Growth Reactors
Attribute	**Fixed Bed Reactors**
Has this process option been used at the scale required for Kaiser?	No. Fixed bed reactors are typically not used for the flow rates (MGD range) expected at the Kaiser Facility.
Are operation and maintenance requirements infrequent and straightforward?	Yes. Post treatment will likely be required to remove biomass that may have sloughed off from reactor bed. Nutrient addition may be required.
Has this process option been proven effective under COC and site conditions similar to those at Kaiser?	Uncertain. Currently there are many different types of reactor configurations available. Based on loading data (3.5 to 4.5 kg $BOD/m^3 \cdot d$ or 10 to 12 kg $COD/m^3 \cdot d$), loading rates from the Facility may be too low and will decrease over time. Pilot-scale tests will be required to verify performance at the Kaiser Facility.
Is process option accepted?	No. Technology typically not used at scale required at Kaiser. Uncertainty of system performance during course of cleanup.

Table 4-26 – Reliability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for Attached Growth Reactors
Attribute	**Fluidized Bed Reactors (FBRs)**
Has this process option been used at the scale required for Kaiser?	No. Fluidized bed reactors are typically not used for the flow rates expected at the Facility (approximately 2.6 MGD range).
Are operation and maintenance requirements infrequent and straightforward?	No. System monitoring will be required to ensure flow rates are sufficient for fluidization and there is not a buildup of biomass that may hinder fluidization. Lack of fluidization may affect system performance. Post-treatment will likely be required to remove biomass that may have sloughed off from reactor bed. Nutrient addition may be required.
Has this process option been proven effective under COC and site conditions similar to those at Kaiser?	Uncertain. The loading rates from the Facility (approximately 3×10^{-3} kg BOD/$m^3 \cdot d$) will be too low to develop and maintain the biomass concentration needed to optimize the performance of the technology. Pilot-scale tests would be required to verify performance.
Is process option accepted?	No. Technology typically not used at scale necessary at Kaiser, is relatively complex to operate, and uncertainty of system performance during course of cleanup.

Table 4-27 – Reliability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for Chemical Oxidation
Attribute	**UV with Hydrogen Peroxide or Ozone**
Has this process option been used at the scale required for Kaiser?	Yes. *Ex situ* chemical oxidation technology perox-pure™ can treat SVOCs at concentrations less than 500 mg/L at flow rates expected at the Facility (based on information provided by vendor) (EPA 1993).
Are operation and maintenance requirements infrequent and straightforward?	No. Perox-pure™ technology is available on skid-mounted units. Units contain electrical and mechanical parts required for chemical oxidation including automated, self-cleaning mechanism for UV lamps. Pretreatment of wastewater is required to remove suspended solids from influent stream which will decrease fouling of UV lamps and maintain efficiency of the system (EPA 1993). Hydrogen peroxide will need to be added to influent stream and there are some health and safety concerns associated with this chemical.
Has this process option been proven effective under COC and site conditions similar to those at Kaiser?	Yes. Per vendor information, perox-pure™ technology can treat SVOCs at concentrations less than 500 mg/L. Perox-pure™ technology relies on the destruction of organic compounds by hydroxyl radicals formed from UV photocatalysis of hydrogen peroxide. Over the course of *ex situ* treatment, influent concentrations are expected to decrease, which may require adjustments to hydrogen peroxide rates (EPA 1993).
Is process option accepted?	No. High O&M requirements based on the complexity of the system.

Table 4-28 – Reliability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

Attribute	Process Options for Carbon Adsorption Granular Activated Carbon (GAC)
Has this process option been used at the scale required for Kaiser?	Yes, but GAC is typically used as a final polishing step, that is, following removal of the bulk of suspended solids, oil, and grease by another technology. However, at the Facility, influent contaminant concentrations are low enough that GAC adsorption can be used for SVOC and PCB removal.
Are operation and maintenance requirements infrequent and straightforward?	Yes. Pretreatment will be required to remove suspended solids to prevent early carbon bed fouling. Periodically, the carbon bed will need to be backflushed to remove accumulated solids. At exhaustion, the carbon bed will have to be disposed of and, depending on concentrations of PCBs, spent carbon may have to be disposed of as hazardous waste.
Has this process option been proven effective under COC and site conditions similar to those at Kaiser?	Yes.
Is process option accepted?	Yes, should be able to treat influent stream to *ex situ* system and relatively low O&M requirements.

Table 4-29 – Reliability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

	Process Options for Sedimentation
Attribute	**Sedimentation Tanks**
Has this process option been used at the scale required for Kaiser?	Yes, conventional technology for the removal of particles denser than water (Metcalf & Eddy 2003).
Are operation and maintenance requirements infrequent and straightforward?	Yes. Periodically, settled sludges in tanks will have to be removed, thickened, and eventually disposed of properly.
Has this process option been proven effective under COC and site conditions similar to those at Kaiser?	Yes, however, only as a suspended solids removal step pre- or post-SVOC treatment. For treatment of SVOCs by UV oxidation, sedimentation could be used as a pretreatment step to remove suspended solids. Based on the expected low concentrations of suspended solids in extracted groundwater, it is judged that sedimentation tanks would not be an effective technology for the *ex situ* treatment system at the Facility.
Is process option accepted?	No. Based on low TSS concentrations of the influent stream.

Table 4-30 – Reliability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

Attribute	Process Options for Depth Filtration Single Medium, Dual Media, Multimedia
Has this process option been used at the scale required for Kaiser?	Yes, conventional technology for the removal of particles approximately 1 µm or greater in diameter (Metcalf & Eddy 2003). Sand bed filters and black walnut shell (BWS) filter are depth filters in use at Kaiser's IWT Plant.
Are operation and maintenance requirements infrequent and straightforward?	Yes. Periodically filter will need to be backflushed to remove accumulated solids.
Has this process option been proven effective under COC and site conditions similar to those at Kaiser?	Yes, however, as a pretreatment step for filtration technologies (surface and membrane filtration) designed to remove submicron particulates and/or technologies that are sensitive to solids fouling.
Is process option accepted?	Yes, however, best as pretreatment for smaller filtration technologies or technologies sensitive to solids fouling.

Table 4-31 – Reliability of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

Attribute	Process Options for Surface Filtration Bag, Cartridge, or Disk Filter
Has this process option been used at the scale required for Kaiser?	Yes, conventional technology. Cloth medium filters have pore sizes of 10 to 30 µm (Metcalf & Eddy 2003). Cartridge filters with pore sizes as low as 0.5 µm are available (McMaster Carr 2009).
Are operation and maintenance requirements infrequent and straightforward?	Yes. Periodically filter units will have to be replaced after they are exhausted.
Has this process option been proven effective under COC and site conditions similar to those at Kaiser?	Yes, however, as a pretreatment step to filtration technologies (surface and membrane filtration) designed to remove submicron particulates and/or PCB removal technologies that are sensitive to solids fouling such as carbon adsorption.
Is process option accepted?	Yes, as a filtration step pre- or post-GAC treatment.

Table 4-32 - Summary of *Ex Situ* Groundwater Treatment Technologies for the Petroleum Hydrocarbon Groundwater Plumes

Remediation Technology	Process Option	Physical and Chemical Screening	Implementability Screening	Reliability Screening
Oil-water Separation[a]	API Separator	**Retained**	**Retained**	**Retained**
	Dissolved Air Flotation (DAF)	**Retained**	Eliminated	Eliminated
Suspended Growth Reactors	Aeration Basin	**Retained**	Eliminated	--
	Aerated Ponds or Lagoon	**Retained**	Eliminated	--
	Stabilization Ponds	Eliminated	--	--
	Sequencing Batch Reactors (SBRs)	**Retained**	**Retained**	Eliminated
	Constructed Wetlands	Eliminated	--	--
Attached Growth Reactors	Trickling Filter	**Retained**	**Retained**	Eliminated
	Rotating Biological Contactors (RBCs)	**Retained**	**Retained**	Eliminated
	Roughing Filter	Eliminated	--	--
	Fixed Bed Reactors	**Retained**	**Retained**	Eliminated
	Fluidized Bed Reactors (FBRs)	**Retained**	**Retained**	Eliminated
Chemical Oxidation	UV with Hydrogen Peroxide or Ozone	**Retained**	**Retained**	Eliminated
Adsorption	Carbon Adsorption	**Retained**	**Retained**	**Retained**
Suspended Solids Removal	Sedimentation	**Retained**	**Retained**	Eliminated
	Percipitation	Eliminated	--	--
	Depth Filtration	**Retained**	**Retained**	**Retained**
	Surface Filtration	**Retained**	**Retained**	**Retained**

Note:
(a) Screening of oil/water separation technologies is presented in Appendix H. There are no screening tables for oil/water separation technologies.

Table 4-33 - Design Criteria and Equipment Information for the *Ex Situ* Treatment System

Vessel	Basis of Design	Design Values	(Number) and Size of Equipment for Costing Purposes	References
Oil/Water Separator	Hydraulic retention time (HRT)	HRT = 1 hr	(1) 100,000 gallon	Assumed HRT.
Depth Filtration	Filtration rate, typical bed depth, number of beds	Filtration rate = 240 $L/m^2 \cdot d$ Typical depth = 920 mm Number of beds = 5	(5) 500,000 gallon	Filtration rate for dual-medium filter bed (graded anthracite and sand) from Example 11-3, p. 1063, Metcalf and Eddy 2003. Depth from Table 11-6, p. 1070, Metcalf and Eddy 2003.
Surface Filtration	Filtration rate, typical drum dimensions	Filtration rate = 0.54 $m^3/m^2 \cdot min$ Drum diameter = 4.5 ft Drum diameter = 10 ft	(8) 1,000 gallon	Filtration rate, typical drum dimensions from Table 11-14, p. 1100, Metcalf and Eddy 2003.
Carbon Adsorption	Empty bed contact time (EBCT), size of bed, density of carbon	EBCT = 10 min Min. size of each bed = 8,000 gallons Density of carbon = 450 g/L Three beds in parallel, 2 series of 3 beds.	(6) 10,000 gallon	EBCT from Table 11-3, p. 1152, Metcalf and Eddy 2003. Assumed size of bed and GAC density from Example 11-10, p. 1155, Metcalf and Eddy 2003.

Table 4-34 – Summary of Monitoring Requirements for Remedial Alternative C4: Groundwater Extraction with *Ex Situ* Treatment for Petroleum Hydrocarbon Groundwater Plumes [a]

Locations	Medium	Frequency	Parameters (methods)	Equipment	Comment	Evaluation Criteria
Installation						
Ambient air	Air	1 time per day	VOCs	MultiRae	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD
Ambient air	Air	1 time per day	Dust generation from visual observation.	NA	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD
Annual O&M						
Groundwater monitoring along treatment train and effluent	Water	Monthly	Diesel- and heavy oil-range hydrocarbons, PCBs, pH.	Sample port	As required by the *ex situ* O&M Plan and Discharge Permits.	Groundwater SL
Treatment system pressures	Water	Weekly	Pressure	Pressure gage	As required by the *ex situ* O&M Plan.	TBD
Treatment flow rates	Water	Weekly	Flow rate	Flow meter	As required by the *ex situ* O&M Plan.	TBD
Conveyance Pipe	Galvanized Iron	Weekly	Visual signs of deterioration (e.g., abrasion, leaks) to be recorded. Leaks to be repaired.	NA	As required by the *ex situ* O&M Plan.	TBD

Table 4-34 – Summary of Monitoring Requirements for Remedial Alternative C4: Groundwater Extraction with *Ex Situ* Treatment for Petroleum Hydrocarbon Groundwater Plumes [a]

Locations	Medium	Frequency	Parameters (methods)	Equipment	Comment	Evaluation Criteria
Oil/Water Separator	Water, FPP	Weekly	Measure FPP thickness to monitor product recovery at Facility and ensure proper operation of separator.	Oil water interface meter	As required by the *ex situ* O&M Plan.	TBD

Notes:

(a) This table presents an overview of monitoring requirements for the groundwater extraction and *ex situ* treatment system portion of Alternative C4. Refer to Tables 4-4 and 4-5 for monitoring requirements for Alternatives C1 and C2.

TBD To be determined.

Table 4-35 - Summary of Detailed Analysis of Alternatives Applicable to SVOCs and Comingled PCBs in Petroleum Hydrocarbon Groundwater Plumes at the Kaiser Facility

	Criteria	Alternative C1	Alternative C2	Alternative C3	Alternative C4
		Institutional Controls, Monitoring, MNA, and Current Groundwater IRM System Operation	Alternative C1 Plus Expanded Hydraulic Containment and FPP Recovery	Alternative C2 Plus *In Situ* Enhanced Bioremediation	Alternative C2 Plus *Ex Situ* Treatment
Threshold Requirements	Overall Protection of Human Health and the Environment	The petroleum groundwater plume AOCs are located at depths that prevent Facility workers and visitors from direct contact with COCs in these areas. Institutional controls in place at Kaiser reduce the potential for worker exposure to COCs and prevent the potential release of COCs to the environment from industrial activities at the Facility. Biodegradation of petroleum hydrocarbon COCs and comingled PCBs in groundwater in the Wastewater Treatment area is being promoted through natural attenuation and the introduction of oxygenated groundwater at the downgradient edge of the plume. Alternative C1 does not provide additional actions to the existing IRM to reduce the concentration of COCs in the petroleum plumes. The risk to receptors in the Spokane River is controlled under Alternative C1 through the capture zone and hydraulic containment of groundwater COCs provided by the IRM, and through natural attenuation causing the petroleum hydrocarbon plumes to shrink. It can be concluded that Alternative C1 is protective of human health and the environment, and provides the same degree of protection to human health and the environment as Alternative C2, C3, or C4.	Alternative C2 expands the capture zone and hydraulic containment of the petroleum hydrocarbon groundwater plumes at the Facility. The combined benefit of expanded hydraulic containment, added FPP removal, and active natural attenuation in Alternative C2 greatly decreases the possibility that groundwater COCs above SLs and PCULs are reaching the Spokane River. The human direct contact pathway to Facility workers and visitors is mitigated because of the depth (greater than 20 feet) of the petroleum groundwater plume AOCs, through implementation of institutional controls, and because the groundwater plumes do not appear to be reaching surface water based on the results of ongoing groundwater monitoring. It is concluded that Alternative C2 is protective of human health and the environment. Alternative C2 provides the same degree of protection to human health and the environment as Alternatives C1, C3, and C4.	The depth of the petroleum groundwater plumes eliminates the direct contact exposure pathway for Facility workers and visitors. Physical and administrative controls and BMPs reduce worker exposure and potential future releases into the environment. Hydraulic containment combined with natural attenuation processes prevents SVOCs and comingled PCBs present in the petroleum groundwater plumes from reaching the river. *In situ* treatment is estimated to remove approximately 690,000 pounds of SVOCs from the petroleum groundwater plume over the restoration time frame. Short-term risks associated with the operation of the treatment system and other elements of the alternative are manageable. Alternative C3 is judged to be protective of human health and the environment. Alternative C3 provides the same degree of protection to human health and the environment as Alternatives C1, C2, and C4.	Alternative C4 will actively extract contaminated groundwater. This water will be treated in an *ex situ* treatment system where SVOCs and comingled PCBs will be removed by GAC adsorption and destroyed during GAC regeneration or incineration, and FPP will be recovered by an oil/water separator and belt skimming (part of Alternatives C1 and C2). Extraction of groundwater is estimated to remove approximately 690,000 pounds of SVOCs from the petroleum groundwater plumes during the restoration time frame. Alternative C4 includes operation of a hydraulic containment system (Alternative C2), which is expected to prevent migration of COCs to the Spokane River during the course of *ex situ* treatment, and natural attenuation processes are expected to continue to occur during this time. Alternative C4 provides the same degree of protection to human health and the environment as Alternatives C1, C2, and C3.
Threshold Requirements	Comply with Cleanup Standards	The implementation of Alternative C1 may result in compliance with MTCA cleanup requirements if the point of compliance is established throughout Facility soil and groundwater. Compliance will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of cleanup actions that are implemented. Compliance with the final groundwater CULs established in the Cleanup Action Plan will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in these alternatives (WAC 173-340-720[9][c][vi]). Alternative C1 does not meet the threshold requirement established in WAC 173-340-360(2)(c)(ii)(A) because there are presently areas at the Facility where FPP collects on the water table but where existing FPP recovery systems are not operating.	The implementation of Alternative C2 is expected to result in compliance with MTCA cleanup requirements if the point of compliance is established througout Facility soil and groundwater. Compliance will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of cleanup actions that are implemented. Compliance with the final groundwater CULs established in the Cleanup Action Plan will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in these alternatives (WAC 173-340-720[9][c][vi]). Alternative C2 expands FPP recovery measures to include areas at the Facility where LNAPL collects on the water table and where existing FPP recovery systems are not operating (refer to Section 4.1.2.3). As a result, Alternative C2 meets the threshold requirement established by WAC 173-340-360(2)(c)(ii)(A), with which Alternative C1 is not compliant.	Alternative C3 is expected to reduce the quantity of SVOCs in the petroleum groundwater plumes by approximately 690,000 pounds and PCBs by 4 pounds during its restoration time frame and removes remaining FPP. It is expected to reduce concentrations below SLs and PCULs in approximately 4 to 30 years. Hydraulic containment and natural attenuation processes prevents SVOCs and comingled PCBs in the petroleum groundwater plumes from reaching the river. Alternative C3 is expected to meet MTCA standards for petroleum hydrocarbons regardless of whether a conditional point of compliance is established by Ecology for the petroleum plumes. Alternative C3 is judged to comply with cleanup standards and meet threshold requirements.	Alternative C4 is estimated to reduce the quantity of SVOCs in the petroleum groundwater plumes by approximately 690,000 pounds and PCBs by 4 pounds and removes the remaining FPP (providing source control) by *ex situ* oil-water separation and belt skimming. It is expected to reduce concentrations below SLs and PCULs in about 3 to 24 years. Containment will also be provided (Alternative C2) and, combined with natural attenuation processes, will prevent migration of SVOCs and comingled PCBs to the Spokane River. Alternative C4 is judged to comply with cleanup standards and meet threshold requirements.
Threshold Requirements	Comply with Applicable State & Federal Law	The Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC) are not relevant or appropriate, and do not apply to cleanup actions approved by Ecology under MTCA. The State Waste Discharge Permit Program (Chapter 173-216 WAC) and the Underground Injection Control Program (Chapter 173-218 WAC) are not relevant and appropriate or applicable to Alternative C1. Since the groundwater extracted by the IRM comes from deep in the aquifer and does not contain COCs above detection limits, its redistribution to the shallow depths of the aquifer does not degrade the aquifer or interfere with the beneficial uses of that portion of the aquifer. Thus, the placement of groundwater extracted from deeper in the aquifer into shallower depths at the Kaiser Facility is not a regulated discharge and does not require a waste discharge permit. Distribution well WW-UVB-1-HS is not a UIC well, and its registration as a UIC well is not required.	The Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC) are not relevant or appropriate, and do not apply to cleanup actions approved by Ecology under MTCA. The State Waste Discharge Permit Program (Chapter 173-216 WAC) and the Underground Injection Control Program (Chapter 173-218 WAC) are not relevant and appropriate, or applicable to Alternative C2. Since the groundwater extracted by the expanded containment system comes from deep in the aquifer and does not contain COCs above detection limits, its redistribution to the shallow depths of the aquifer or to the Spokane River does not degrade or interfere with the beneficial uses of these waters of the state. Thus, the groundwater extracted by the containment system is not a regulated discharge and does not require a waste discharge permit. Distribution well WW-UVB-1-HS is not a UIC well, and its registration as a UIC well is not required.	The Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC) are not relevant or appropriate, and do not apply to cleanup actions approved by Ecology under MTCA. The material injected to stimulate in situ bioremediation does not fall under the material categories of the State Waste Discharge Permit Program (Chapter 173-216 WAC); thus, a waste discharge permit would not be required. However, the injection of these materials into the subsurface may require registration with the UIC Program (Chapter 173-218 WAC) if the injection points are classified as UIC wells. Alternative C3 is judged to comply with applicable state and federal laws.	The Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC) are not relevant or appropriate, and do not apply to cleanup actions approved by Ecology under MTCA. Hydraulic containment and natural attenuation processes prevents SVOCs and comingled PCBs present in the petroleum groundwater plume from reaching the river. Effluent discharged from the ex situ treatment system will be used in plant processes or for other permitted purposes. The effluent does not contain any materials known to originate from industrial, commercial, or municipal operations, but may be considered a waste material in some situations (WAC 173-216-030[19]). A waste discharge permit may be required if the intent of discharge of the effluent constitutes it as a waste material. In the event that the treated effluent is discharged into the subsurface from an aboveground location, UIC Program registration may be required if the well receiving the effluent is classified as a UIC well per Chapter 173-218 WAC. Alternative C4 is judged to comply with applicable state and federal law.
Threshold Requirements	Provide for Compliance Monitoring	Alternative C1 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative C2 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative C3 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative C4 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.
Disproportionate Cost Analysis	Protectiveness	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.
Disproportionate Cost Analysis	Permanence	Alternative C1 will reduce the toxicity and volume of COCs that can be biodegraded or reduced through natural attenuation processes. The mobility of the majority of groundwater COCs is reduced by the plume capture zone and hydraulic containment provided by the groundwater IRM system, which prevents COC migration to the Spokane River. Institutional controls in place at Kaiser help to prevent the release of COCs into the environment. Alternative C1 is judged to be less permanent than Alternatives C2, C3, and C4.	Alternative C2 will reduce the toxicity and volume of COCs through FPP removal and natural attenuation processes. The mobility of the groundwater COCs is reduced by the expanded hydraulic containment provided in this alternative, which prevents COC migration to the Spokane River. FPP mass on the water table will be reduced through operation of new skimming wells for FPP recovery. Alternatives C2 through C4 are expected to destroy the same quantitiesof SVOCs and PCBs in their respective time frames. While Alternatives C3 and C4 have shorter restoration time frames than Alternative C2, they generate treatment residuals (e.g., reaction products, spent GAC) that must be managed. Alternatives C2, C3, and C4 are judged to provide the same degree of permanence.	Alternative C3 is estimated to destroy approximately 690,000 pounds of SVOCs and 4 pounds of PCBs during its restoration time frame, and is expected to attain concentrations below SLs and PCULs. FPP mass will be reduced through FPP recovery using belt skimmers. Hydraulic containment, *in situ* bioremediation and natural attenuation processes prevents SVOCs and comingled PCBs in the petroleum groundwater plumes from reaching the river. Natural attenuation processes are expected to continue. Alternatives C2 through C4 are expected to destroy the same quantitiesof SVOCs and PCBs in their respective time frames. While Alternative C3 has shorter restoration time frame than Alternatives C2 and C4, it generates treatment residuals (e.g., reaction products) that must be managed. Alternatives C2, C3, and C4 are judged to provide the same degree of permanence.	Alternative C4 is estimated to destroy approximately 690,000 pounds of SVOCs and 4 pounds of PCBs during its restoration time frame. It is expected to reduce concentrations below SLs and PCULs in about 3 to 24 years. FPP mass will be reduced through FPP recovery using belt skimmers and *ex situ* oil/water separation. During *ex situ* treatment, the containment system (Alternative C2) and natural attenuation processes will prevent migration of the plume to the Spokane River. Alternatives C2 through C4 are expected to destroy the same quantities of SVOCs and PCBs in their respective time frames. While Alternative C4 has shorter restoration time frame than Alternative C2, it generates treatment residuals (e.g., spent GAC) that must be managed. Alternatives C2, C3, and C4 are judged to provide the same degree of permanence.

Table 4-35 - Summary of Detailed Analysis of Alternatives Applicable to SVOCs and Comingled PCBs in Petroleum Hydrocarbon Groundwater Plumes at the Kaiser Facility

	Criteria	Alternative C1 Institutional Controls, Monitoring, MNA, and Current Groundwater IRM System Operation	Alternative C2 Alternative C1 Plus Expanded Hydraulic Containment and FPP Recovery	Alternative C3 Alternative C2 Plus *In Situ* Enhanced Bioremediation	Alternative C4 Alternative C2 Plus *Ex Situ* Treatment
Disproportionate Cost Analysis	Effectiveness over the Long Term	This alternative is expected to reduce the concentration of COCs currently present in the petroleum hydrocarbon groundwater plumes to concentrations below SLs and PCULs in approximately from 4 to 34 years. The operation of the existing groundwater IRM system provides a plume capture zone and hydraulic containment plus partial FPP removal, which helps to prevent groundwater COCs from reaching the Spokane River, based on available groundwater monitoring data (Hart Crowser 2012a). Alternative C1 is expected to be less effective over the long term than Alternatives C2, C3, and C4.	Alternative C2 is expected to reduce the concentration of COCs present in the petroleum hydrocarbon groundwater plumes below SLs and PCULs in approximately 4 to 34 years. The depth of the petroleum groundwater plume AOCs prevents Facility workers and visitors from directly contacting or ingesting COCs in these locations. The plume capture zone and hydraulic containment provided in Alternative C2 will help to prevent the groundwater COCs from reaching the Spokane River. Bench- and/or pilot-scale tests will be needed to develop evidence to support the premise that PCBs that are comingled with SVOCs will be biodegraded once the PCBs enter the aqueous phase. Alternatives C2, C3, and C4 have equivalent long-term effectiveness.	Alternative C3 will use hydraulic containment and natural attenuation processes to prevent SVOCs and comingled PCBs from reaching the river. Alternative C3 is expected to actively reduce the SVOC mass in the petroleum groundwater plumes by approximately 690,000 pounds during its restoration time frame through *insitu* treatment. There is a potential risk of changing the valence state of metals, thereby increasing their toxicity and mobility. Bench- and/or pilot-scale tests will be required before Alternatives C3 and C4 could be implemented. Alternatives C2, C3, and C4 have equivalent long-term effectiveness.	Alternative C4 will use hydraulic containment and natural attenuation processes to prevent SVOCs and comingled PCBs from reaching the river. Alternative C4 actively reduces the SVOC mass in the petroleum groundwater plumes by an estimated 690,000 pounds over its restoration time frame. Bench- and/or pilot-scale tests will also be required before Alternatives C3 and C4 could be implemented. Bench- and/or pilot-scale tests will be required before Alternatives C3 and C4 could be implemented. Alternatives C2, C3, and C4 have equivalent long-term effectiveness.
	Management of Short-Term Risks	Alternative C1 uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create any new or additional risk to human health and the environment. The short-term risks that are associated with implementation of institutional controls include industrial hazards that are present in locations where the institutional controls are being implemented. Alternative C1 poses fewer short-term risks than Alternatives C2, C3, and C4.	This alternative uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring. The short-term risks that are associated with implementation of institutional controls include industrial hazards that are present in the locations where the institutional controls are being implemented. Additional short-term risks are associated with the construction of new groundwater extraction and skimming wells. Alternative C2 poses more short-term risks than Alternative C1, but fewer than Alternatives C3 and C4.	Short-term risks to construction workers during the installation and/or execution of the alternative will be mitigated by their adherence to the HASP prepared to guide the health and safety aspects of the construction work. Additional risks are associated with the storage and handling of nutrients (ammonium nitrate) and hydrogen peroxide which can increase explosion risk. There is a potential risk of changing the valence state of metals, thereby increasing their toxicity and mobility. Alternative C3 has greater short-term risks than Alternatives C1, C2, and C4.	This alternative will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks to workers installing and operating the *ex situ* treatment system will be mitigated by adherence to the HASP and O&M plan specific to the *ex situ* treatment system. An experienced contractor will manage the removal, transportation, and regeneration or incineration of spent carbon. Alternative C4 produces more short-term risks than Alternatives C1 and C2, but fewer than Alternative C3.
	Technical and Administrative Implementability	Alternative C1 is more implementable than Alternatives C2, C3, and C4, since the actions associated with the implementation of Alternative C1 are already in place and successfully operating at the Kaiser Facility.	BMPs, groundwater monitoring, and institutional controls are already in place and successfully operating at the Kaiser Facility. The installation of groundwater extraction wells and FPP skimming wells has been employed at Kaiser in the past and is a practice with which Kaiser is familiar. Bench- and/or pilot-scale tests will be needed to develop evidence to support the premise that PCBs that are comingled with SVOCs will be biodegraded once the PCBs enter the aqueous phase. Alternative C2 is more implementable than Alternatives C3 and C4, but less implementable than Alternative C1.	BMPs, monitoring, and institutional controls are already in place and successfully operating at the Facility. Hydraulic containment is currently being used at the Facility and has been empirically demonstrated to be effective. Bioremediation techniques have been successfully demonstrated at other similar sites (FRTR 2010). The injection of nutrients and hydrogen peroxide may require a UIC Program authorization. On-site pilot-scale testing will be required to determine if Alternative C3 will reach treatment objectives. Alternative C3 is less implementable than Alternatives C1 and C2, but is expected to have the same degree of implementability as Alternative C4.	BMPs, groundwater monitoring, and institutional controls are already in place and successfully operating at the Kaiser Facility. The expansion of hydraulic containment (Alternative C2) will be similar to the installation of the existing IRM system. Technical and administrative implementability of the *ex situ* treatment system is more complex. Technical and administrative staff will be needed for the design, construction, and operation of an *ex situ* groundwater treatment system. Staff will also be needed to complete permitting, O&M manuals, and to properly train operating staff. Alternative C4 is less implementable than Alternatives C1, C2, but is expected to have the same degree of implementability as Alternative C4.
	Consideration of Public Concerns	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.
	Conceptual-Level Cost (NPV -35/+50 percent)	$21.0 million	$22.9 million	$28.1 million	$41.0 million
	Total Cost per Pound of COC Treated or Contained	Not estimated -- Existing baseline condition.	$33 per pound of SVOC contained	$41 per pound of SVOC destroyed	$59 per pound of SVOC destroyed
	Restoration Time Frame	The time frame needed for recovery to occur through natural attenuation processes and through operation of the groundwater IRM system in Alternative C1 ranges from approximately 4 years for the South plume in the Oil House area to approximately 34 years for the North plume in the Wastewater Treatment area, which is comparable to Alternative C2. Alternative C1 has a longer restoration time frame than Alternatives C3 and C4.	The time frame needed in Alternative C2 for recovery to occur through natural attenuation processes and through operation of a groundwater hydraulic containment system ranges from about 4 years for the South plume in the Oil House area to approximately 34 years for the North plume in the Wastewater Treatment area. The restoration time frame of Alternative C2 is similar to the time frame for Alternative C1, but requires a longer time frame than Alternatives C3 and C4.	The restoration time frames for Alternative C3 is estimated to range from approximately 4 years (South plume in the Oil House area) to approximately 30 years (North plume in the Wastewater Treatment area). Approximately 690,000 pounds of SVOCs are estimated to be destroyed during this time. Alternative C3 has a shorter restoration time frame than Alternatives C1, C2, but longer than Alternative C4.	The restoration time frames for Alternative C4 is estimated to range from approximately 3 years (South plume in the Oil House area) to approximately 24 years (North plume in the Wastewater Treatment area). Approximately 690,000 pounds of SVOCs are estimated to be destroyed during this time. Alternative C4 has a shorter restoration timeframe than Alternatives C1, C2, and C3.

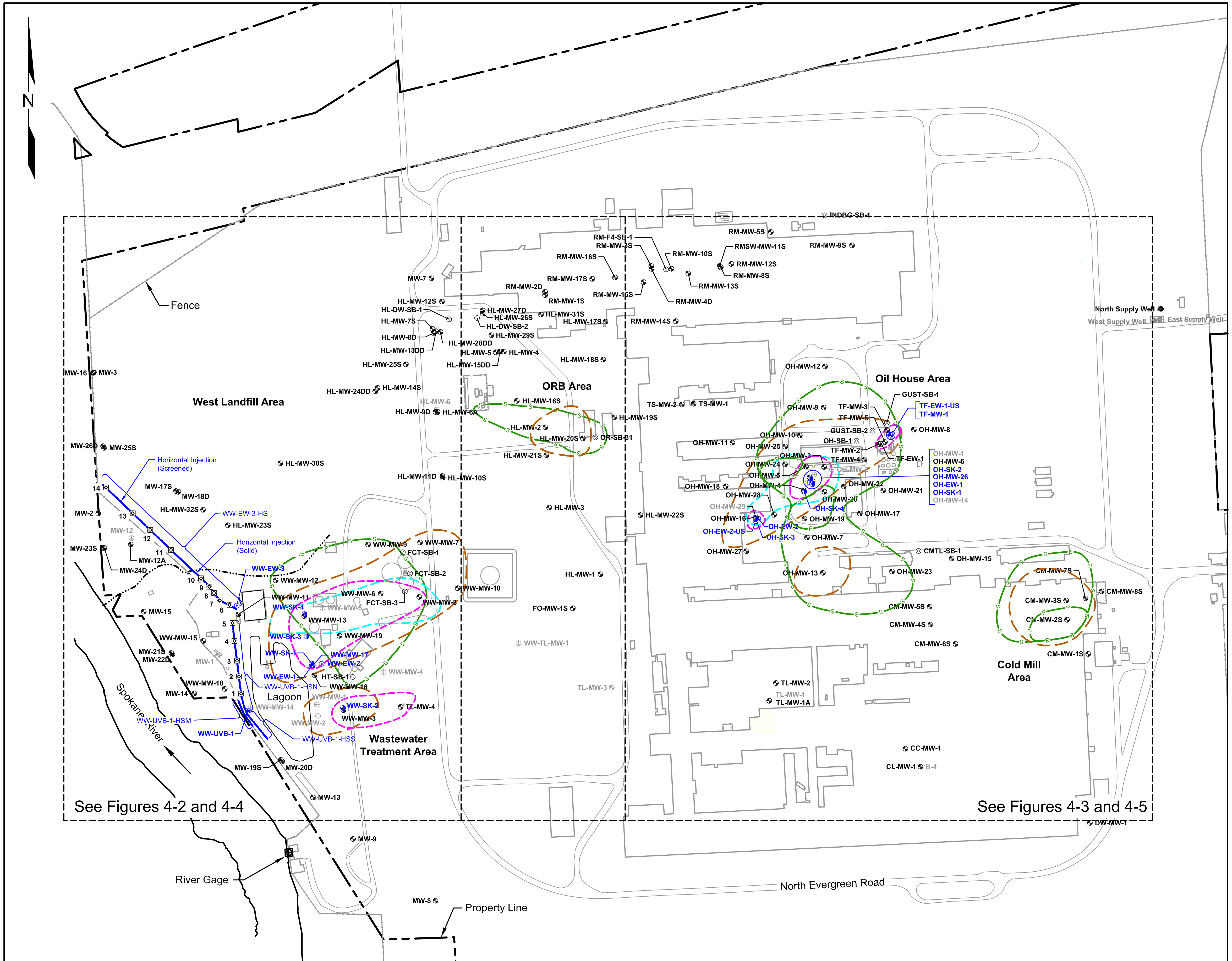
Table 4-36 - Summary of Detailed Analysis of Alternatives Applicable to SVOCs and Comingled PCBs in Smear Zone Soil at the Kaiser Facility

	Criteria	Alternative C1 Institutional Controls, Monitoring, MNA, and Current Groundwater IRM System Operation	Alternative C2 Alternative C1 Plus Expanded Hydraulic Containment and FPP Recovery	Alternative C3 Alternative C2 Plus *In Situ* Enhanced Bioremediation
Threshold Requirements	Overall Protection of Human Health and the Environment	The SVOCs and comingled PCBs in smear zone soil AOCs are located at depths that prevent Facility workers and visitors from direct contact with these COCs in these areas. Institutional controls in place at Kaiser include physical and administrative controls and BMPs that are currently being used to reduce the potential for worker exposure to COCs. Institutional controls also include measures to prevent the potential release of COCs to the environment during industrial activities taking place at the Facility. COC source control in smear zone soil under Alternative C1 relies on natural attenuation processes and on FPP removal through skimming wells. Alternative C1 does not provide actions in addition to the existing IRM to actively reduce the concentration of COCs in smear zone soil. Potential risks to the environment remain at the Facility because the soil to groundwater exposure pathway persists in the smear zone soil AOCs; however, hydraulic containment, partial FPP removal, and natural attenuation processes prevent COCs from reaching the Spokane River. Alternative C1 provides the same degree of protection to human health and the environment as Alternatives C2 and C3.	The human direct contact pathway to Facility workers/visitors is mitigated because of the depth of smear zone soil and through institutional controls that reduce the potential for worker exposure to COCs and which also include measures to prevent the potential release of COCs to the environment during industrial activities taking place at the Facility. Natural attenuation and FPP removal processes will reduce COC concentrations in smear zone soil over a long time. Alternative C2 expands FPP recovery measures at the Facility to include areas where FPP has been observed in the subsurface but is not currently being recovered. Potential risks to the environment remain at the Facility because the soil to groundwater exposure pathway persists in the smear zone soil AOCs; however, hydraulic containment and natural attenuation processes prevent COCs from reaching the Spokane River. Alternative C2 expands the hydraulic containment of the petroleum hydrocarbon groundwater plumes at the Facility. Alternative C2 is judged to provide the same degree of protection to human health and the environment as Alternatives C1 and C	The depth of the smear zone soil SVOCs and comingled PCBs eliminates the direct contact exposure pathway for Facility workers and visitors. Physical and administrative controls and BMPs reduce worker exposure and potential future releases of SVOCs and comingled PCBs into the environment. A plume capture zone and hydraulic containment prevents SVOCs and comingled PCBs present in smear zone soil from reaching the river. *In situ* treatment is estimated to remove approximately 44 percent (690,000 pounds) of SVOCs and 4 pounds of PCBs from the smear zone soil during the restoration time frame. Alternative C3 expands FPP recovery measures to include areas at the Facility where FPP collects on the water table and where existing FPP recovery systems are not operating (refer to Section 4.1.1.2). Short-term risks associated with the operation of the treatment system and other elements of the alternative are manageable. Alternative C3 is judged to be protective of human health and the environment. Alternative C3 is judged to provide the same degree of protection to human health and the environment as Alternatives C1 and C2.
	Comply with Cleanup Standards	Smear zone soil cleanup levels will be considered to be met when groundwater cleanup levels have been achieved. Compliance with SLs and PCULs will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of cleanup actions that are implemented. Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternative C1, compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in Alternative C1 (WAC 173-340-720[9][c][vi]). There are areas at the Facility where LNAPL collects on the water table in the smear zone and where existing FPP recovery systems are not operating (refer to Section 4.1.1.2). As a result, Alternative C1 does not meet the threshold requirement established by WAC 173-340-360(2)(c)(ii)(A).	Smear zone soil cleanup levels will be considered to be met when groundwater cleanup levels have been achieved. Compliance will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of cleanup actions that are implemented. Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternative C2, compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in Alternative C2 (WAC 173-340-720[9][c][vi]). Alternative C2 expands FPP recovery measures to include areas at the Facility where LNAPL collects on the water table and where existing FPP recovery systems are not operating (refer to Section 4.1.1.2). As a result, Alternative C2 meets the threshold requirement established by WAC 173-340-360(2)(c)(ii)(A), with which Alternative C1 is not compliant.	Alternative C3 is expected to reduce the quantity of SVOCs in the smear zone soil AOCs by approximately 44 percent during the restoration time frame. Smear zone soil cleanup levels will be considered to be met when groundwater cleanup levels have been achieved. Compliance will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of cleanup actions that are implemented. Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternative C3, compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in Alternative C2 (WAC 173-340-720[9][c][vi]). Alternative C3 meets the threshold requirement established by WAC 173-340-360(2)(c)(ii)(A).
	Comply with Applicable State & Federal Law	COCs are removed from smear zone soil as groundwater flows through the soil. The existing IRM system is part of Alternative C1. The existing IRM system was judged to be compliant with applicable state and federal laws (refer to Table 4-35).	COCs are removed from smear zone soil as groundwater flows through the soil. The existing IRM system is part of Alternative C1. The existing IRM system was judged to be compliant with applicable state and federal laws (refer to Table 4-35).	The material injected to stimulate *in situ* bioremediation does not fall under the material categories of the State Waste Discharge Permit Program (Chapter 173-216 WAC). Thus, a waste discharge permit would not be required. However, the injection of these materials into the subsurface may require registration with the UIC Program (Chapter 173-218 WAC) if the injection points are classified as UIC wells. Alternative C3 is judged to comply with applicable state and federal laws.
	Provide for Compliance Monitoring	Alternative C1 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative C2 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative C3 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.
Disproportionate Cost Analysis	Protectiveness	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.
	Permanence	Alternative C1 will reduce the toxicity and volume of COC concentrations that can be biodegraded or reduced through natural attenuation and FPP removal processes. Institutional controls in place at Kaiser help to prevent the release of COCs into the environment by the Facility's industrial activities. Alternative C1 is judged to provide less permanence than Alternatives C2 and C3, since it is expected to remove less FPP than Alternatives C2 and C3.	Alternative C2 will reduce the toxicity and volume of COC concentrations through natural attenuation and FPP removal processes. FPP mass in the smear zone will be reduced through operation of new skimming wells for FPP recovery. Alternatives C2 and C3 are expected to destroy the same quantities of SVOCs and PCBs in their respective time frames. While Alternative C3 has shorter restoration time frame than Alternatives C2, it generates treatment residuals (e.g., reaction products) that must be managed. Alternatives C3 and C2 are judged to provide the same degree of permanence.	Alternative C3 is estimated to reduce the mass of SVOCs by approximately 844 percent in the petroleum groundwater plume and associated smear zone soil during the restoration time frame. FPP mass will be reduced through FPP recovery using belt skimmers. Natural attenuation processes are expected to continue. Alternative C2 and C3 are expected to destroy the same quantities of SVOCs and PCBs in their respective time frames. While Alternative C3 has shorter restoration time frame than Alternatives C2, it generates treatment residuals (e.g., reaction products) that must be managed. Alternatives C3 and C2 are judged to provide the same degree of permanence. Alternative C3 is more permanent than Alternatives C1 and C2.

Table 4-36 - Summary of Detailed Analysis of Alternatives Applicable to SVOCs and Comingled PCBs in Smear Zone Soil at the Kaiser Facility

	Criteria	Alternative C1 Institutional Controls, Monitoring, MNA, and Current Groundwater IRM System Operation	Alternative C2 Alternative C1 Plus Expanded Hydraulic Containment and FPP Recovery	Alternative C3 Alternative C2 Plus *In Situ* Enhanced Bioremediation
Disproportionate Cost Analysis	Effectiveness over the Long Term	Smear zone soil cleanup levels will be considered to be met when groundwater cleanup levels have been achieved. This alternative will not add additional activity, beyond the significant benefits provided by biodegradation, to reduce the concentration of COCs currently present in smear zone soil to concentrations below SLs and PCULs. This alternative is expected to reduce the concentration of COCs currently present in the petroleum hydrocarbon groundwater plumes to concentrations below SLs and PCULs in approximately from 4 to 34 years. FPP mass in the smear zone will be reduced through operation of new skimming wells for FPP recovery. Alternative C1 will be less effective over the long term than Alternatives C2 and C3.	Smear zone soil cleanup levels will be considered to be met when groundwater cleanup levels have been achieved. The depth of the smear zone soil AOCs prevents Facility workers and visitors from directly contacting or ingesting COCs in these locations. FPP mass in the smear zone will be reduced through operation of new skimming wells for FPP recovery. Alternative C2 is expected to reduce the concentration of COCs present in smear zone soil to below SLs and PCULs in approximately 4 to 34 years. Alternatives C2 and C3 have equivelant long-term effectiveness.	Alternative C3 will use a plume capture zone and hydraulic containment to prevent SVOCs and comingled PCBs from reaching the river. Alternative C3 is expected to actively reduce the SVOC mass in the petroleum groundwater plumes by approximately 690,000 pounds and the PCBs by 4 pounds during its restoration time frame. There is a potential risk of changing the valence state of metals, thereby increasing their toxicity and mobility. Bench- and/or pilot-scale tests will be required before Alternative C3 could be implemented. Alternatives C3 and C2 are judged to have equivelant long-term effectiveness.
	Management of Short-Term Risks	Alternative C1 uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create any new or additional risk to human health and the environment. The short-term risks that are associated with implementation of institutional controls include industrial hazards that are present in the locations where the institutional controls are being implemented. Alternative C1 poses fewer short-term risks than Alternatives C2 and C3.	Alternative C2 uses existing procedures to implement institutional controls and BMPs. The short-term risks that are associated with implementation of institutional controls include industrial hazards that are present in the locations where the institutional controls are being implemented. Additional short-term risks are associated with the construction of new FPP skimming wells. Bench- and/or pilot-scale tests will be required before Alternative C2 could be implemented. Alternatives C2 and C3 are judged to have equivalent long-term effectiveness.	Short-term risks to construction workers during the installation and/or execution of the alternative will be mitigated by their adherence to the HASP prepared to guide the health and safety aspects of the construction work. Additional risks are associated with the storage and handling of nutrients (ammonium nitrate) and hydrogen peroxide which can increase explosion risk. There is a potential risk of changing the valence state of metals, thereby increasing their toxicity and mobility. Alternative C3 has more short-term risks than Alternatives C1 and C2.
	Technical and Administrative Implementability	Alternative C1 is more implementable than Alternatives C2 and C3, since all of the actions associated with the implementation of Alternative C1 are already in place and successfully operating at the Kaiser Facility.	BMPs and institutional controls are already in place and successfully operating at the Kaiser Facility. The installation of FPP skimming wells has been employed at the Facility in the past and is a practice with which Kaiser is familiar. Bench-and/or pilot-scale tests will be needed to develop evidence to support the the premise that PCBs that are comingled with SVOCs will be biodegraded once the PCBs enter the aqueous phase. Alternative C2 is more implementable than Alternative C3, but less implementable than Alternative C1.	BMPs, monitoring, and institutional controls are already in place and successfully operating at the Facility. Hydraulic containment is currently being used at the Facility and has been empirically demonstrated to be effective. Bioremediation techniques have been successfully demonstrated at other similar sites (FRTR 2010). On-site pilot-scale testing will be required to determine whether Alternative C3 will reach treatment objectives. The injection of nutrients and hydrogen peroxide may require a UIC Program authorization. On-site pilot-scale testing will be required. Alternative C3 is less implementable than Alternatives C1 and C2.
	Consideration of Public Concerns	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.
	Conceptual-Level Cost (NPV -35/+50 percent)	$21.0 million	$22.9 million	$28.1 million
	Total Cost per Pound of COC Treated or Contained	Not estimated -- Existing baseline condition.	$33 per pound of SVOC contained	$41 per pound of SVOC destroyed
	Restoration Time Frame	Smear zone soil cleanup levels will be considered to be met when groundwater cleanup levels have been achieved. The time frame needed for recovery to occur through natural attenuation processes and through operation of the groundwater IRM system in Alternative C1 ranges from approximately 4 years for the South plume in the Oil House area to approximately 34 years for the North plume in the Wastewater Treatment area. Alternative C1 has a longer restoration time frame than Alternative C3. Alternatives C1 and C2 have comparable restoration time frames.	Smear zone soil cleanup levels will be considered to be met when groundwater cleanup levels have been achieved. The time frame needed for recovery to occur through natural attenuation processes and through operation of the groundwater IRM system in Alternative C1 ranges from approximately 4 years for the South plume in the Oil House area to approximately 34 years for the North plume in the Wastewater Treatment area. The restoration time frame of Alternative C2 is comparable to Alternative C1, but requires a longer time frame than Alternative C3.	Smear zone soil cleanup levels will be considered to be met when groundwater cleanup levels have been achieved. The restoration time frame for Alternative C3 is estimated to range from approximately 4 years (South plume in the Oil House area) to approximately 30 years (North plume in the Wastewater Treatment area). Approximately 44 percent of the SVOC mass in the smear zone treatment area is estimated to be destroyed during this time. Alternative C3 has a shorter restoration time frame than Alternatives C1 and C2.

Site Plan - Groundwater IRM System, Petroleum Hydrocarbon Groundwater Plumes, Free Phase Petroleum, and Smear Zone Soil AOCs



Exploration Location and Number

OH-EW-1 ⊙ Extraction Well

OH-MW-03 Monitoring Well

TL-MW-3 Abandoned Monitoring Well

OH-SK-1 Skimming Well

TF-EW-1-US Upper Screen Well

North Supply Well ● Supply Well

West Supply Well ● Backup Supply Well

Inferred Extent of Diesel and Heavy Oil in Groundwater (2009/2010) Exceeding Screening Level Based on Best Available Data

Inferred Extent of Free Phase Petroleum in Groundwater (2009/2010) Based on Best Available Data

Inferred Extent of PCB Concentrations Exceeding Screening Level Associated with Petroleum Hydrocarbons. PCB Concentrations Are Not Dissolved in Groundwater.

Smear Zone Soil

—S— SVOC Area of Screening Level Exceedance in Smear Zone Soil

—P— Comingled PCB Area of Screening Level Exceedance in Smear Zone Soil

Note:

1. Groundwater IRM system components are shown in blue.

0 400 800

Scale in Feet

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2644-125 *5/12*

Figure 4-1

Diesel/Heavy Oil and Free Phase Petroleum in Groundwater and SVOC Smear Zone Soil
West Area

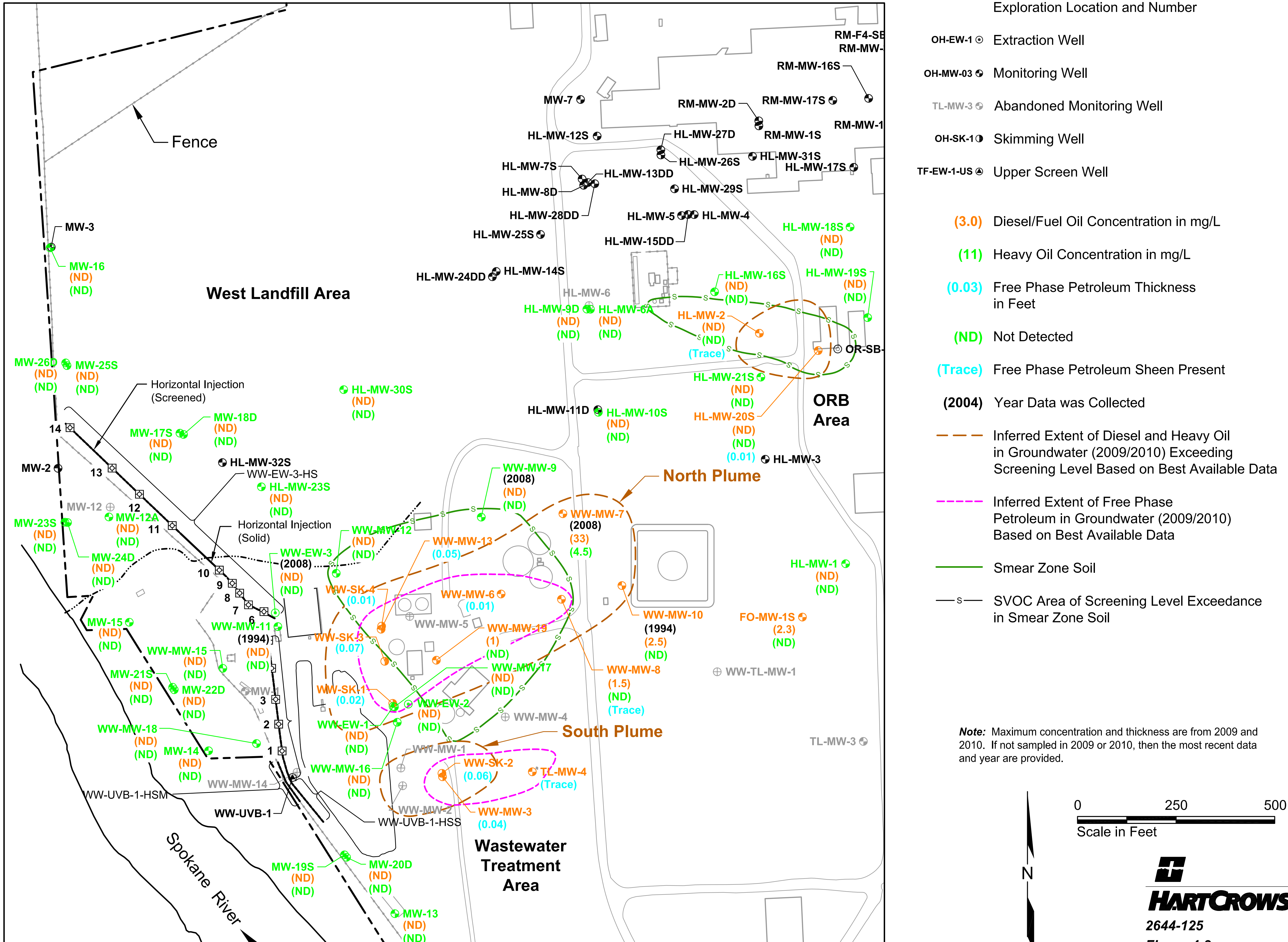

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Figure 4-2

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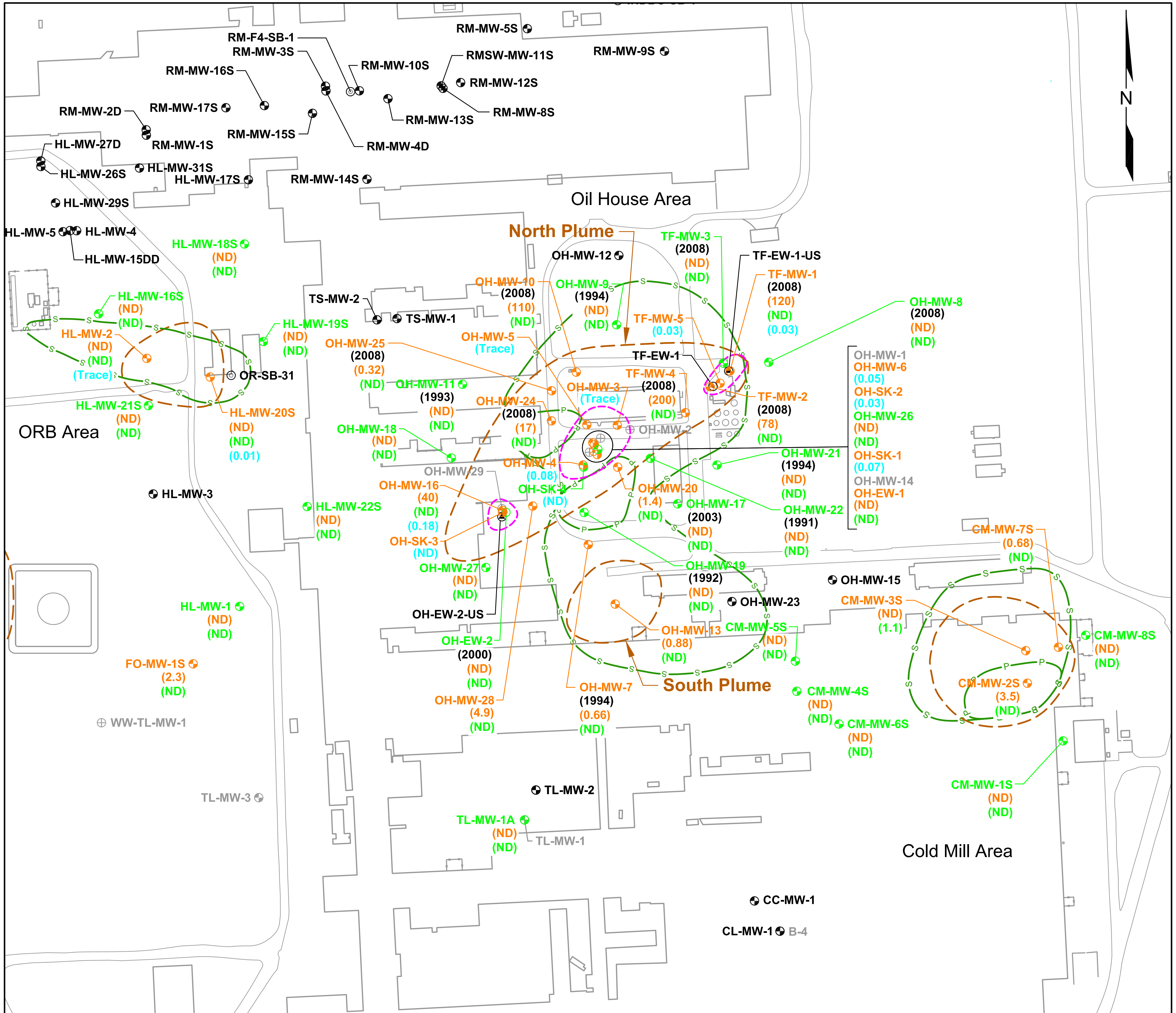
Diesel/Heavy Oil and Free Phase Petroleum in Groundwater and SVOC Smear Zone Soil
East Area



Exploration Location and Number

OH-EW-1	Extraction Well
OH-MW-03	Monitoring Well
TL-MW-3	Abandoned Monitoring Well
OH-SK-1	Skimming Well
TF-EW-1-US	Upper Screen Well
(3.0)	Diesel/Fuel Oil Concentration in mg/L
(11)	Heavy Oil Concentration in mg/L
(0.03)	Free Phase Petroleum Thickness in Feet
(ND)	Not Detected
(Trace)	Free Phase Petroleum Sheen Present
(2004)	Year Data was Collected
	Inferred Extent of Diesel and Heavy Oil in Groundwater (2009/2010) Exceeding Screening Level Based on Best Available Data
	Inferred Extent of Free Phase Petroleum in Groundwater (2009/2010) Based on Best Available Data
	Smear Zone Soil
—s—	SVOC Area of Screening Level Exceedance in Smear Zone Soil
—P—	Comingled PCB Area of Screening Level Exceedance in Smear Zone Soil

Note:
1. Maximum concentration and thickness are from 2009 and 2010. If not sampled in 2009 or 2010, then the most recent data and year are provided.

0 250 500
Scale in Feet

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2644-125 ***5/12***

Figure 4-3

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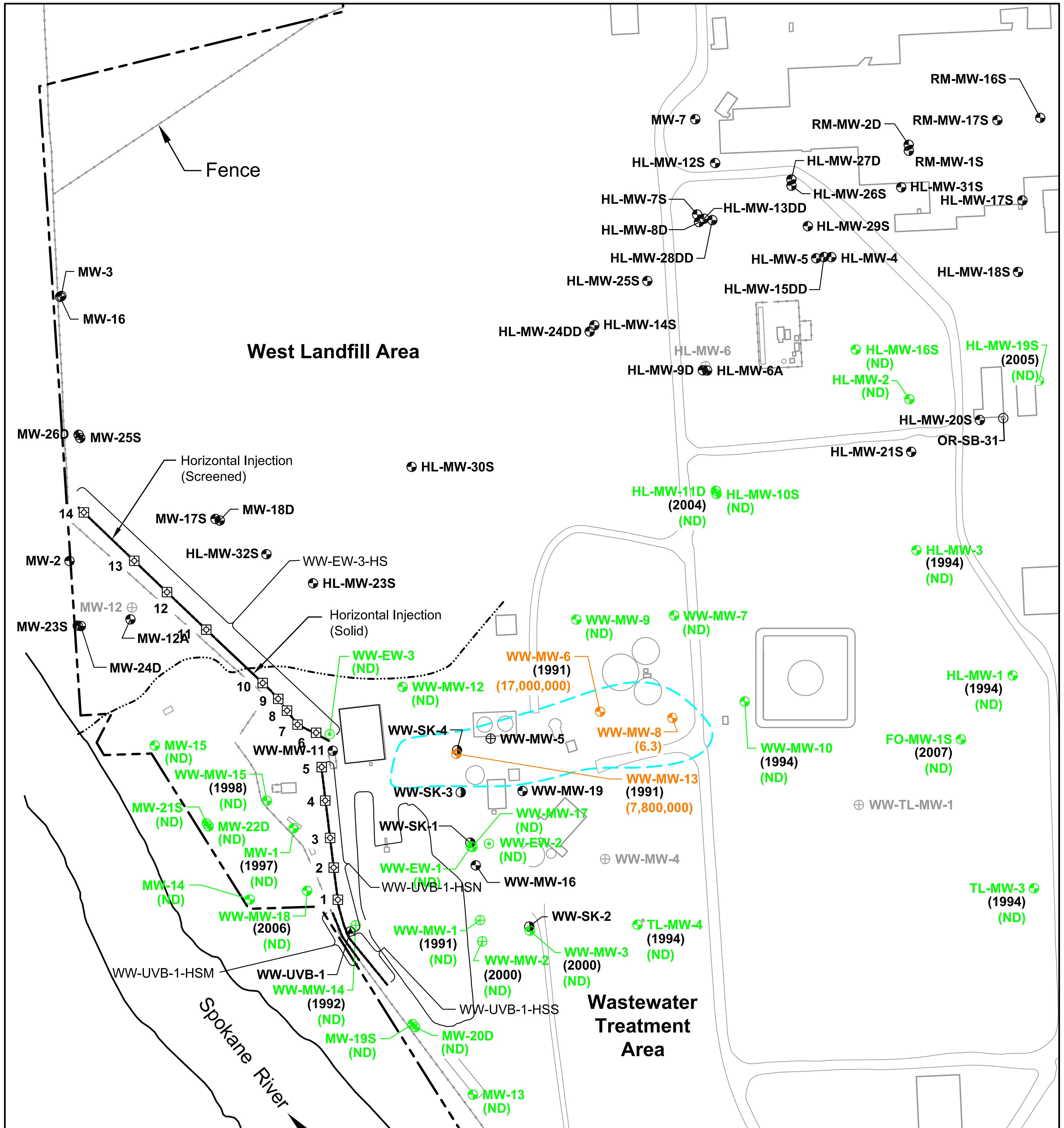
Total PCB Concentrations Associated with Petroleum Hydrocarbons in Groundwater
West Area - Most Recently Measured



Exploration Location and Number

- OH-EW-1 ⦿ Extraction Well
- OH-MW-03 Monitoring Well
- TL-MW-3 Abandoned Monitoring Well
- OH-SK-1 Skimming Well
- TF-EW-1-US Upper Screen Well
- North Supply Well ● Supply Well
- West Supply Well ● Backup Supply Well
- (3.0) Total PCB Concentration in ng/L
- J Estimated Value
- P GC Confirmation Criteria was Exceeded
- T Value Is Between the MDL and MRL
- (ND) Not Detected
- (2004) Year Data Were Collected
- — — — Inferred Extent of PCB Concentrations Exceeding Screening Level Associated with Petroleum Hydrocarbons. PCB Concentrations Are Associated with Petroleum and Are Not Dissolved in Groundwater.

Notes:

1. PCBs associated with the Remelt plume are discussed in Section 5.
2. Total PCB concentrations are from 2008. If not sampled in 2008, then the sampling year is provided.

N

0 250 500
Scale in Feet

HARTCROWSER

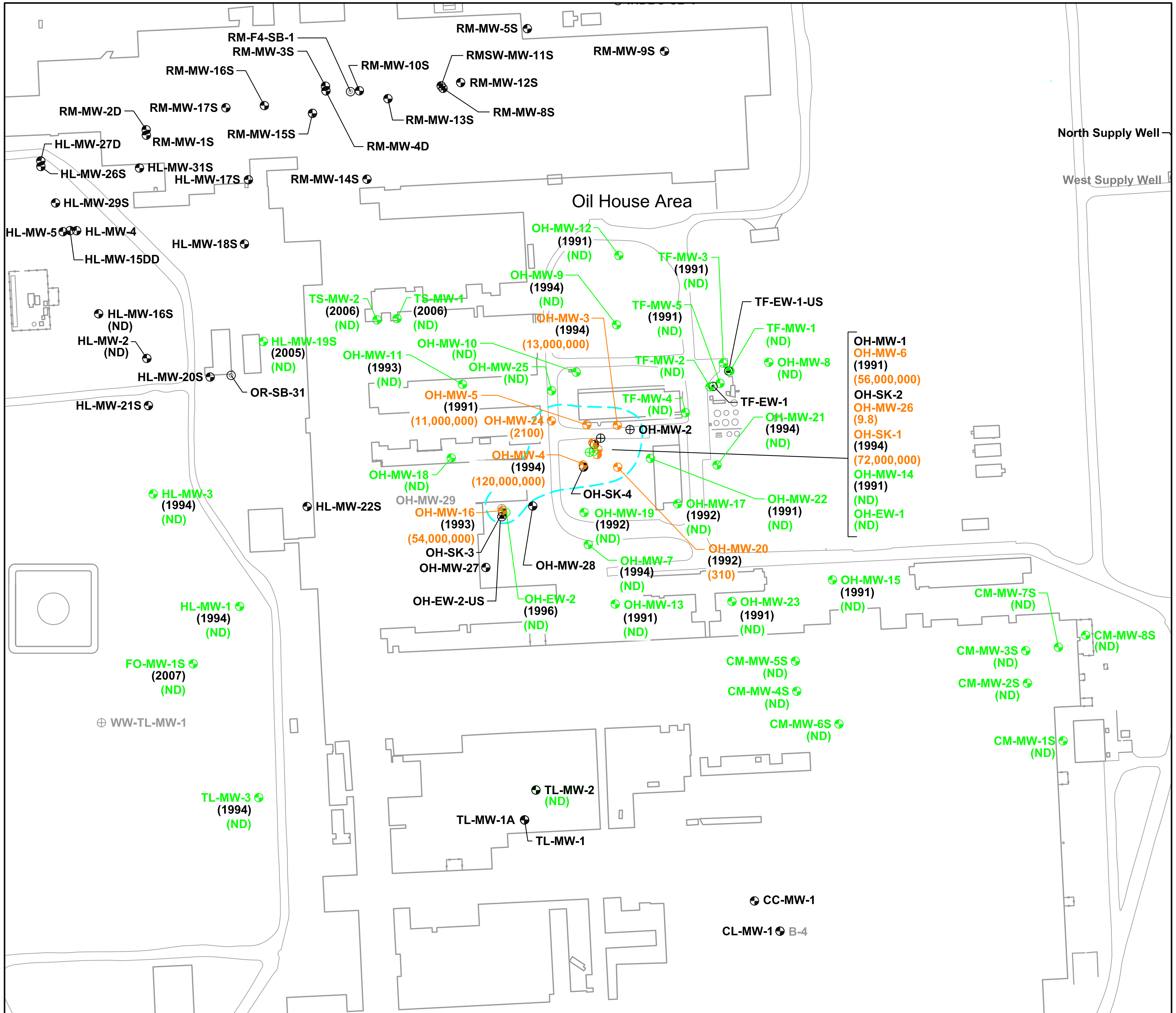
2644-125 *5/12*

Figure 4-4

EAL 05/14/12 2644125-060.dwg

Total PCB Concentrations Associated with Petroleum Hydrocarbons in Groundwater

East Area - Most Recently Measured



Exploration Location and Number

OH-EW-1	Extraction Well
OH-MW-03	Monitoring Well
TL-MW-3	Abandoned Monitoring Well
OH-SK-1	Skimming Well
TF-EW-1-US	Upper Screen Well
North Supply Well	Supply Well
West Supply Well	Backup Supply Well
(3.0)	Total PCB Concentration in ng/L
J	Estimated Value
P	GC Confirmation Criteria was Exceeded
T	Value Is Between the MDL and MRL
(ND)	Not Detected
(2006)	Year Data Were Collected
— — —	Inferred Extent of PCB Concentrations Exceeding Screening Level Associated with Petroleum Hydrocarbons. PCB Concentrations Are Associated with Petroleum and Are Not Dissolved in Groundwater.

Notes:

1. PCBs associated with the Remelt plume are discussed in Section 5.
2. Total PCB concentrations are from 2008. If not sampled in 2008, then the sampling year is provided.

0 250 500
Scale in Feet

N

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Figure 4-5

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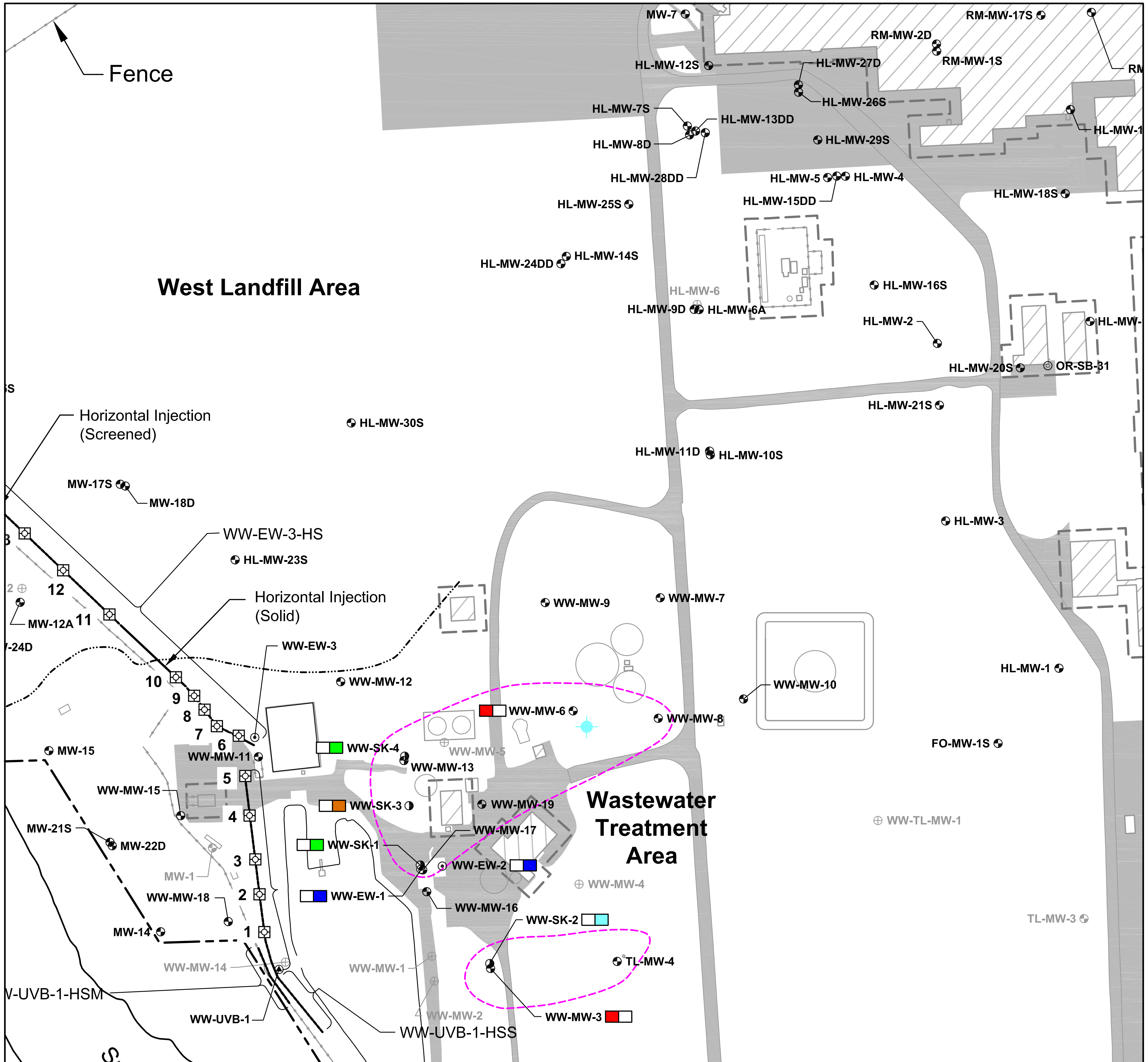
Existing and Proposed FPP Recovery Location Plan
West Area



Exploration Location and Number

- OH-EW-1 Extraction Well
- OH-MW-03 Monitoring Well
- TL-MW-3 Abandoned Monitoring Well
- OH-SK-1 Skimming Well
- TF-EW-1-US Upper Screen Well
- Proposed Skimming Well
- Inferred Extent of Free Phase Petroleum in 2009
- 20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation
- Existing Paved Area
- Existing Building

Well Type

Free Phase Product Thickness

- Wells with Significant Product Thickness[a]
- Groundwater Extraction Well (Current)
- Skimming Well Currently Running
- Previous Skimming Well
- Previous Skimming Well to be Restarted as Part of Alternative C2

Note a: For basis of determination of significant product thickness, see Section 4.1.2.3.

N

0 200 400
Scale in Feet

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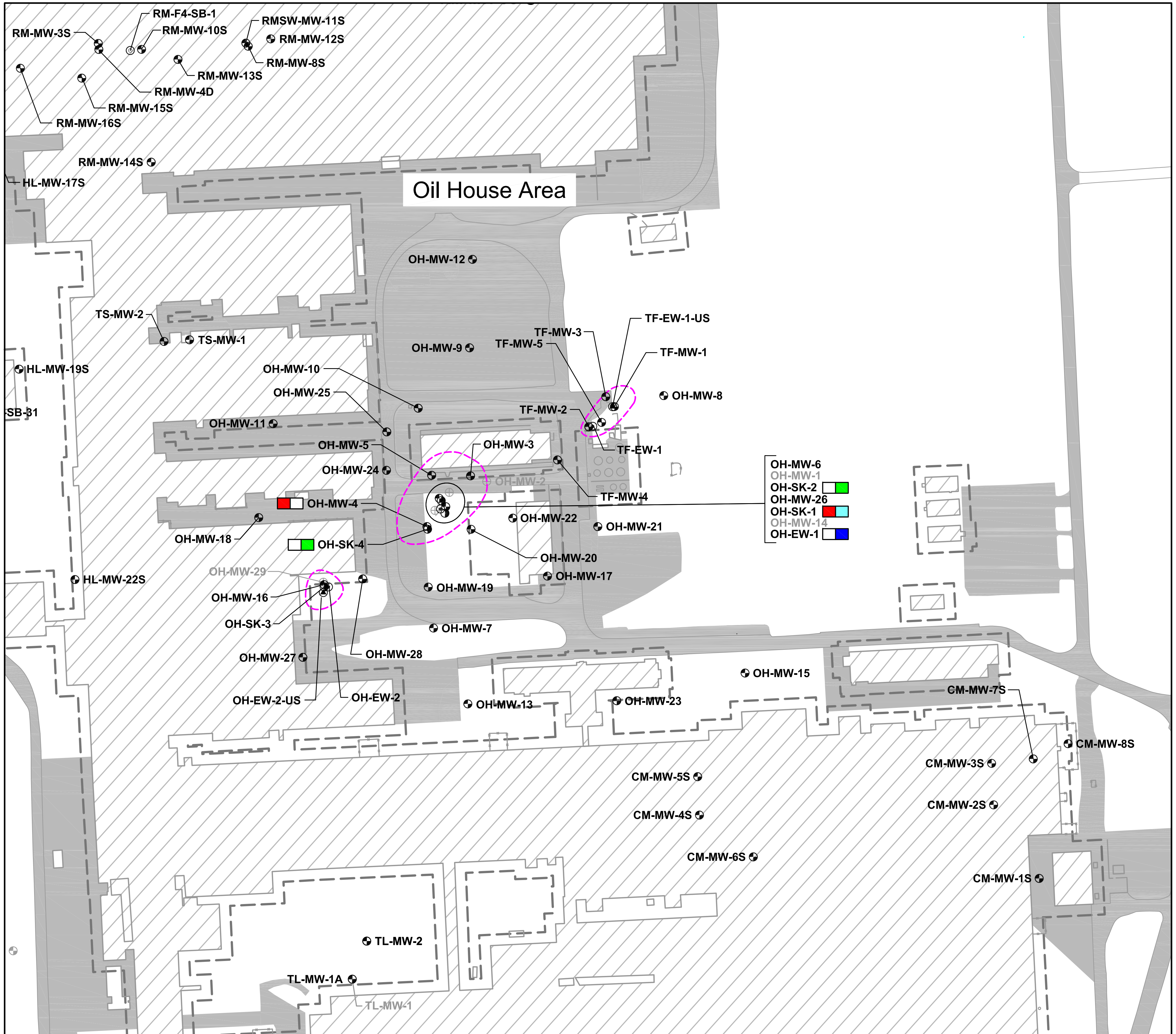
2644-125 ***5/12***

Figure 4-6

EAL 05/14/12 2644125-062.dwg

Existing and Proposed FPP Recovery Location Plan
East Area



Exploration Location and Number

OH-EW-1 Extraction Well

OH-MW-03 Monitoring Well

TL-MW-3 Abandoned Monitoring Well

OH-SK-1 Skimming Well

TF-EW-1-US Upper Screen Well

Inferred Extent of Free Phase Petroleum in 2009

20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation

Existing Paved Area

Existing Building

Well Type

Free Phase Product Thickness

Wells with Significant Product Thickness[a]

Groundwater Extraction Well (Current)

Skimming Well Currently Running

Previous Skimming Well

Previous Skimming Well to be Restarted as Part of Alternative C2

Note a: For basis of determination of significant product thickness, see Section 4.1.2.3.

0 200 400
Scale in Feet

N

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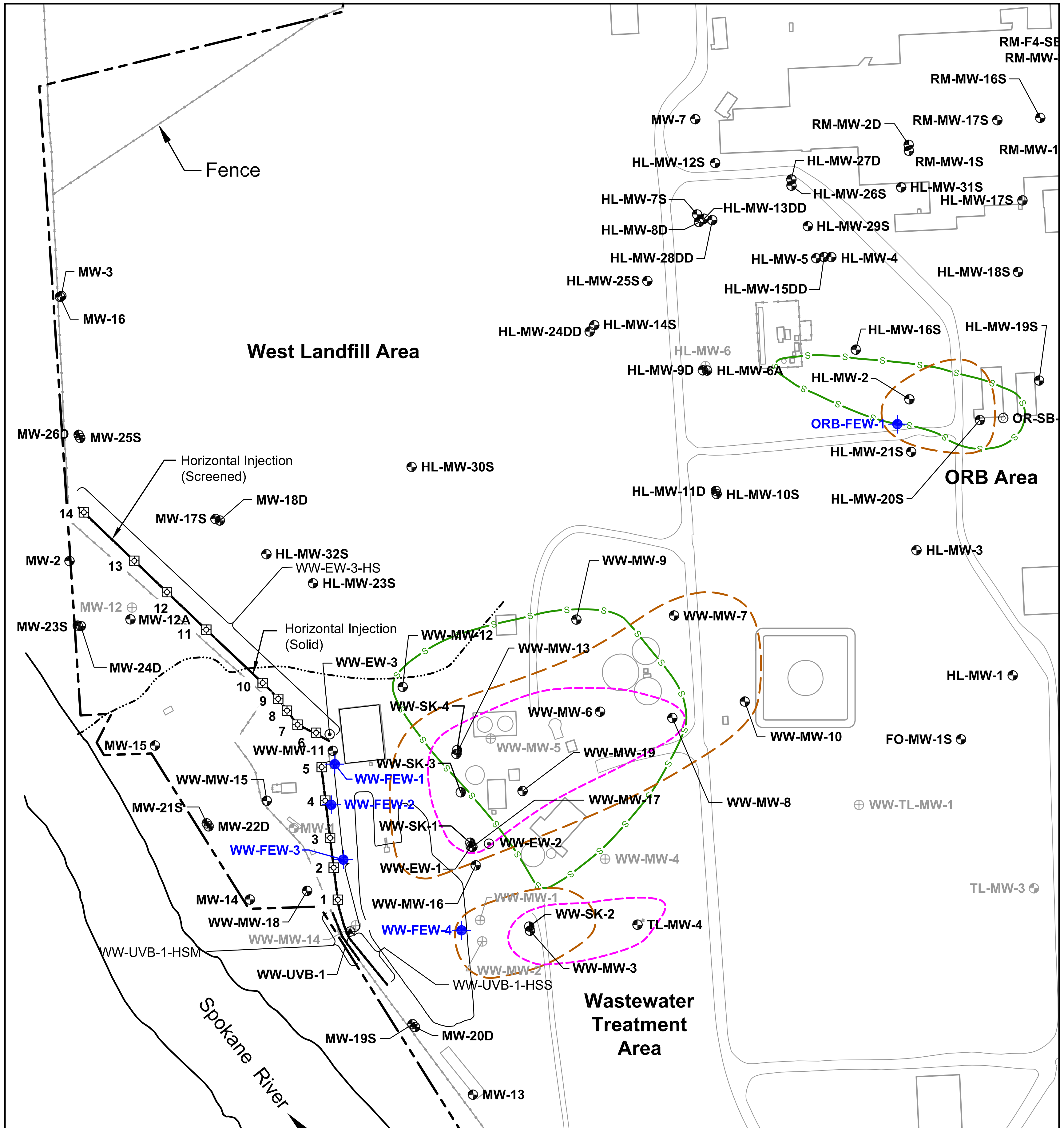
Figure 4-7

EAL 05/14/12 2644125-062.dwg

Alternative C2 - Proposed Groundwater Extraction Well Location Plan for Scenarios C2b and C2c
West Area



Exploration Location and Number

ORB-FEW-1 Proposed Extraction Well

OH-EW-1 Extraction Well

OH-MW-03 Monitoring Well

TL-MW-3 Abandoned Monitoring Well

OH-SK-1 Skimming Well

TF-EW-1-US Upper Screen Well

Inferred Extent of Diesel and Heavy Oil in Groundwater (2009/2010) Exceeding Screening Level Based on Best Available Data

Inferred Extent of Free Phase Petroleum in Groundwater (2009/2010) Based on Best Available Data

Smear Zone Soil

SVOC Area of Screening Level Exceedance in Smear Zone Soil

Notes:

1. Only extraction well ORB-FEW-1 is installed in Alternative C2b. All new extraction wells are installed in Alternative C2c.

N

0 250 500

Scale in Feet

HARTCROWSER

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Figure 4-8

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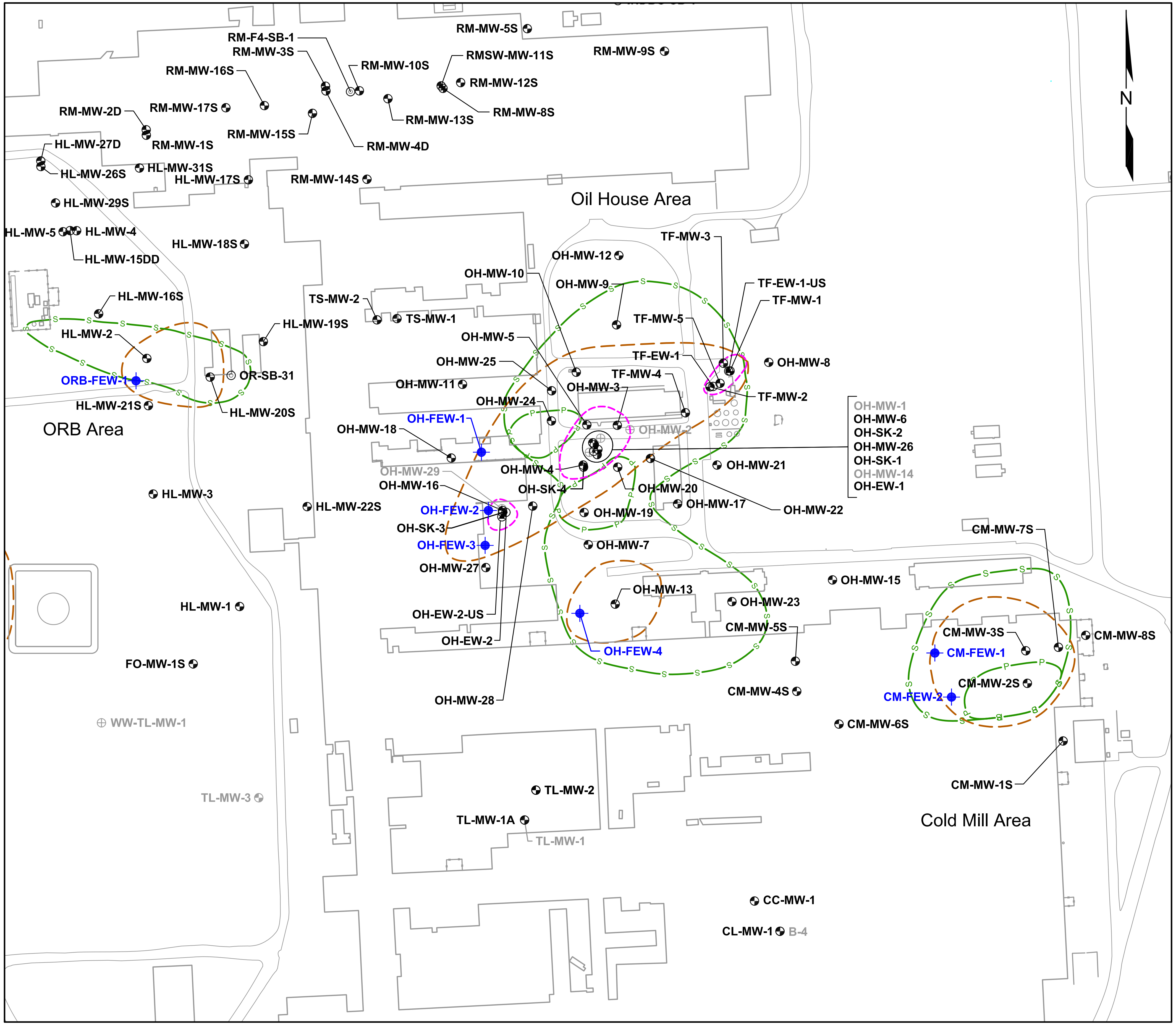
Alternative C2 - Proposed Groundwater Extraction Well Location Plan for Scenarios C2b and C2c

East Area



Exploration Location and Number

- CM-FEW-1 Proposed Extraction Well
- OH-EW-1 Extraction Well
- OH-MW-03 Monitoring Well
- TL-MW-3 Abandoned Monitoring Well
- OH-SK-1 Skimming Well
- TF-EW-1-US Upper Screen Well

- Inferred Extent of Diesel and Heavy Oil in Groundwater (2009/2010) Exceeding Screening Level Based on Best Available Data
- Inferred Extent of Free Phase Petroleum in Groundwater (2009/2010) Based on Best Available Data
- Smear Zone Soil
- —S— SVOC Area of Screening Level Exceedance in Smear Zone Soil
- —P— Comingled PCB Area of Screening Level Exceedance in Smear Zone Soil

Notes:

1. Only extraction well ORB-FEW-1 is installed in Alternative C2b. All new extraction wells are installed in Alternative C2c.

0 250 500

Scale in Feet

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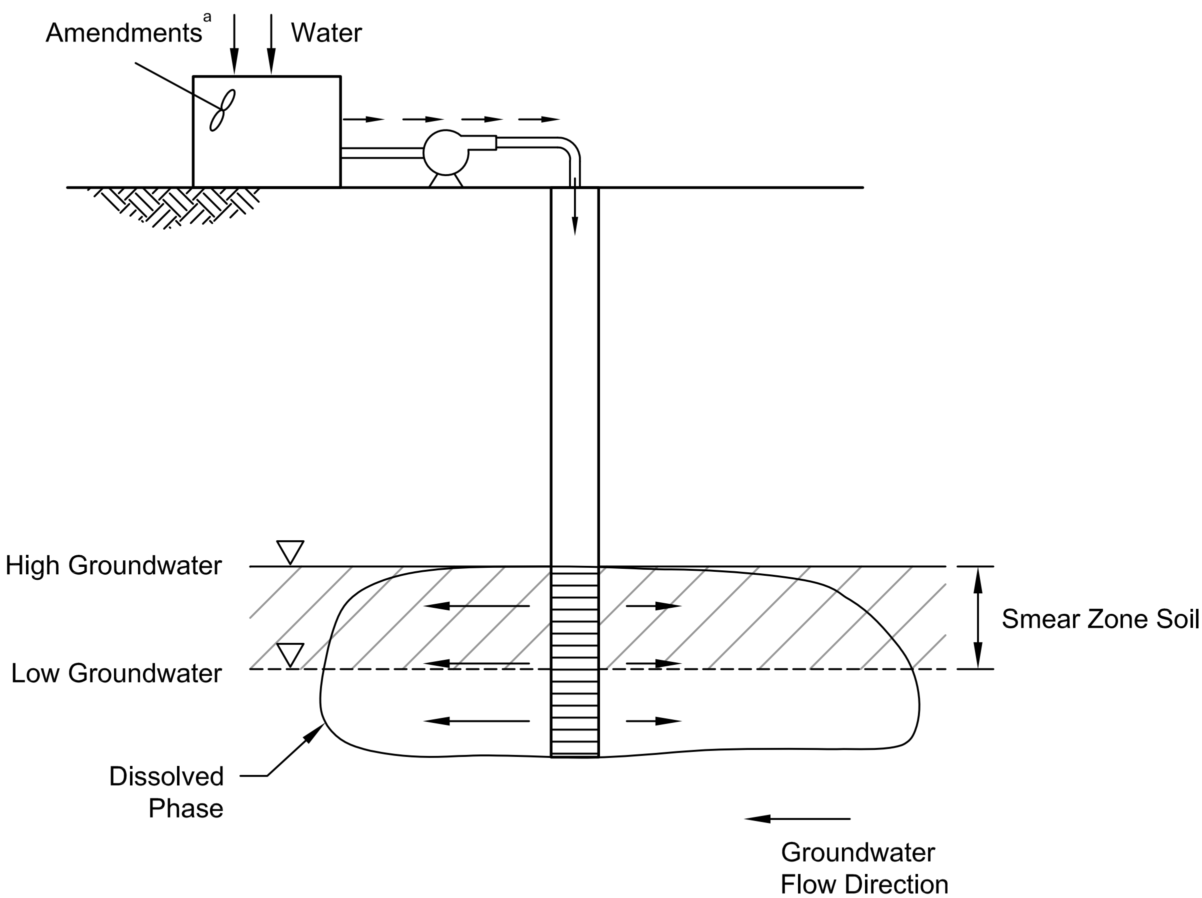
Figure 4-9

EAL 05/14/12 2644125-064.dwg

Alternative C3 - Typical In Situ Treatment Configuration for Petroleum Groundwater Plume and Associated Smear Zone Soil AOCs



NOT TO SCALE

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Note a: Amendments for *in situ* enhanced bioremediation include nutrients, dilute hydrogen peroxide, and surfactants.

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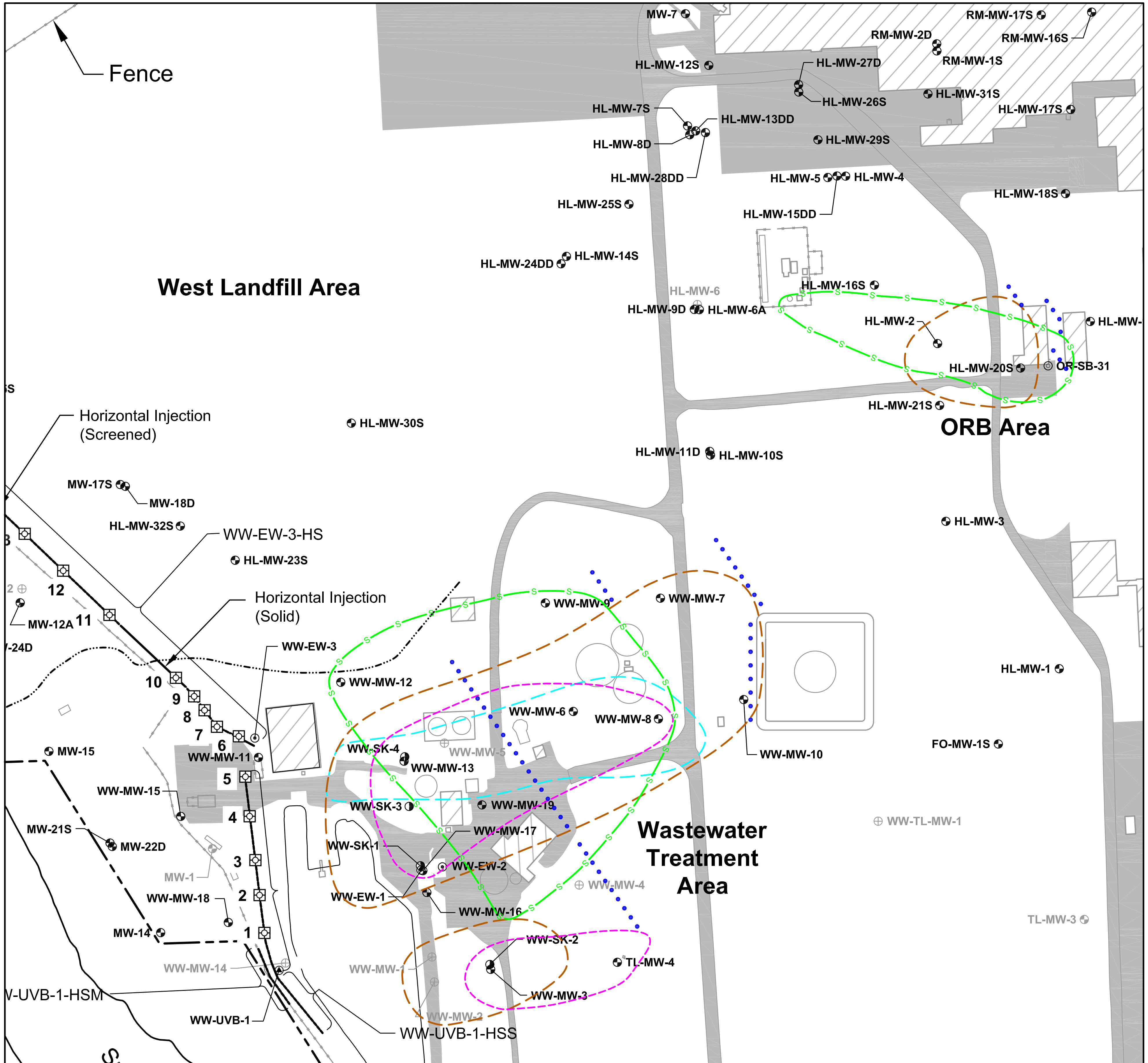
Figure 4-10

Alternative C3 - In Situ Bioremediation Injection Well Location Plan

West Area



Exploration Location and Number

- Proposed Injection Well
- OH-EW-1 Extraction Well
- OH-MW-03 Monitoring Well
- TL-MW-3 Abandoned Monitoring Well
- OH-SK-1 Skimming Well
- TF-EW-1-US Upper Screen Well

- Inferred Extent of SVOC Groundwater Exceeding Screening Level
- Inferred Extent of PCB Groundwater Concentrations Associated with Petroleum Hydrocarbons Exceeding Screening Level
- Inferred Extent of Free Phase Petroleum
- Smear Zone Soil
- SVOC Area of Screening Level Exceedance in Smear Zone Soil

- Existing Paved Area
- Existing Building

N

0 200 400
Scale in Feet

HARTCROWSER

Alternative C3 - In Situ Bioremediation Injection Well Location Plan
East Area

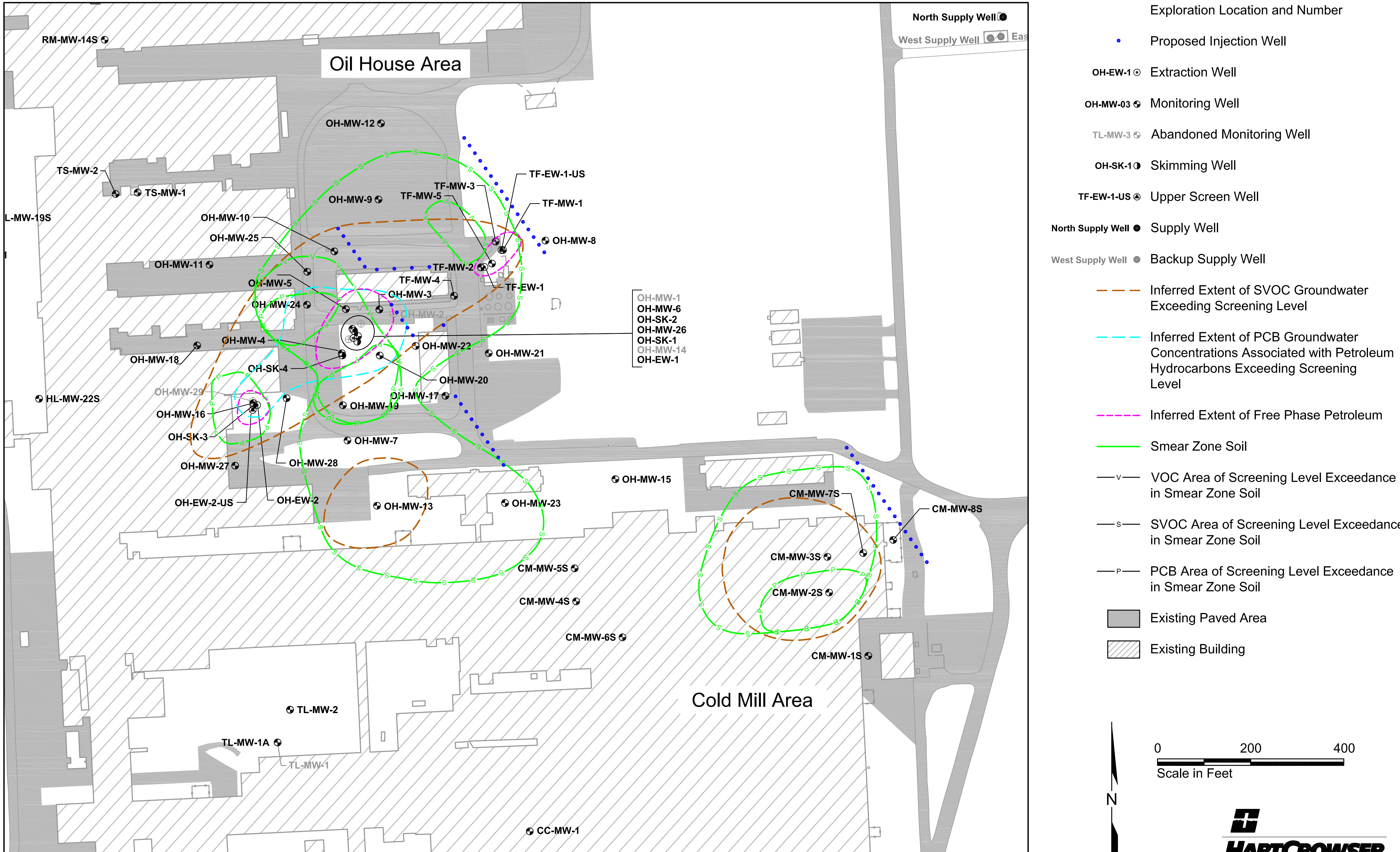


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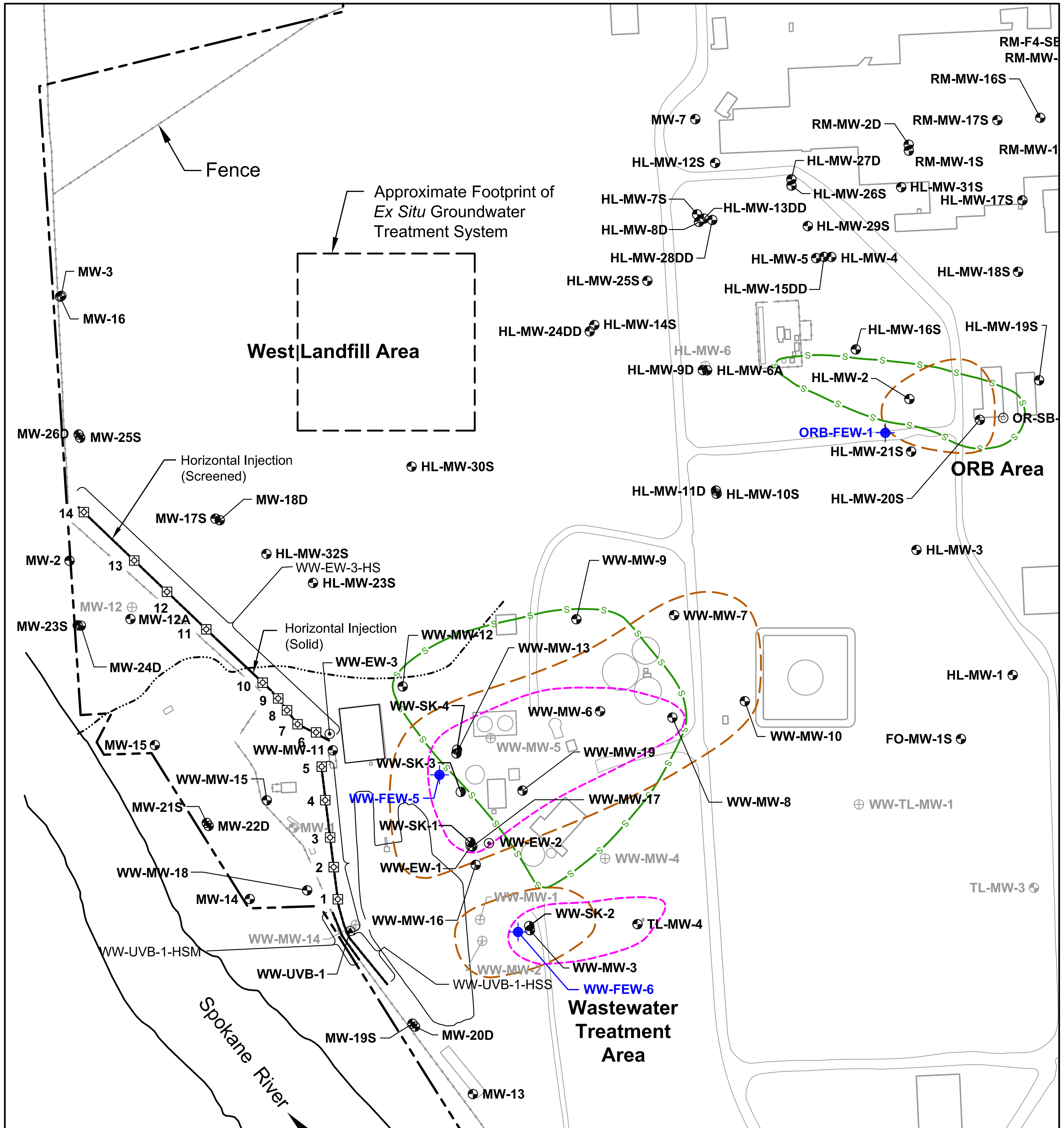
Figure 4-12

EAL 05/14/12 2644125-066.dwg

Alternative C4 - Proposed Groundwater Extraction Well Location Plan
West Area



Exploration Location and Number

- ORB-FEW-1 Proposed Extraction Well
- OH-EW-1 Extraction Well
- OH-MW-03 Monitoring Well
- TL-MW-3 Abandoned Monitoring Well
- OH-SK-1 Skimming Well
- TF-EW-1-US Upper Screen Well

- Inferred Extent of Diesel and Heavy Oil in Groundwater (2009/2010) Exceeding Screening Level Based on Best Available Data
- Inferred Extent of Free Phase Petroleum in Groundwater (2009/2010) Based on Best Available Data
- Smear Zone Soil
- SVOC Area of Screening Level Exceedance in Smear Zone Soil

0 250 500
Scale in Feet

N

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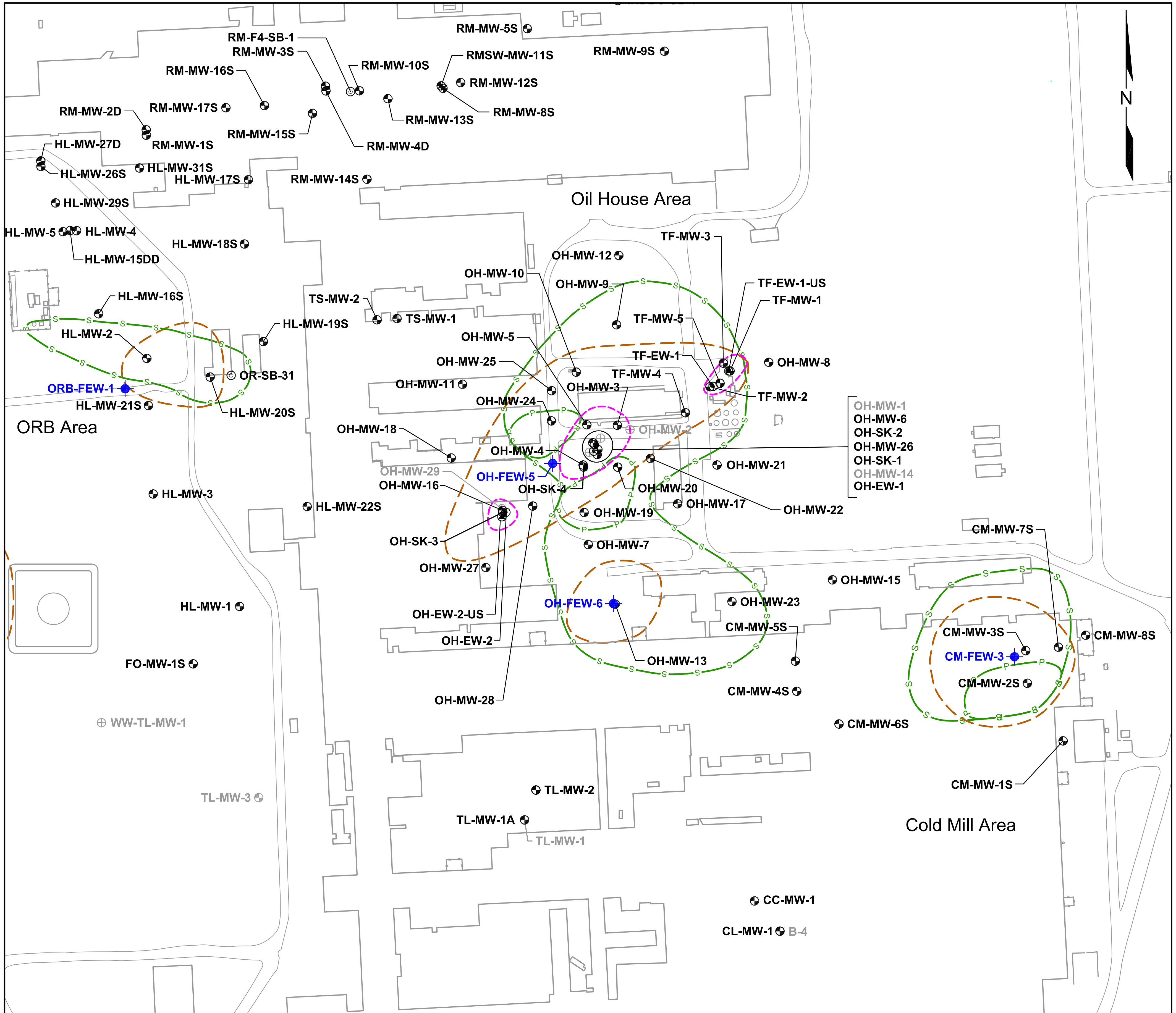
Figure 4-13

EAL 05/14/12 2644125-067.dwg

Alternative C4 - Proposed Groundwater Extraction Well Location Plan

East Area



Exploration Location and Number

- CM-FEW-1 Proposed Extraction Well
- OH-EW-1 Extraction Well
- OH-MW-03 Monitoring Well
- TL-MW-3 Abandoned Monitoring Well
- OH-SK-1 Skimming Well
- TF-EW-1-US Upper Screen Well

- Inferred Extent of Diesel and Heavy Oil in Groundwater (2009/2010) Exceeding Screening Level Based on Best Available Data
- Inferred Extent of Free Phase Petroleum in Groundwater (2009/2010) Based on Best Available Data
- Smear Zone Soil
- S — SVOC Area of Screening Level Exceedance in Smear Zone Soil
- P — Comingled PCB Area of Screening Level Exceedance in Smear Zone Soil

0 250 500

Scale in Feet

HARTCROWSER

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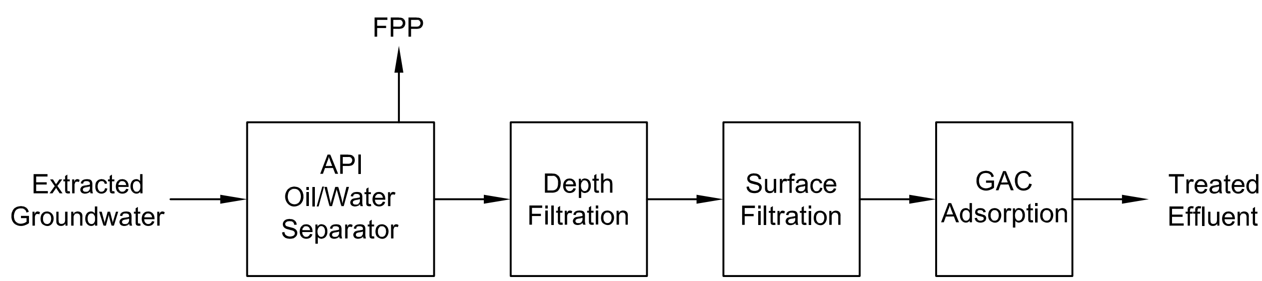
Figure 4-14

EAL 05/14/12 2644125-068.dwg

Alternative C4 - Proposed Ex Situ Treamtent Process Flow Diagram for Petroleum Hydrocarbon Groundwater Plumes



EAL 05/14/12 2644125-069.dwg

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Figure 4-15

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CONTENTS (Continued)

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TABLES

FIGURES

5.0 REMEDIATION ALTERNATIVES FOR THE REMELT/HOT LINE GROUNDWATER PLUME AND ASSOCIATED SMEAR ZONE SOIL

Section 5 of this feasibility study (FS) evaluates the technology-based remedial alternatives identified in the Feasibility Study Technical Memorandum (FSTM) (Hart Crowser 2012c) for the Remelt/Hot Line groundwater plume identified at the Facility (FSTM Section 6) and the smear zone soil associated with this plume (FSTM Section 4). An additional alternative, Alternative D4, has been included at the request of Ecology (Ecology 2011).

PCBs were identified as the COC for the Remelt/Hot Line groundwater plume in Section 6 of the FSTM. The Remelt/Hot Line groundwater plume does not contain free phase product (FPP) nor SVOCs (including diesel- and heavy oil-range petroleum hydrocarbons and carcinogenic polycyclic aromatic hydrocarbons [cPAHs]). Arsenic, iron, and manganese concentrations in the plume were below SLs (refer to Section 6 of the FSTM). Smear zone soil in the Remelt/Hot Line contains low concentrations (average of 0.07 mg/kg) of widely dispersed PCBs. The smear zone soil acts as a secondary PCB source area that seasonally contacts groundwater, allowing PCBs in the smear zone to partition into groundwater. There is also one soil AOC that contains heavy oil near well RM-MW-14S. This heavy oil AOC is located near the north end of the Hot Line and does not appear to contribute to the Remelt/Hot Line groundwater plume (see below).

Many of the potential remedial technologies identified in the FSTM for the Remelt/Hot Line groundwater plume (FSTM Table 6-5) were similar to the technologies identified as potential remedial technologies for smear zone soil containing PCBs alone (FSTM Table 4-15). Thus, Section 5 of this FS jointly discusses the process of identifying the most appropriate technology-based remedial alternatives for PCBs in the Remelt/Hot Line groundwater plume and in the smear zone soil associated with this plume.

The most appropriate technology-based alternative identified in Section 5 for the Remelt/Hot Line groundwater plume and associated smear zone soil is assembled with the technology-based alternatives identified for the other AOCs at the Facility in Sections 2 (near-surface soil), 3 (vadose zone soil), and 4 (petroleum hydrocarbon groundwater plumes and associated smear zone soil) to identify the appropriate area-based remedial alternative(s) for each operating area of the Facility in Section 6 of this FS.

Section 5 is organized as follows:

- Section 5.1 – Description of Remedial Alternatives for the Remelt/Hot Line Groundwater Plume and Associated Smear Zone Soil;
- Section 5.2 – Evaluation of Remedial Alternatives for the Remelt/Hot Line Groundwater Plume and Associated Smear Zone Soil; and
- Section 5.3 – Comparative Analysis of Remedial Alternatives for the Remelt/Hot Line Groundwater Plume and Associated Smear Zone Soil.

Costs have been estimated for the remedial alternatives for the Remelt/Hot Line groundwater plume and smear zone soil. These costs are summarized for each alternative in their respective descriptions in Section 5.1. Cost estimate summary tables and backup calculations for each alternative are provided in Appendix D. Table D-1 in that appendix compares the net present value costs of the remedial alternatives. These estimated costs are used in Sections 5.2 and 5.3 as part of the process of evaluating each technology-based remedial alternative for the remediation of the PCBs in the Remelt/Hot Line groundwater plume and associated smear zone soil. The same cost estimating resources described in Section 2 are used to prepare estimated costs for the alternatives discussed in this section. The cost tables in Appendix D are annotated to reflect the resources used to estimate costs (-35 to +50 percent) for each line item.

Groundwater modeling is used in this section to assist in understanding the Remelt/Hot Line groundwater plume and to provide information needed to assess remedial alternatives (for example, well locations and groundwater extraction flow rates needed to achieve hydraulic containment). The development, calibration, and output of the groundwater model are contained in Appendix E.

5.0.1 Development of Cleanup Standards for the Kaiser Facility

The groundwater screening level (SL) developed in the FSTM for PCBs (0.000064 μg/L) was based on the protection of surface water. The current groundwater method detection limit (MDL) for the standard analytical method (modified Method 8082) used at the site to measure PCB concentrations in groundwater is 0.0045 μg/L. The current understanding of the Remelt/Hot Line plume is based on data analyzed using this method.

As discussed in Sections 2.0.1 and 4.0.1, Ecology developed preliminary cleanup levels (PCULs) for both a standard point of compliance (POC) and a conditional

POC (Ecology 2010a and 2010b). The SLs and PCULs for soil and groundwater at the Facility are compared in Tables 2-1 and 4-1, respectively.

The PCUL for PCBs for the standard groundwater POC established by Ecology is 0.000064 µg/L, which is based on the criteria for the protection of surface water published under Section 304 of the Clean Water Act for protection of human health based on water and fish ingestion. Ecology adjusted this value to 0.0045 µg/l, the method detection limit (MDL) for the analytical method used to measure PCB concentrations in groundwater (Ecology 2010a). The MDL may be subject to further discussions. Under a standard POC, this PCUL would need to be met throughout the Facility from the uppermost level of the saturated zone extending vertically to the lowest depth, which could potentially be affected by constituents of concern at the Facility.

If a conditional groundwater POC is establish by Ecology, the PCUL for PCBs is 0.000064 µg/L (adjusted up to the MDL of 0.0045 µg/L) at the point or points of discharge to the surface water. Concentrations of PCBs everywhere else on the Facility may exceed surface water standards but must meet drinking water standards (0.22 µg/L, adjusted down from 0.44 µg/L, the drinking water criterion to bring total cancer risk down to 0.5×10^{-5}) and MTCA threshold requirements (Ecology 2010a).

The Remelt/Hot Line groundwater plume and smear zone soil areas of concern (AOCs) are shown on Figure 5-1. The Remelt/Hot Line groundwater plume shown on Figure 5-1 is an update of the plume depicted on Figure 6-1 of the FSTM. Figure 5-1 uses recent PCB concentration data collected during 2009 and 2010. Figure 6-1 of the FSTM was based on PCB concentration data collected during 2008. The estimated extent of the groundwater plume is based on the MDL (0.0045 µg/L) of modified Method 8082.

The smear zone AOC shown on Figure 5-1 is based on the soil SL (0.014 mg/kg) presented in Table 1 of the FSTM. The estimated mass of PCBs in the smear zone soil presented in the FSTM was derived using a series of assumptions (refer to Appendix D of the FSTM). This FS recalculated the estimated mass of PCBs in the Remelt smear zone using a different set of assumptions (see the PCB Restoration Time Frame Evaluation Memorandum presented in Appendix I). For instance, only the smear zone soil locations that fell within the Remelt/Hot Line groundwater plume were included in the revised calculation of estimated PCB mass.

Although the soil and groundwater PCULs were provided during the writing of this FS report, Ecology has allowed the continued use of the SLs in developing and evaluating the remediation alternatives for groundwater and smear zone soil presented herein (Ecology 2010b). Only a standard POC was considered during the development of the SLs in the FSTM. The SL and the PCUL for a standard POC are both 0.000064 μg/L. For the purposes of Section 6, the use of PCULs for groundwater will allow for a discussion of the impacts that both a standard POC and a conditional POC would have on each alternative that is evaluated. Compliance with cleanup standards for smear zone soil will be considered to be met when groundwater cleanup levels have been achieved (Ecology 2011).

The decision to grant a conditional POC will be documented in the Cleanup Action Plan (CAP), in which final cleanup standards (i.e., cleanup levels and points at which these levels must be met) for the Facility will be presented.

5.1 DESCRIPTION OF REMEDIAL ALTERNATIVES FOR THE REMELT/HOT LINE GROUNDWATER PLUME AND ASSOCIATED SMEAR ZONE SOIL

This section discusses the technology-based remedial alternatives developed in the FSTM for the Remelt/Hot Line groundwater plume and associated smear zone soil. Background information describing the characteristics of the plume precedes discussion of the remedial alternatives. This section is organized as follows:

- Section 5.1.1 – Characteristics of the PCBs Present in the Remelt/Hot Line Groundwater Plume;
- Section 5.1.2 – Recent Footprint of the Remelt/Hot Line Groundwater Plume – Shallow Groundwater;
- Section 5.1.3 – Groundwater Quality of the Deeper Aquifer;
- Section 5.1.4 – Alternative D1: Institutional Controls, Monitoring, and Monitored Natural Attenuation;
- Section 5.1.5 – Alternative D2: Alternative D1 Plus Containment;
- Section 5.1.6 – Alternative D3: Alternative D2 Plus Groundwater Extraction with *Ex Situ* Treatment; and
- Section 5.1.7 – Alternative D4: Alternative D1 Plus Groundwater Extraction with *Ex Situ* Treatment.

The FSTM evaluated a wide range of technologies that were potentially applicable to the dilute PCB concentrations detected in the Remelt area smear zone (average concentration of 0.07 mg/kg--refer to Appendix I). No successful full-scale applications of these technologies for soil (such as that present in the Remelt/Hot Line area) at depths of 68 to 80 feet bgs were identified.

Alternative D2 extracts groundwater to contain the Remelt/Hot Line groundwater plume. The extracted groundwater is conveyed to a location upgradient of the Oil House area. The PCB mass (about 5 pounds over 30 years) in the Remelt/Hot Line plume will be transferred to the petroleum hydrocarbon smear zone in the Oil House area where the continued natural attenuation (e.g. sorption, biodegradation, chemical stabilization) of petroleum hydrocarbons and comingled PCBs is expected to continue. The Oil House groundwater plume is also degraded and contained through bioremediation and the IRM.

Considerable evidence is available to prove that the bioremediation of petroleum hydrocarbons has occurred and is continuing to occur at the Site (refer to Appendix F). The biodegradation of PCBs that are comingled with petroleum hydrocarbons in the Oil House and other areas of the Site may also be occurring. Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established. Bench- and-or pilot-scale tests will be completed prior to the completion of the CAP for the Site.

5.1.1 Characteristics of PCBs in the Remelt/Hot Line Groundwater Plume

The concentration of PCBs in the Remelt/Hot Line plume is very low and varies from non-detect up to 2,000 nanograms per liter (ng/L) (or 2.0 micrograms per liter [µg/L]) in April 2010 (refer to Figures 5-1 and 5-4).

5.1.1.1 Facilitated Transport of PCBs by Colloids

The PCBs in the Remelt/Hot Line groundwater plume are in a dilute solution and appear to be bound, at least in part, to the colloidal particles in the plume. Particulates that can move through soil with groundwater must be small enough to move through the soil pore spaces. Colloids are particles in the size range of 10^{-3} to 1 micrometer (µm), which have been shown to move through soil pores in a variety of groundwater systems. Because of their physical and chemical properties, colloids are a special class of matter with properties that lie between those of the dissolved and solid states (refer to Section 6.2.1 of the FSTM).

Colloids may be mobilized by either chemical or physical processes. Chemical processes favoring mobilization include changes in solution chemistry, such as changes in ionic strength, pH, organic matter concentration, or adsorption of ions and macromolecules that alter surface charge. Physical processes include pumping, sampling, and flow velocity associated with groundwater in addition to rapid water infiltration from the ground surface.

For migration of a colloidal particle to occur in an aquifer, the diameter of the migrating colloidal particle must be significantly smaller than the diameter of the soil pore. If this is not the case, the particle will essentially be filtered from the migrating liquid. The soil in the upper portion of the aquifer at the Facility generally consists of sand and sandy gravel with scattered open work zones (Hart Crowser 2012a). The open work zones are poorly sorted gravels with little or no sand or other fines between individual pieces of gravel. These materials typically exhibit a high degree of permeability, which would accommodate the passage of migrating colloidal particles in groundwater at the Facility.

A groundwater sample from well HL-MW-5 collected in 2004 was subjected to colloidal particle characterization. Analysis indicated a particle grain size ranging from smaller than 0.3 µm to greater than 25 µm in length. The effective diameter of the majority of particles was less than 1.6 µm, indicating that the majority of the particulate matter was in the optimal range for colloidal transport. Most of the particulate material analyzed in the sample appeared to be quartz (Hart Crowser 2005).

Colloids have a high surface-area-to-mass ratio because of their very small size, and thus present a large surface area available for adsorbing and transporting compounds such as PCBs, which have low aqueous solubility and a greater affinity for adsorption onto solid surfaces. As a result, PCBs can migrate with groundwater flow by adsorption or occlusion with colloids, resulting in unexpected mobility for an otherwise low-solubility compound. Typically, when compounds are adsorbed onto colloids, their transport behavior is determined by the properties of the colloid, not the properties of the sorbed constituent. Transport of PCBs by colloidal migration has been modeled by Hart Crowser (Hart Crowser 2012a, Section 6) and by others (Chatzikosma and Voudrias 2007). Both models conclude that the concentration of PCBs in a groundwater environment such as at the Facility will be significantly reduced by removing colloids from the groundwater plume. Technologies potentially applicable to the removal of colloids from extracted groundwater as part of *ex situ* treatment are assessed in Sections 5.1.6 and 5.1.7 for Alternatives D3 and D4, respectively.

5.1.2 Recent Footprint of the Remelt/Hot Line Groundwater Plume – Shallow Groundwater

The discussion of the recent footprint of the Remelt/Hot Line plume presented in this section is based on measurements of total PCB concentration using modified Method 8082 with an MDL for total PCBs of 0.0045 µg/L.

The plume starts in the Remelt casting area and extends about 2,000 feet downgradient of the source area, where it appears to terminate in the former West Landfill area (Figure 5-1). There have also been infrequent low concentrations of PCBs in some of the wells located between the leading edge of the plume and the Spokane River. These anomalous detections near the river are not consistent with observations that would be expected if they originated from the Remelt area of the Facility (see below). This section of the FS presents the available data and identifies the leading edge of the PCB plume based on that data and the MDL. Additional investigations near the river are ongoing to better understand the infrequent PCB occurrences in that area.

Groundwater data for the Remelt/Hot line plume presented on Figure 6-1 of the FSTM were collected during 2008. Additional PCB groundwater data were collected during April and October 2009 and during April 2010. Groundwater elevation and PCB concentration contour maps for these comprehensive sampling rounds are summarized on Figures 5-2, 5-3, and 5-4, respectively. Quarterly groundwater sampling rounds in January and July focused mainly on perimeter wells near the Spokane River and did not provide sufficient areal PCB data coverage to allow for PCB plume contouring. In addition, in June 2010 a limited number of groundwater samples were collected from select wells near the leading edge of the known PCB plume to provide additional data for ongoing evaluations near the river. These data also did not provide sufficient data to allow PCB concentrations to be contoured.

A summary of the PCB data collected from eight wells extending from the leading edge of the Remelt/Hot Line groundwater plume (well HL-MW-30S) down to approximately the Kaiser property line (wells MW-15, MW-23S, and MW-25S) are summarized in Table 5-1. Data statistics for the eight wells for the samples listed in Table 5-1 are summarized in Table 5-2, including the total number of samples analyzed. The wells included in Tables 5-1 and 5-2 were selected based on their proximity to the known Remelt/Hot Line PCB plume. Shallow wells on the leading edge of the plume (e.g., well HL-MW-30S), which are downgradient within the groundwater flow and PCB plume pathway, are included. These tables also include perimeter wells north and south of the PCB plume (e.g., MW-15 and MW-25S). The PCB detection frequency, minimum and maximum detected concentrations, date of maximum detected concentration, and mean and median concentration values contained in Table 5-2 are based only on detected PCB data. This method of calculating mean and median values results in very conservative concentration values. A less conservative approach, which is typically acceptable, is to use one-half of the reporting limit for results that are below the reporting limit. However, for this evaluation a more conservative data averaging approach was taken.

Wells MW-15 and MW-25S are not directly in the path of the Remelt/Hot Line PCB plume but they are perimeter wells that are close enough to the flow path of the plume to warrant discussion (see Figures 5-2 through 5-4). These perimeter wells have each had one low-level detection of PCBs (Tables 5-1 and 5-2). Well MW-15 had one estimated detection of 1.9 ng/L in July 2007 of its 41 sampling events. Well MW-25S had one estimated detection of 4.4 ng/L also in July 2007 of its 31 sampling events. Based on these analytical results, and the fact that PCBs were detected less than 5 percent of the samples analyzed, the Remelt/Hot Line PCB plume is not impacting these wells, and the wells are not considered to be a part of the Remelt/Hot Line groundwater plume.

As shown on Figures 5-2 through 5-4, low concentrations of PCBs have been infrequently detected in some of the wells located north of the West Discharge Ravine (WDR) and west of the leading edge of the PCB plume. Well HL-MW-30S is at the leading edge of the PCB plume and has had consistent detections of PCBs ranging from 100 to 220 ng/L with a mean PCB concentration of about 147 ng/L (Table 5-2). Shallow wells located west of the leading edge of the PCB plume that are in line with the plume flow path include MW-17S, HL-MW-32S, HL-MW-23S, MW-12A, and MW-23S. PCB detections in these five wells, while infrequent, reveal some interesting patterns:

- Recent PCB data in wells near the river (MW-23S, MW-12A) are not consistent with what would be expected if these detections were from the Remelt/Hot Line PCB plume, in that wells upgradient of MW-23S and MW-12A sometimes do not have detectable PCBs or have PCB concentrations that are much lower than concentrations in MW-23S and MW-12A.

- For wells located downgradient of the leading edge of the Remelt/Hot Line PCB plume (MW-23S, MW-12A, MW-17S, HL-MW-32S, and HL-MW-23S), 32 PCB detections have occurred in 126 samples, for a 25 percent detection frequency. This low detection frequency is not consistent with the much higher detection frequency that occurs in wells known to be located within the Remelt/Hot Line plume (e.g., HL-MW-30S).

- The 32 PCB detections in wells MW-23S, MW-12A, MW-17S, HL-MW-32S, and HL-MW-23S, except for nine, have occurred during the high river and high groundwater stages between the months of January and June.

Each of these observations is discussed in more detail in the following subsections.

5.1.2.1 Where is the Leading Edge of the Remelt/Hot Line PCB Plume?

The discussion of the location of the leading edge of the Remelt/Hot Line plume presented in this section is based on measurements of total PCB concentration using modified Method 8082 with an MDL for total PCBs of 0.0045 μg/L.

Figure 5-2 shows groundwater contours and PCB detections in shallow wells in April 2009. Total PCBs at the leading edge of the Remelt/Hot Line PCB plume were detected in well HL-MW-30S at a concentration of 170 ng/L. Shallow wells MW-17S and HL-MW-23S are located about 300 feet downgradient of well HL-MW-30S and neither of these wells had detectable PCB concentrations during the April 2009 groundwater sampling event. During the same sampling event, well MW-12A, located about 300 feet downgradient of wells MW-17S and HL-MW-23S, had a PCB concentration of 52 ng/L, and well MW-23S, located about 150 feet downgradient of well MW-12A, had an estimated PCB concentration of 19 ng/L. These data raised questions as to whether the narrowness of the PCB plume could be causing it to travel between wells MW-17S and HL-MW-23S. In response to these questions, Kaiser installed well HL-MW-32S between these two sentinel wells in September 2009.

In October 2009, groundwater from well HL-MW-30S contained PCBs at a concentration of 110 ng/L. During this same sampling event, none of the wells located downgradient of well HL-MW-30S contained detectable PCBs, including new well HL-MW-32S (Figure 5-3). This time of year typically has the lowest groundwater and river elevations and highest groundwater flow gradient toward the river (see below).

In April 2010, sentinel wells MW-17S and HL-MW-23S had low detected concentrations of PCBs in groundwater of 7.9 and 10 ng/L, respectively (Figure 5-4). Groundwater from new well HL-MW-32S, located midway between the two sentinel wells, did not have detectible PCB concentrations. During the same period, groundwater from well MW-12A contained a PCB concentration of 64 ng/L, and no PCBs were detected in well MW-23S at the Facility property line.

PCB analytical results from the three sampling events (April 2009, October 2009, and April 2010) are not consistent with observations that would be expected if the detections in wells (e.g., MW-12A and MW-23S) near the river were coming from the Remelt/Hot Line PCB plume. The three sentinel wells located between the leading edge of the plume at well HL-MW-30S and downgradient protection wells (MW-12A and MW-23S) near the river have significantly different PCB detection frequencies and concentrations than would be expected if the infrequent detections in MW-12A and MW-23S were from the Remelt/Hot Line PCB plume. This is especially evident in the April 2009 and April 2010 analytical results, where PCB results from the three sentinel wells were either below detection limits or significantly lower than results for well MW-12A near the river (see Figures 5-2 and 5-4).

Thus, the weight of evidence suggests that the leading edge of the Remelt/Hot Line PCB plume is located near well HL-MW-30S, and that wells MW-12A and MW-23S are not part of the Remelt/Hot line PCB plume.

Ecology is considering the use of EPA Method 1668 proposed in the Federal Register in September 2010 to measure the concentration of PCBs in groundwater. This method has a reporting limit in the 20 pg/L range. It is not known as this FS is being prepared whether this method will be promulgated by EPA and if it is, what the final method detection limits will be. In addition, the MTCA may need to be modified to use the new analytical method for compliance under MTCA (see WAC 173-340-830[3][c] and [d]).

5.1.2.2 Detection Frequencies in Wells Near the Spokane River are Inconsistent

The known extent of the Remelt/Hot Line PCB plume, from its source in the Remelt facility downgradient to well HL-MW-30S, has been relatively consistent and predictable (Hart Crowser 2012a). PCBs have been consistently detected in well HL-MW-30S during its 13 sampling events, from 2007 to 2010, at concentrations ranging between 100 and 220 ng/L. The PCB plume is well established and, other than a slight seasonal fluctuation in the flow direction (more northerly in high groundwater periods and more southerly in lower groundwater conditions), the size and shape of the plume is relatively consistent.

However, PCB analytical results from wells MW-23S and MW-12A are not consistent with the known Remelt/Hot Line PCB plume behavior, either in frequency of detection and PCB concentration profiles (Tables 5-1 and 5-2). PCB concentrations ranging from 6.9 to 25 ng/L were detected in the well along the Facility property line (well MW-23S) in four of 31 sampling events, for a 13 percent detection frequency (Table 5-2). Similarly, PCBs at concentrations from

4.7 to 95 ng/L were detected in well MW-12A at a 33 percent detection frequency (13 of 40 sampling events from 1999 to 2010).

The three sentinel wells located between well HL-MW-30S and the Spokane River show similar inconsistencies in detection frequencies and concentrations, as follows (see Table 5-2):

- Well MW-17S has had 17 PCB detections in 33 sampling events, a 51 percent detection frequency from 2001 to 2010, at concentrations ranging from 4.1 to 23 ng/L. Note also that the detected concentration range in this well is lower than in well MW-12A.

- New well HL-MW-32S had one PCB detection in June 2010 of four sampling events, a 25 percent detection frequency from October 2009 to June 2010, at a concentration of 10 ng/L (Table 5-2).

- Well HL-MW-23S has had eight PCB detections in 18 sampling events, a 44 percent detection frequency, at concentrations ranging between 5.1 and 17 ng/L. Similar to well MW-17S, the detected concentration ranges from this well are below those in well MW-12A.

Thus, the detection frequency and the detected concentrations of PCBs in the wells downgradient of the leading edge of the Remelt/Hot Line PCB plume (near HL-MW-30S) are inconsistent with wells within the known plume boundary and need to be further assessed. This inconsistency provides further evidence that wells MW-12A and MW-23S are not part of the Remelt/Hot Line PCB plume.

5.1.2.3 PCB Detections Relative to River Stage and Groundwater Hydrographs

Groundwater hydrographs are presented on Figures 4-10 and 4-11 in the Final Groundwater RI Report (Hart Crowser 2012a). Figure 5-5 (in this FS) shows Spokane River readings from the staff gage located at the river pump house at the Kaiser Facility between January 2002 and June 2010. These figures show that, in general, the groundwater and river stages were highest between January and June and lowest between July and December in a typical year. During the winter and spring months, when both river stage and groundwater elevations are the highest, the groundwater gradient across the Facility is the flattest (see Table 4-1, Hart Crowser 2012a). That is, groundwater moves faster when the gradient is steeper (July through December), and vice versa.

At the Kaiser Facility, groundwater moves faster toward the river when the groundwater gradient is steepest. Thus, it is expected that the maximum extent of the Remelt/Hot Line PCB plume would occur between July and December in a typical year. Accordingly, if the PCB detections near the river were from the known Remelt/Hot Line PCB plume, one would expect to see the majority of the PCB detections near the river during the summer and fall months. However, this is not the case (see Table 5-1):

- Well MW-17S has seven PCB detections, which except for two, occur during the winter/spring months when the groundwater gradients and flow rates are the lowest;

- The single PCB detection in new well HL-MW-32S occurred in June 2010 during the low groundwater gradient period (i.e., high groundwater elevation);

- Well HL-MW-23S has eight PCB detections, five of which were during the low gradient, high groundwater elevation months, in the winter through spring period;

- Well MW-12A has 13 PCB detections, only 3 of which are during the high groundwater gradient months when the groundwater elevations are at their lowest; and

- Well MW-23S has had four PCB detections, which except for one, have occurred during the low groundwater gradient, high groundwater elevation months.

To better understand the PCB detection concentrations and detection frequencies in the wells near the river, Kaiser installed continuously recording pressure transducers in the river near the mouth of the WDR, at the Kaiser staff gage located at the river pump house, and in five monitoring wells (MW-23S, MW-24D, MW-12A, MW-17S, and HL-MW-23S) in early September 2009. Preliminary data from these wells (the study is ongoing) indicate that the groundwater elevation responds nearly instantaneously to increased river stage throughout the study area, and that there is a groundwater gradient reversal when the river stage rises above a certain level. This reversal dramatically changes the groundwater flow direction near the river making the net groundwater flow direction more northerly and closer to parallel to the river. It appears that PCB detections in wells near the river may be occurring during these high river stage events.

In summary, available PCB data from groundwater samples collected near the river (at wells MW-12A and MW-23S) indicate that the majority of PCB detections in these wells occur when the gradient is the flattest and groundwater is moving slower than at other times of the year. This is also when gradient reversals are most likely to occur because of the increased water level elevations in the river. This is not consistent with what would be expected if these wells were part of the Remelt/Hot Line groundwater plume.

5.1.2.4 Conclusions on the Extent of the Remelt/Hot Line PCB Plume

As discussed above, it appears that infrequent low-level concentrations of PCBs detected in wells downgradient of the leading edge of the Remelt/Hot Line PCB plume are not connected to the Remelt/Hot Line PCB plume. The Remelt/Hot Line PCB plume appears to end at a location between well HL-MW-30S and the three sentinel wells (MW-17S, HL-MW-32S, and HL-MW-23S) located just downgradient from well HL-MW-30S.

Occasional PCB detections in wells near the river are most prevalent during high river stage months and may be caused by changes in the direction of groundwater flow close to the river.

5.1.2.5 Additional Work Required

The source of PCBs detected in wells downgradient of the Remelt/Hot Line PCB plume is not known. Further investigation is needed to identify a potential source area. Kaiser is working with Ecology to plan additional investigations concurrent with the review and approval of this FS. This will entail the installation of soil borings in the WDR, installation of additional groundwater monitoring wells, ongoing continuous monitoring of groundwater and river elevations near wells MW-12A and MW-23S, and soil and groundwater sampling and analysis near the Spokane River. This work is scheduled to begin in the fall of CY 2011. The results of this additional work will be presented in an addendum to this FS.

5.1.3 Groundwater Quality of the Deeper Aquifer

Kaiser has 17 groundwater monitoring wells that are screened entirely below the top of the water table. The PCB data collected from these wells are summarized in Table 5-3. Of these 17 wells, 13 are constructed with the top of the well screen located between 10 and 30 feet below the water table. These wells include HL-MW-5 and the wells with the letter “D” following the well number (e.g., HL-MW-27D). Four other wells are constructed with the top of the well screen located about 50 to 60 feet below the top of the water table. These deep well completions are identified with the letters “DD” following the well number (e.g., HL-MW-13DD).

Sections 5.3.3 and 6.3 of the Final Groundwater RI present detailed discussions of the nature and extent of PCBs in the shallow and deep portions of the aquifer (Hart Crowser 2012a). Data in that report were collected through calendar year 2008. Since that time, additional groundwater sampling rounds have occurred (Table 5-3). Recent PCB analytical results from 2009 to 2010 for deep wells (with a "D" in the well name and HL-MW-5) did not have detections since 2008, except for the following:

- HL-MW-5 had detections of PCBs during the five sampling events through April 2010. PCB detections in this well occur regularly, and the detections since 2008 are within the expected range (120 to 230 ng/L) for this well. This was the first well installed at Kaiser that was intended to be screened entirely below the water table. It consists of a 2-foot well screen at a depth of between 93 and 95 feet below ground surface. In a typical year, the well screen is within about 10 to 20 feet of the top of the water table. Thus, this well screen is within the shallow portion of the Remelt/Hot Line PCB plume and does not indicate deep PCB migration of the plume.

- HL-MW-8D had PCB detections during the three monitoring events that have occurred since 2008. These PCB detections and the detected concentration ranges (39 to 57 ng/L) are typical for this well. It is screened between 83 and 103 feet below ground surface, and the dedicated pump in this well is located in the middle of the well screen for sampling using low-flow sampling techniques.

- HL-MW-9D had one low-level PCB detection of 6.8 ng/L in April 2010. This well has a screen located between about 100 to 120 feet below ground surface and is sampled using low-flow sampling techniques from the middle of the screen interval. It is not typical for this well to have detectable PCBs (Table 5-3). Of the 13 sampling events conducted at this well since 2004, there have been only three PCB detections ranging up to an estimated concentration of 8.8 ng/L.

Of the four deepest monitoring wells at the Facility, only two (HL-MW-13DD and HL-MW-28DD) have had detections since 2008. These two wells are located within 20 feet of each other near the center of the Remelt/Hot Line PCB plume, just west of the Remelt building (Figures 5-2 through 5-4). PCB detections in these two wells occur regularly, and the concentrations detected are within expected ranges (120 ng/L for HL-MW-13DD and 170 to 210 ng/L for HL-MW-28DD) based on historical data (Table 5-3).

Groundwater monitoring results from wells screened below the water table indicate that only one area of the Facility appears to have significant PCB detections deeper than about 20 to 30 feet below the top of the water table. This area is associated with the well cluster containing HL-MW-13DD and HL-MW-28DD located west of the Remelt building.

5.1.4 Alternative D1: Institutional Controls, Monitoring, and Monitored Natural Attenuation (MNA)

Alternative D1 consists of institutional controls, monitoring, and monitored natural attenuation (MNA) for remediation of the Remelt/Hot Line groundwater plume and associated smear zone soil at the Kaiser Facility.

The Remelt/Hot Line groundwater plume and smear zone soil areas of concern (AOCs) are shown on Figure 5-1. The Remelt/Hot Line groundwater plume shown on Figure 5-1 is an update of the plume depicted on Figure 6-1 of the FSTM. Figure 5-1 uses recent PCB concentration data collected during 2009 and 2010. Figure 6-1 of the FSTM was based on PCB concentration data collected during 2008. The technical elements of Alternative D1 are evaluated in Sections 5.2 and 5.3.

The institutional controls, monitoring, and MNA elements of Alternative D1 are common to each of the remedial alternatives that are evaluated in this section of the FS. The institutional control and monitoring elements of Alternative D1 are the same as the elements contained in Alternative A1 for near-surface soil. These elements are described in Sections 2.1.1.1 and 2.1.1.2, respectively. The environmental upgrades that have been completed or that are planned for the Remelt complex are summarized in Table 2-2 and will not be described further in Section 5. Additional institutional controls (if any) that are associated with each remedial alternative proposed for the Remelt/Hot Line groundwater plume and associated smear zone soil are included in the description of that alternative provided in this section of the FS (Sections 5.1.4 through 5.1.7). Similarly, any additional monitoring requirements for each alternative are discussed in the section of the FS devoted to that alternative.

5.1.4.1 Monitored Natural Attenuation

Alternative D1 includes monitoring of natural attenuation inn the Remelt/Hot Line groundwater plume. Natural attenuation of contaminants in groundwater generally occurs through physical, chemical, and biological processes. Physical processes such as advection, diffusion, and dispersion typically help reduce contaminant concentrations for more effective contaminant mass reduction through biological and chemical processes. Biological and chemical processes destroy contaminant mass, reducing both concentrations and plume dimensions.

The result of natural attenuation processes can be observed on Figures 5-2 through 5-4, which show how the PCB concentration in groundwater declines with increasing distance from apparent source areas along the direction of groundwater flow. However, because of the high permeability of the soil matrix, rapid groundwater flow rate, and suspected colloidal transport of PCBs at the Facility, the effect of natural attenuation processes in reducing PCB concentration below the PCB PCUL is observed after the groundwater plume has travelled about 1,100 feet from the Remelt building. It can be concluded that the natural attenuation processes that are occurring in the Remelt/Hot Line groundwater plume at the Facility have stabilized the leading edge of the PCB plume approximately 650 feet from the Spokane River (refer to Figures 5-2 through 5-4).

PCBs in the Remelt/Hot Line area that are in the aqueous phase may be amenable to biodegradation under both anaerobic and aerobic conditions. This natural attenuation is expected to be concentrated in locations near the source areas of the PCBs where concentrations are high enough to be amenable to biodegradation. At very low concentrations (e.g., areas greater than 500 feet from the source), there may not be enough PCBs to sustain a microbial population. Aerobic degradation is expected to focus on the mono- and di-chlorinated biphenyls, while anaerobic degradation is expected to be focused on tri- and higher chlorinated PCBs. The natural attenuation of PCBs in the Remelt/Hot Line is discussed further in Appendix F.

MNA will be implemented as part of each remedial alternative for the Remelt/Hot Line groundwater plume. Groundwater analytical data that are applicable to MNA are being collected as part of the existing Kaiser Sampling and Analysis Plan (Hart Crowser 2007a), as amended (Kaiser 2010a). Natural attenuation of the Remelt/Hot Line groundwater plume will be assessed primarily using PCB concentration data to determine whether the leading edge of the plume is continuing to stay at least 650 feet from the Spokane River. To estimate costs for Alternative D1, it is assumed that the existing groundwater protection and performance monitoring regime (see Section 2.1.1.2 and Table 2-3) provides adequate PCB concentration data to assess the plume boundaries.

5.1.4.2 Restoration Time Frame for Alternative D1

For the purposes of this FS, the mechanism for reducing mass of the PCBs in the smear zone is assumed to be through leaching of PCBs from the smear zone soil into the groundwater. PCBs in the groundwater are then naturally attenuated through a variety of mechanisms including biodegradation, dispersion, dilution, and sorption. The natural attenuation of PCBs is discussed in more detail in Appendix F.

The observed attenuation was modeled using regression analysis to predict concentrations at the river based on the empirical data. The curve fitting approach was used to develop an equation that would predict a concentration in the source area that would be protective of receptors in the Spokane River with the knowledge that attenuation is occurring as the groundwater travels from the source area to the river. A PCB concentration of 0.060 µg/L in the source area (2,300 feet upgradient of the river) was predicted to naturally attenuate to 0.000064 µg/L at the river and protect the receptors that may be present. This predictive equation is expected to provide a conservative estimate of the natural attenuation of the PCBs in the Remelt/Hot Line plume. More information on the equation developed to predict the attenuation of PCBs in the Remelt/Hot line groundwater plume is presented in Appendix E.

The estimated restoration time frame for Alternative D1 to reduce the concentration of PCBs in the plume to SLs and PCULs for the standard POC is approximately 280 years to reach the modified Method 8082 MDL of 0.0045 µg/L and 590 years to reach 0.000064 µg/L. If a conditional POC is granted, it is expected to take 6 years for the PCB concentration in the plume to be less than the PCUL of 0.22 µg/L (adjusted down from 0.44 µg/L, the drinking water criterion) and the concentration of PCBs in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Table 5-4). PCBs are not currently reaching the Spokane River from the Remelt/Hot Line plume at concentrations above the current PCUL (modified Method 8082 MDL of 0.0045 µg/L).

If the PCUL for a conditional POC is established as 0.000064 µg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 µg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 µg/L by the time the PCBs reach the river (see Appendices E and I). It is expected to take about 100 years for the PCB concentrations in groundwater and smear zone soil to decline to these values.

5.1.4.3 Alternative D1 Estimated Cost

Assuming an operating period of 30 years and a discount rate of 7 percent, the total net present value cost (NPV) of Alternative D1, which includes institutional controls, monitoring, and MNA, is $19.8 million (Appendix D, Table D-2). The estimated costs for Alternative D1 assume baseline institutional control and monitoring costs that are similar to those for Alternative A1 (see Table A-2 in Appendix A).

5.1.5 Alternative D2: Alternative D1 Plus Containment

Alternative D2 adds the additional protection of hydraulic containment to the elements of Alternative D1. Alternative D2 considers the applicability of two types of containment technologies for the Remelt/Hot Line groundwater plume and associated smear zone soil: surface containment and hydraulic containment.

The leading edge of the plume is considered to be stable and located more than 650 feet from the Spokane River. The future use of proposed EPA Method 1668 to measure ultra low PCB concentrations may indicate that PCBs reach the River at a concentration below 0.0045 µg/L, and perhaps below a concentration of 0.000064 µg/L. The combined benefit of natural attenuation and containment provided by the implementation of Alternative D2 would prevent these low concentrations of PCBs from reaching the receptors in the Spokane River.

The institutional control and MNA elements of Alternative D2 are the same as the elements presented in Alternative D1, described in Section 5.1.1, and are not discussed further in this section. Alternative D2 will require additional monitoring elements, which are described in Section 5.1.5.3 and in Table 5-4.

5.1.5.1 Surface Containment

Surface containment of the Remelt area smear zone AOC is provided by the existing building roof and floor slab that overlies nearly the entire smear zone AOC (Figure 5-1). However, because of the nature of the smear zone and ongoing contact between groundwater and smear zone soil, implementing surface containment of the smear zone soil AOC will not provide significant remedial benefit for this area. The Remelt/Hot Line smear zone in soil is an artifact of groundwater fluctuation, which causes colloidal and any free phase PCBs present to spread vertically through the soil matrix, leaving behind a zone of residual contamination. Because groundwater remains in contact with the smear zone as the water table fluctuates seasonally, the smear zone is considered a secondary source of PCB impacts on groundwater at the Facility. This constitutes an ongoing exposure pathway between impacted soil and groundwater that would not be remedied by surface containment technology.

The purpose of surface containment is to sever exposure pathways that pose a potential threat to human health or the environment. At the Kaiser Facility, surface containment would be used to sever the direct-contact exposure pathway between COC-impacted, near-surface soil and Facility workers and visitors, and to prevent rainwater from infiltrating through impacted near-surface and deep vadose zone soil and potentially conveying COCs to groundwater.

(Surface containment of near-surface soil AOCs and deep vadose zone soil AOCs is discussed under Alternatives A2 and B2, respectively, in Sections 2.1.2.2 and 3.1.2.)

Because of the depth of the smear zone and water table, the direct-contact exposure pathway does not exist for the Remelt/Hot Line groundwater plume and smear zone soil AOCs. Thus, surface capping above these AOCs would not provide significant additional benefit. Because smear zone soil and groundwater are in ongoing contact, rainwater that infiltrates from the surface and travels through the smear zone does not affect this exposure pathway. Thus, existing surface containment or its expansion would not provide added benefit by mitigating rainwater infiltration. For these reasons, applying surface containment technology beyond the existing building to the smear zone soil AOC will not be considered as a new element of Alternative D2.

5.1.5.2 Hydraulic Containment

Hydraulic containment of the majority of the Remelt/Hot Line PCB plume at the Facility is the active technology used to prevent the Remelt/Hot Line plume from reaching the Spokane River. Alternative D2 considers two potential containment scenarios for the Remelt/Hot Line plume, which are summarized as follows:

Scenario D2a. This scenario assesses adding the operation of one extraction well at the leading edge of the groundwater plume, located near well HL-MW-30S (Figure 5-6).

Scenario D2b. Scenario D2b assesses adding the operation of extraction wells (near wells HL-MW-6A and HL-MW-14S, Figure 5-6) at the midpoint of the plume, closer to the apparent source of PCBs in the smear zone below the Remelt area.

Scenario Descriptions and Modeling Results

Modeling results for Scenarios D2a and D2b are summarized below, together with a description of each scenario. Scenarios D2a and D2b involve the installation of new groundwater extraction wells. The locations of these wells are shown on Figure 5-6. The new extraction wells employed in these scenarios will be installed outside of the buildings at the Facility. The details of model development and calibration are provided in Appendix E, together with the model results for these scenarios.

Scenario D2a. This scenario involves the installation and operation of a groundwater extraction well at the leading edge of the Remelt/Hot Line groundwater plume. To create a capture zone for the Remelt/Hot Line plume that originates at this location, groundwater would need to be extracted from the aquifer through one new well (PCB-FEW-1) at a flow rate of approximately 3.7 million gallons per day (MGD), as determined by the model results. The groundwater capture zone provided in this scenario is shown on Figure E-13 in Appendix E.

A pumping rate was calculated that will theoretically hydraulically contain the PCBs moving with the groundwater in the AOC to prevent their spread beyond the capture zone. It is assumed that pumping a water volume equal to a 20-foot-thick layer of the upper reach of the aquifer over the 5.1-acre AOC would hydraulically contain the PCBs in this plume.

Implied in this assumption is that PCBs entering the aquifer from sources in the Remelt area would be contained in the upper reaches of the aquifer and prevented from migrating to deeper zones, as has been detected at wells HL-MW-13DD and HL-MW-28DD. These two wells are the deepest monitoring wells in this area with screened intervals of 140 to 150 feet bgs. These wells generally draw water 40 to 50 feet deeper than the majority of wells in this AOC. Detections of PCBs in these deep wells remain somewhat anomalous. Nearby deep-screened wells HL-MW-15DD and HL-MW-24DD have been non-detect for PCBs during past monitoring events. Ecology has determined that the PCBs detected in these deeper wells are localized and not moving toward the Spokane River (Ecology 2011).

Hydraulically containing this large 5.1-acre plume would require an estimated pumping rate of 3.7 MGD. The PCB concentration in groundwater is expected to decrease over time as the PCB mass is extracted with the groundwater flowing through the area. The mass removal rate was estimated as a first-order process. The mass removal rate equation and its derivation are presented in Appendix E.

The estimated initial predicted average PCB groundwater concentration in the area of the smear zone soil is approximately 0.24 µg/L (see Table 5-4). At this concentration, an estimated 0.32 gram of PCBs per day would be present in the groundwater that flows through the smear zone soil each day. The list of assumptions implicit in this approach is provided in Appendix E. Since the mass removal rate is a function of the contaminant mass remaining in the smear zone, the removal rate will decrease over time as PCB mass is extracted.

The 0.32 gram of PCBs in groundwater will be extracted by the 3.7 MGD pumping rate required to contain the Remelt/Hot Line plume. The concentration of PCBs in the extracted groundwater is estimated to be approximately 0.023 µg/L (see Table 5-4). This concentration is assumed to continuously decrease over time as PCB mass is extracted from the smear zone. After 30 years of continuous extraction, the resulting extracted groundwater is estimated to have a PCB concentration of approximately 0.011 µg/L. Handling the extracted groundwater generated in this scenario is discussed below.

Scenario D2b. This scenario includes the operation of three extraction wells (PCB-FEW-2, PCB-FEW-3, and PCB-FEW-4) at the midpoint of the plume, west of the Remelt building, to hydraulically contain the plume (Figure 5-6). One possible configuration would be to install the three extraction wells in a line trending from northwest to southeast as shown on Figure 5-6. The rationale behind selecting this specific location for the extraction wells is that they would provide containment of the plume closer to the apparent PCB source below the Remelt area (Figure 5-6). Additionally, extracting groundwater at this location would hydraulically contain PCBs in the shallow and deep plumes. The downgradient edge of the deeper PCB groundwater plume is located in this approximate area.

Extracting groundwater at this midpoint would separate the downgradient portion of the plume from its upgradient part and from the apparent PCB source below the Remelt area. Since the downgradient part of the plume would be cut off from the source, PCBs would be expected to dissipate by natural attenuation processes (see Section 5.1.4.1 and Appendix F).

To achieve containment in Scenario D2b, groundwater would need to be extracted at a total flow rate of approximately 3.0 MGD, based on the model results for this scenario. The capture zone provided in this scenario is shown on Figure E-14 in Appendix E. Groundwater extracted from wells PCB-FEW-2, PCB-FEW-3, and PCB-FEW-4 is expected to contain approximately 0.34 gram of PCBs per day. Handling the extracted groundwater in this scenario is discussed below.

As in Scenario D2a, the PCB concentration in groundwater is expected to decrease over time as the PCB mass is extracted along with the groundwater. The mass removal rate was estimated as a first-order decay process. The initial mass removal rate in Scenario D2b is the same as in Scenario D2a and is based on the same assumptions. The 0.34 gram of PCBs per day will be extracted in the 3.0 MGD required to contain the Remelt/Hot Line plume. The initial concentration of PCBs in the extracted groundwater is estimated to be approximately 0.029 µg/L (see Table 5-4). This concentration is assumed to continuously decrease over time as PCB mass is extracted from the smear zone. After 30 years of continuous extraction, the extracted groundwater is estimated to have a PCB concentration of approximately 0.014 µg/L.

If a standard POC is established by Ecology, the concentration of PCBs in the Remelt/Hot Line plume is expected to decrease to 0.0045 µg/L in approximately 170 years and to 0.000064 µg/L in approximately 350 years (refer to Appendix I).

If a conditional POC is granted, it is expected to take approximately 4 years for the PCB concentration in the plume to be less than the PCUL of 0.22 µg/L (adjusted down from 0.44 µg/L, the drinking water criterion) and the concentration of PCBs in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I). PCBs are not currently reaching the Spokane River from the Remelt/Hot Line plume at concentrations above the current PCUL (modified Method 8082 MDL of 0.0045 µg/L).

If the PCUL for a conditional POC is established as 0.000064 µg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 µg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 µg/L by the time the PCBs reach the Spokane River (see Appendix E and I). It is expected to take about 60 years for the PCB concentrations in smear zone soil to decline to these values. The hydraulic containment provided by Alternative D2 will prevent PCBs at concentrations above 0.000064 µg/L from reaching the river.

Discussion of Results

Because both Scenario D2a and D2b achieve containment of the Remelt/Hot Line plume, selection of the appropriate scenario for Alternative D2 will be based on the advantages and disadvantages of use or disposal options for the extracted groundwater, on the anticipated operating period of the containment system, and its associated capital and annual O&M costs. Capital costs are defined as those expenditures that are initially incurred to construct a remedial action, whereas annual O&M costs are post-construction costs necessary to ensure the continued effectiveness of the remedial action and are incurred over the lifetime of the remedial action (EPA 2000a).

The operation of the extraction well at the leading edge of the Remelt/Hot line plume will cause additional migration of PCBs toward this extraction well. (The Scenario D2a capture zone is shown on Figure E-13 in Appendix E.) Another potential drawback of this scenario is that PCB-impacted groundwater located in the deep plume (see discussion of wells HL-MW-13DD and HL-MW-28DD above) may be drawn into the downgradient reach of the deep areas that are currently not impacted by PCBs, thus contaminating these areas.

The model results show that the total extraction flow rate needed to achieve hydraulic containment of the Remelt/Hot Line plume decreases with more localized containment. Hydraulic containment by extracting groundwater at the leading edge of the Remelt/Hot Line plume in Scenario D2a requires a total extraction flow rate of 3.7 MGD to contain the entire plume. In Scenario D2b, hydraulic containment of the plume closer to the apparent PCB source reduces the total extraction rate by 0.7 MGD to approximately 3.0 MGD. The new estimated total quantity of groundwater extracted at the Facility, if Alternative D2 is implemented, will range from 19.7 to 20.4 MGD (refer to Table E-4 in Appendix E).

The groundwater extracted in Scenarios D2a and D2b is expected to initially contain about 0.3 gram of PCBs per day (Table 5-4). The PCB concentration in groundwater is expected to decrease over time as the PCB mass is extracted by the groundwater flowing through the area. Since the mass removal rate is a function of the contaminant mass remaining in the smear zone, the removal rate will decrease over time as PCB mass is extracted. The resulting concentration of the extracted groundwater is estimated to be approximately 0.040 μg/L for Scenarios D2a and D2b. After 30 years of continuous extraction, the resulting extracted groundwater is estimated to have PCB concentrations of 0.015 μg/L and 0.020 μg/L in Scenarios D2a and D2b, respectively.

The benefit of Scenario D2b is that the extraction wells will be located at the leading edge of the PCB-impacted groundwater in the deep plume (which lies beneath the mid portion of the shallow PCB plume) and prevent additional migration of PCBs. (The Scenario D2b capture zone is shown on Figure E-14 in Appendix E.)

Extracted Groundwater Management

The PCB-impacted groundwater recovered in Scenarios D2a and D2b will be conveyed via an underground pipe around the north side of the Remelt building and will be directed into a horizontal infiltration gallery located upgradient of the Oil House area (Figure 5-6). The infiltration gallery is expected to be located approximately 3,300 feet from the Spokane River. The PCB concentrations in groundwater recovered by Scenarios D2a and D2b are above the PCUL for a standard POC (0.000064 μg/L). However, if a conditional POC is granted, the recovered groundwater is expected to have a concentration that is below the PCUL (0.22 μg/L). Calculations presented in Appendix E predict that PCBs will reach the Spokane River from the Oil House area at concentrations below 0.000064 µg/L if the PCBs enter the groundwater at a location that is 3,300 feet from the river at a concentration of 0.22 µg/L.

PCBs are hydrophobic (Hart Crowser 2012a), and because of their affinity for petroleum hydrocarbons, the PCBs are expected to become adsorbed or sequestered by the petroleum hydrocarbons in the smear zone soil as the extracted groundwater infiltrates through it. The PCBs are expected to be attenuated by the natural processes that will anaerobically and aerobically degrade the PCBs as they are released by the SVOCs and enter the aqueous phase. If PCBs adsorbed to FPP are recovered through the FPP recovery systems in place, the PCBs could also be removed and disposed of with the recovered FPP.

The PCBs (approximately 9 pounds) that are presently comingled with SVOCs (approximately 587,000 pounds) in the Oil House area (refer to Appendix I) and the very small quantities of additional PCBs that will be introduced to the Oil House area by Alternative D2 (approximately 5.1 pounds over 30 years) are expected to be biodegraded by anaerobic and aerobic bacteria (refer to Appendix F) as the PCBs enter the aqueous phase over time.

In addition, the recovered groundwater at the pumping location contains dissolved oxygen in the 8 to 10 mg/L range (see Figure F-1, Appendix F). Introducing aerated water into the petroleum groundwater AOCs in the Oil House area would enhance biodegradation of petroleum hydrocarbon COCs. This application of aerated water to promote biodegradation is similar to what is currently being done at the existing groundwater IRM system (see Section 4.1.1.2).

The smear zone in the Oil House area contains an estimated mass of about 587,000 pounds of SVOCs (refer to Appendix I). Natural attenuation of the groundwater plume in this area is expected to require approximately 28 years to reduce the concentration of SVOCs in groundwater to the PCUL of 500 µg/L (Appendix I).

Approximately 293,000 pounds of SVOCs are expected to remain in the smear zone soil at that time (refer to Appendix I). The initial expected concentration of PCBs in the groundwater recovered from the Remelt/Hot Line plume and infiltrated upgradient of the Oil House area at that time is expected be approximately 0.015 to 0.020 µg/L (refer to Table 5-4). Over the 28-year restoration time frame for SVOCs approximately 4.9 pounds of PCBs would be added to the Oil House area. There is sufficient petroleum hydrocarbon mass in the Oil House smear zone to sequester and otherwise contain this small quantity of PCBs. The PCBs are expected to be biodegraded by anaerobic and aerobic bacteria as the PCBs enter the aqueous phase over time (refer to Appendix F).

Selected Hydraulic Containment Scenario

Scenario D2b was selected as the preferred scenario for Alternative D2 because of its greater containment efficiency and the lower risk of drawing PCB-impacted groundwater into the deeper, uncontaminated portion of the aquifer. Scenario D2b requires greater up-front capital expenditure than Scenario D2a, but presents lower annual operating costs. The estimated costs for the two scenarios fall into a narrow range, about $22.9 million for Scenario D2a and $23.1 million for Scenario D2b (see Section 5.1.2.4 and Tables D-3 and D-4 in Appendix D).

Scenario D2b includes installing three groundwater extraction wells (PCB-FEW-2, PCB-FEW-3, and PCB-FEW-4) to contain the Remelt/Hot Line plume. For cost estimating purposes, it is assumed that these wells will be 16 inches in diameter and will be installed to a depth of 130 feet with 40-foot screens to extract groundwater from the aquifer. This well diameter is based on existing groundwater extraction wells that operate at flow rates similar to the expected extraction rate of Scenario D2b.

Groundwater extraction pumps and associated piping will be installed in the wells to extract groundwater at a rate of approximately 3.0 MGD. As discussed above, extracted groundwater will be conveyed to a horizontal infiltration gallery located upgradient of the Oil House AOCs (Figure 5-6). Conveyance piping will be installed underground, as needed, to minimize interference with industrial activities at the Facility. The piping will extend from the extraction point east to Evergreen Road, then north and east along the perimeter road north of the Remelt building. At the eastern end of the Remelt building, the underground pipeline will turn south to the new horizontal infiltration gallery on the east side of the Tank Farm located just east of the Oil House. The infiltration gallery will consist of a series of trenches containing permeable media, and will be designed to accommodate the extraction flow rate of approximately 3.0 MGD. It is assumed that the extracted groundwater will be directed to the horizontal infiltration gallery without the use of a perforated pipe. Under this alternative, the entire groundwater extraction and infiltration system will operate completely underground. Because of the transmissive nature of the Spokane Aquifer, the groundwater hydrology is not changed and there is no net loss or gain to groundwater at the Facility.

The groundwater extraction system will operate continuously to provide uninterrupted hydraulic containment of the Remelt/Hot Line plume.

Performance of the hydraulic containment system will be assessed through ongoing monitoring of groundwater PCB concentrations at the Facility to determine whether PCB migration toward the Spokane River is occurring. The monitoring requirements of the hydraulic containment element of Alternative D2 are discussed in Section 5.1.5.3.

The effects of infiltrating about 3.0 MGD of groundwater under Alternative D2 (Scenario D2b) upgradient of the Oil House area on the effectiveness of the containment of the petroleum hydrocarbon groundwater plumes provided by Alternative C2 was assessed (refer to Table E-4 and Figure E-15 in Appendix E). Groundwater infiltration upgradient of the Oil House area did not have any negative impacts on containment of the plumes provided by Alternative C2.

5.1.5.3 Restoration Time Frame for Alternative D2

The assumptions used to estimate the restoration time frame for Alternative D2 are described in Appendix I. If a standard POC is established by Ecology, the estimated restoration time frame for Alternative D2 is approximately 170 years to reduce PCB concentrations in the Remelt/Hot Line groundwater plume to the modified Method 8082 MDL of 0.0045 μg/L and 350 years to reduce PCB concentrations in the plume to 0.000064 μg/L.

If a conditional POC is established by Ecology, it is expected to take 4 years for the PCB concentration in the plume to reach the PCUL of 0.22 μg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Table 5-4). PCBs are not currently reaching the river from the Remelt/Hot Line plume at concentrations above the MDL (0.0045 μg/L).

If the PCUL for a conditional POC is established as 0.000064 μg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 μg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 μg/L by the time the PCBs reach the river (see Appendix E and I). It is expected to take about 60 years for the PCB concentrations in smear zone soil to decline to this value. The hydraulic containment provided by Alternative D2 will prevent PCBs at concentrations above 0.000064 μg/L from reaching the Spokane River.

5.1.5.4 Monitoring Requirements for Alternative D2

Monitoring will be required during installation of the hydraulic containment system, in addition to subsequent monitoring during its O&M period. Monitoring requirements unique to Alternative D2 are summarized in Table 5-5.

Monitoring the performance of the hydraulic containment system (i.e., assessing the boundary status of the Remelt/Hot Line plume over time) will be included in the regular groundwater monitoring program at the Facility, as discussed in Section 5.1.4 for Alternative D1.

The hydraulic containment system will be monitored regularly. Monitoring includes checking equipment operation on a regular basis, collecting system readings and measurements, and performing necessary system maintenance. For cost estimating purposes, it is assumed that Kaiser personnel (one person) will monitor the system once per week.

Monitoring of the natural recovery of the PCBs in the Remelt/Hot Line plume will continue as described in Section 5.1.4.1 and discussed in Appendix F. Evidence of the biodegradation of PCBs in the Oil House area will need to be obtained by monitoring activities during the pilot test phase of the cleanup action.

5.1.5.5 Alternative D2 Estimated Costs

Assuming an operating period of 30 years and a discount rate of 7 percent, the total NPV cost of the unique elements of Alternative D2 (Scenario D2b), which excludes the elements of Alternative D1 that are included in this alternative, is approximately $3.3 million (Appendix D, Table D-4). The combined estimated NPV cost of Alternative D2 (including elements of Alternative D1) totals about $23.1 million.

5.1.6 Alternative D3: Alternative D2 Plus Groundwater Extraction with Ex Situ Treatment

Alternative D3 adds *ex situ* treatment of the PCB-impacted groundwater extracted from the Remelt/Hot Line plume in Alternative D2. As mentioned in Section 5.1.1.1, PCBs in the Remelt/Hot Line plume are in a dilute solution and appear to be bound, at least in part, to the colloidal particles in the plume. While treatment with granular activated carbon (GAC) is considered a presumptive remedy for the treatment of soluble PCBs, there is no presumptive remedy for the treatment of colloidal PCBs. Therefore, the *ex situ* treatment system will include unit processes for suspended solids and colloidal removal to help attain system effluent concentrations to satisfy the required PCB PCUL (0.000064 μg/L) established for a standard POC.

The components of this treatment system have never been used to remove colloidal PCBs at the very low concentrations that are present in the Remelt/Hot Line plume. Bench- and pilot-scale testing will be required to determine whether the *ex situ* treatment system will remove soluble and colloidal PCBs to the degree needed to meet the PCULs established by Ecology.

The *ex situ* treatment steps include pretreatment (coagulation, pH adjustment, flocculation, and filtration), adsorption (GAC, MYCELX®), and post-treatment (coagulation, pH adjustment [if needed], flocculation, and filtration). Bench- and pilot-scale testing will be required to determine the necessary degree of pH adjustment, the appropriate type of coagulant and flocculent, and to confirm that the type of filtration device(s) selected in this FS to remove colloidal particles and suspended solids will be effective in pretreating influent to the adsorber and polishing effluent. Bench- and pilot-scale tests will also be needed to confirm that the adsorbent selected in the FS will be effective in removing very low concentrations of soluble PCBs from the Remelt/Hot Line plume, and to define the operating parameters of the adsorption process.

5.1.6.1 Characteristics of the Remelt/Hot Line PCB Plume and Associated Smear Zone Soil

Remelt/Hot Line PCB Plume AOC

PCB-impacted groundwater in the Remelt/Hot Line area is encountered in an elongated northeast-southwest trending plume. The PCB plume extends from the apparent source areas in the Remelt area and follows the local groundwater flow direction west-southwest toward the Spokane River (Figures 5-1 through 5-4). For a detailed discussion of the Remelt/Hot line plume, refer to Sections 5.1.1 through 5.1.3.

A groundwater sample from well HL-MW-5, collected in 2004, was subjected to colloidal particle characterization. This analysis indicated a particle size ranging from smaller than 0.3 μm to greater than 25 μm in effective diameter, with about 30 percent of the particles less than 1 μm in effective diameter and 60 percent less than 2 μm in effective diameter. The effective diameter of the majority of particles was less than 1.6 μm, indicating that the majority of the particulate matter was in the optimal range for colloidal transport. Most of the particulate material analyzed in the sample appeared to be quartz (Hart Crowser 2005).

Extracted Groundwater Characteristics

The pathways by which PCBs in the Remelt/Hot Line plume and associated smear zone soil can potentially reach receptors are, respectively, the soil to groundwater and the groundwater to surface water pathways. The soil to groundwater pathway assumes that PCBs in smear zone soil could be mobilized into groundwater at concentrations that cause an exceedance of groundwater

SLs. This pathway was determined to have the most impact on the SLs established for soil at the Facility.

Site-specific information was used to determine the partitioning coefficient of SVOCs from smear zone soils to groundwater to estimate the restoration time frame for technologies applied to the petroleum-contaminated groundwater and associated smear zone soils in Section 4.1.6.3. The partitioning coefficient for PCBs was calculated from the organic carbon-water partition coefficient for total PCBs provided in Ecology's Cleanup Levels and Risk Calculation (CLARC) tool. The partitioning coefficient for PCBs from smear zone soils to groundwater was listed as 310 L/kg in the CLARC database (Appendix E).

Contaminant leaching from smear zone soil into groundwater is expected to occur only within about a 10-foot-thick smear zone. The contaminant mass available for treatment in extracted groundwater is based on the groundwater flux into the smear zone AOC, and the concentration of PCBs dissolved in the groundwater is based on partitioning from the soil matrix. The groundwater flow rate through smear zone soil was calculated by multiplying the groundwater flux (gpd/square feet) (refer to Appendix E) by the cross sectional area of the smear zone normal to the groundwater flow direction. The cross sectional area is conservatively determined from the widest portion of the smear zone, perpendicular to groundwater flow, and to the thickness of the smear zone.

The PCB concentration in groundwater is expected to decrease over time as the PCB mass is extracted by the groundwater flowing through the area. The mass removal rate was estimated as a first-order decay process. The mass removal rate equation and its derivation are presented in Appendix E. The initial predicted average PCB groundwater concentration in the area of the smear zone soil is estimated to be approximately 0.240 µg/L. At this concentration, an estimated 0.34 gram of PCBs is present in the groundwater that flows through the smear zone soils each day. The list of assumptions implicit in this approach is provided in Appendix E. Since the mass removal rate is a function of the contaminant mass remaining in the smear zone, the removal rate will decrease over time as PCB mass is extracted.

The 0.34 gram of PCBs will be extracted in the 3.0 MGD required to contain the Remelt/Hot Line plume. The resulting concentration of the extracted groundwater is estimated to be 0.029 µg/L (refer to Table 5-4). This concentration is assumed to continuously decrease over time as PCB mass is extracted from the smear zone. After 30 years of continuous extraction, the resulting extracted groundwater is estimated to have a PCB concentration of 0.014 µg/L. The extracted concentrations (0.014 to 0.034 µg/L) are above the PCUL for a standard POC (0.000064 µg/L). However if a conditional POC is granted, the extracted groundwater is below the PCB PCUL (0.22 μg/L) for drinking water.

Other extracted groundwater parameters needed to design the *ex situ* treatment system are the concentration of suspended and dissolved solids in the groundwater that will be treated. Total suspended solids (TSS) and total dissolved solids (TDS) concentrations from monitoring wells within the footprint of the Remelt/Hot Line plume may not provide an accurate representation of the TSS and TDS concentrations that will be in the extracted groundwater. The TSS in extracted groundwater can be influenced by well construction and sediment accumulation within the well casing. Typical monitoring wells are installed with a simple sand pack around the screen. Extraction wells are designed and installed with designed wire mesh screens to minimize solid accumulation.

The TDS concentration has not been measured in groundwater collected from monitoring wells at the Facility. The average TDS concentration in groundwater from the existing extraction wells at the Facility is approximately 210 mg/L. TSS is typically not detected above the reporting limit of 1 mg/L. The most recent TSS concentration was 8 mg/L at WW-EW-2 in 2005 (Kaiser Groundwater Database).

5.1.6.2 Description and Evaluation of the *Ex Situ* Groundwater Treatment System Components

Alternative D2 extracts groundwater to hydraulically contain the Remelt/Hot Line plume. The purpose of Alternative D3 is to treat extracted PCB-impacted groundwater. The *ex situ* treatment processes identified in the FSTM included pretreatment (coagulation, pH adjustment, flocculation, and filtration), adsorption (GAC, MYCELX®), and post-treatment (coagulation, pH adjustment if needed, flocculation, and filtration). These technologies were evaluated in the FSTM and were judged to be potentially implementable and reliable. Their use to treat colloidal PCBs present at very low concentrations has not been demonstrated.

For this FS, these technologies are further evaluated based on physical and chemical, implementability, and reliability assessment criteria to determine which unit processes will be part of the proposed *ex situ* treatment system. The technology screening process is based on expected water quality conditions (described above), results from previous bench-scale studies described below, and discussions with vendors. The only way to determine whether the proposed *ex situ* treatment system will remove PCBs to the extent necessary to meet the PCULs established by Ecology is to conduct a series of bench- and/or pilot-scale tests. If initial tests indicate that the treatment train can meet the PCULs established by Ecology, additional tests would be conducted to determine whether the treatment system can operate reliably at the large scale (3 MGD) that is necessary to implement Alternative D3.

Description and Evaluation of Pre-Adsorption Treatment Technologies

The FSTM (Table 6-5) identified a number of potential pretreatment technologies that may be appropriate for removing colloidal particles from groundwater extracted from the Remelt/Hot Line plume. These technologies were categorized as particle aggregation technologies, particle filtration technologies, and membrane technologies, and are evaluated further in this section.

Particle Aggregation Technologies. Coagulation, flocculation, and pH adjustment are the technologies most often used to aggregate low concentrations of small diameter suspended solids and colloidal particulates (similar to those in the Remelt/Hot Line plume) and thus enhance their removal from the waste stream being treated. The general objective of these particle aggregation technologies is to alter the particle size distribution in the waste stream to improve particulate removal in subsequent steps of the treatment process (such as filtration or sedimentation). These technologies are described in Section 6.1.1 of the FSTM.

It should be noted that coagulation and flocculation terminology has been used inconsistently among various sources in industry and academia. For the purposes of this FS, coagulation is defined as the process by which the surface charge of colloidal particles is chemically destabilized to promote inter-particle attraction and/or reduce repulsion. Destabilizing the surface charge improves the likelihood of individual particles sticking to one another when they come into contact, forming a larger aggregated particle. Flocculation can be defined as the physical or hydrodynamic process that promotes particle collisions. The coagulation and flocculation processes are dependent on each other to facilitate aggregated particle growth.

Destabilizing the particle surface charge is achieved by adding one or more coagulants to the incoming stream, followed by rapid mixing to ensure uniform coagulant dispersion. Rapid mixing is accomplished by devices such as vertical impellers, baffles, and pumps. Examples of common inorganic coagulants include aluminum and iron salts and chitosan. Organic coagulants, which consist of synthetically produced, charged polymers, are also used,. Non-ionic (uncharged) polymers constitute a type of coagulant that does not alter the surface charge of particles, but rather promotes coagulation by attaching to and bridging between two or more particles.

Flocculation typically follows, but may overlap, coagulation. Gentle or low-energy mixing is employed to allow destabilized particles to come into contact and aggregate. Flocculation is a longer process than coagulation and typical residence times in flocculation tanks are 10 to 30 minutes (Corbitt 1989). Flocculation may be followed by a sedimentation step to allow gravity to separate aggregated particles from the waste stream. However, in a system that employs other solid-liquid separation processes (such as filtration), the additional cost of the sedimentation step might not be warranted if the solids concentration of the waste stream is already initially low, as is the case in the Remelt/Hot Line plume. In such systems, the flocculation step may be directly followed by filtration.

Adjustment of pH can affect the charge on colloid particle surfaces or the charge on a coagulant added to overcome the repulsive forces that surround the colloidal particles. Adjustment of pH also plays a role in the adsorption of organic materials. In general, the adsorption of organic material from water increases with decreasing pH (Weber 1972). The results of previous bench-scale tests indicate that lowering pH enhanced PCB removal (Hart Crowser 2005).

These aggregation technologies were determined to be implementable and reliable in the FSTM and are retained for evaluation in the FS based on previous bench-scale studies and discussions with vendors. As mentioned above, pH adjustment plus coagulation and flocculation in bench-scale testing appeared to improve PCB removal from groundwater. Retaining coagulation and flocculation is further supported based on discussions with vendors. Based on the water quality described above, vendors recommended the addition of a coagulant followed by flocculation. Bench- and pilot-scale tests will be required to determine the type and amount of coagulant and pH adjustment needed and to confirm that aggregation technologies will be effective in treating PCB-impacted groundwater extracted from the Remelt/Hot Line plume. For the purposes of this FS, chitosan was selected as the coagulant.

Particle Filtration Technologies. Filtration physically separates suspended solid materials from groundwater. Depth and surface filtration were retained in the FSTM as potential filtration technologies. A depth filter removes suspended solids from water as the water travels through the interior of the filter medium, whereas a surface filter removes suspended solids as the water enters the filter.

Depth filters typically consist of a bed of granular material, which can be composed of one or more material layers such as sand and anthracite. Depth filtration is a conventional wastewater technology that can be used for the removal of particles approximately 1 µm or greater in diameter (Metcalf & Eddy 2003).

Surface filters are a conventional wastewater treatment technology that use a sieving mechanism for solid-liquid separation and typically remove particulate matter greater than approximately 10 to 30 μm in diameter. These filters come in different forms, such as bags, cartridges, and disks, and can be made of various materials such as metal, cloth, or synthetics. Surface filters are replaced once they have been exhausted (Metcalf & Eddy 2003). Cartridge filters with pore sizes as low as 0.5 μm are available (McMaster Carr 2009). Filters of smaller pore sizes are typically preceded by larger pore size filters to prevent rapid accumulation of solids. In addition, surface filters are frequently used as a final pretreatment step upstream of technologies that may be very sensitive to fouling, such as GAC adsorption and membrane technologies.

Depth filtration is retained as a pretreatment technology for evaluation in the FS. Depth filters are a conventional wastewater technology and can be designed to treat the expected extraction flow rates from the Remelt/Hot Line plume (currently, sand beds and black walnut shell depth filters are used at the Kaiser IWT Plant). Based on discussions with vendors, a depth filtration treatment step is recommended downstream of the flocculation step. The filter medium type, granular size, bed depth, and the number of filter units necessary depend on parameters such as water quality, influent flow rate, and how well TSS is retained in the filter. Bench- and pilot-scale tests will identify the appropriate medium for the Remelt/Hot Line plume. As part of treatment system O&M, depth filters periodically will need to be backflushed to remove accumulated solids.

Surface filtration is retained as a pretreatment technology for evaluation in the FS. Bench-scale and pilot-scale tests will be required to determine the type and number of filters that should be used. Surface filters have a variety of pore sizes that range from 0.5 to 30 μm (Metcalf & Eddy 2003, McMaster Carr 2009).

The pre-adsorption particle filtration treatment train will include sand filters, followed by a two-stage series of surface filters. As part of treatment system O&M, the surface filter elements will periodically need replacing after they have been exhausted.

Membrane Filtration Technologies. Membrane filtration is a solid-liquid separation technology that can be used to remove particulate and dissolved constituents typically in the size range of 0.0001 to 1.0 μm. Different types of membranes can be defined by their pore size range, such as microfiltration (0.08 to 2.0 μm), ultrafiltration (0.005 to 0.2 μm), nanofiltration (0.001 to 0.01 μm), and reverse osmosis (0.0001 to 0.001 μm) (Metcalf & Eddy 2003). Based on the size of colloidal material present at Kaiser and screening evaluations from the FSTM, microfiltration and ultrafiltration may be applicable technologies. Pretreatment is required prior to membrane filtration.

Pore sizes for microfiltration typically range from about 0.1 to 10 µm. The membranes are located on a support structure (usually tubular). Microfilters can operate at low pressures or they can be part of a pressurized system. Low-pressure systems are usually used where the solids loading is low, chemical conditioning is not usually required, and the solids do not tend to clog the filter medium rapidly. When the membrane becomes clogged, it is replaced. High-pressure systems are used when additional driving force is needed to collect more solids over longer times without clogging, or in systems where a backwash system is used to extend membrane life.

Ultrafiltration is very similar to microfiltration. The solid-liquid separation mechanism is sieving. Unlike microfiltration, pore sizes are smaller and range from 0.005 to 0.2 µm. Because of the smaller pore sizes, ultrafiltration has to operate at higher pressures (around 75 pounds per square inch, gauge [psig]) and, therefore, has higher energy requirements than microfiltration (Metcalf & Eddy 2003).

Microfiltration was eliminated as a potential particle filtration technology based on reliability. Based on the size of particles in Facility groundwater, microfiltration can be used for solids removal and designed for large-scale systems. However, microfiltration may require high pressures, which increase energy and equipment needs for operating the system. Also, microfiltration will likely require significant pretreatment, which can increase O&M needs (Metcalf & Eddy 2003).

Ultrafiltration was eliminated as a potential particle filtration technology based on physical and chemical screening criteria. As mentioned above, pore sizes for ultrafiltration range from 0.005 to 0.2 µm. Based on previous studies at the Facility, particle diameters in groundwater range from 0.3 to 25 µm, and the majority of particles are 1.6 µm in diameter, so ultrafiltration pore sizes would likely be smaller than needed to filter the extracted groundwater. As a result, it is likely that these filters would tend to clog rapidly and require regular O&M attention.

Description and Evaluation of Adsorption Technologies

GAC, powdered activated carbon (PAC), and polymeric adsorbents have been successfully used to remove low concentrations of dissolved PCBs from groundwater. Previously, lab-scale evaluations were performed on groundwater from the Facility to determine how PAC and other additives could improve PCB removal. The details of these evaluations have been reported (Hart Crowser 2004 and 2005).

GAC, PAC, and polymeric adsorbents were evaluated in the FSTM, to determine whether adsorption would be a feasible technology for treating groundwater in the Remelt/Hot Line plume at the Facility. In wastewater treatment systems, PAC is typically used in conjunction with activated sludge to treat contaminants both biologically and by adsorption. In the FSTM, PAC treatment was eliminated as a potential adsorption technology on the basis of reliability since PAC has not been proven effective at a full-scale installation such as the Remelt/Hot Line plume at the Facility (FSTM Section 6.2.2.1).

For this FS, GAC and polymeric adsorbents were further assessed to determine which would be the most feasible technology for the *ex situ* treatment system. A description of these technologies and a screening evaluation is presented below.

GAC Adsorption. GAC adsorption was retained as a remediation technology for PCB-impacted groundwater in the FSTM. The EPA defines GAC adsorption as a presumptive remedy for *ex situ* treatment of soluble organic contaminants in groundwater (EPA 1996c), and the New York State Department of Environmental Conservation identifies groundwater extraction and treatment by GAC as a presumptive remedy for the removal of soluble PCBs from groundwater (NYSDEC 2007). Both pre- and post-GAC groundwater filtration are noted as potentially necessary to achieve improved results.

As described in the FSTM (Section 6.1.2) , the EPA Annual Status Report Remediation database presents CERCLA sites that had *ex situ* treatment systems that used GAC polishing steps to remove PCBs (other contaminants were treated with different types of unit operations) that were present at concentrations in the 1 to 10 mg/L range.

Additional evidence of the potential applicability of GAC adsorption in removing dilute concentrations of PCBs from groundwater has been identified. Carbtrol, an activated carbon supplier, has developed isotherms that evaluate the adsorption rate of activated carbon for different compounds. These isotherms show that PCBs can be adsorbed by activated carbon to produce effluents with PCB concentrations below 1 μg/L (Carbtrol 1990).

The effectiveness of GAC technology is affected by the presence of suspended particles. In a laboratory study where average aqueous PCB concentrations were 4.7 μg/L, TSS concentrations were 10 mg/L, and colloidal particles ranged in size from 0.01 to 1.0 μm, breakthrough of PCBs and particles from the carbon bed occurred at the same time, suggesting that PCBs observed passing through the carbon bed may have been attached to the colloidal material that broke through simultaneously (Jaradat et al. 2009). As described in the FSTM, pre- and post-filtration will likely be necessary to reach optimal PCB removal based on information from Carbtrol and recommendations from carbon vendor Calgon (Carbtrol 1990 and York, T., Calgon, personal communication, 2009).

GAC adsorption is retained as an adsorption technology for Alternative D3. It is an EPA presumptive remedy for the removal of soluble organics and is a conventional wastewater technology that has been used successfully for higher flow rates. Effluent PCB concentrations achieved by GAC beds have been reported in the 0.5 µg/L range (Carbtrol 1990). The authors of this FS identified no full-scale GAC treatment effluent PCB concentrations below 0.5 µg/L. The *ex situ* treatment system used in Alternative D3 must be able to produce effluent PCB concentrations that are below 0.000064 µg/L for a standard POC.

Bench- and pilot-scale studies will be necessary to determine the effectiveness of GAC technology for the treatment of soluble and colloidal PCBs that are present in the Remelt/Hot Line plume. Also, since the effectiveness of PCB removal by GAC adsorption is affected by suspended solids, it is assumed pre- and post-filtration units will be needed for the GAC adsorption step.

Polymeric Adsorption. Polymeric materials are being developed and used in field applications for PCB treatment. One example is a product developed by the MYCELX® Company known as a Hydrocarbon Removal Matrix (HRM) cartridge. HRM cartridges are polypropylene filter cartridges infused with a special polymer compound that actively bonds to hydrocarbons. The polymer compound, known as MYCELX®, is a synthesis of natural and synthetic polymers. The polymer is infused and cured into a variety of substrates (i.e., filter cartridges and adsorbent materials) so that it is homogeneously dispersed throughout the base material(s). As hydrocarbon compounds encounter the polymer, they bond to the polymer and will not re-disperse or emulsify into water (Abbot 2003).

HRM cartridges have been used to remove PCBs at the Carolina Transformer Company (CTC) CERCLA site. Specifically, the HRM filters were part of a treatment system used to treat PCB-impacted water. Surface water and water from a dewatering operation were collected during excavation of PCB-impacted soil at the CTC site. HRM cartridges were used to help reduce PCB concentrations to the 0.5 µg/L range at the CTC site. The *ex situ* treatment system used in Alternative D3 must be able to produce effluent PCB concentrations that are below 0.000064 µg/L for a standard POC.

Based on the high turbidity of the water at CTC, there was extensive pretreatment to reduce or nearly eliminate suspended solids from the water prior to HRM treatment. Pretreatment consisted of coagulation/flocculation tanks, followed by a series of particulate filtration units (employing cartridge and bag filters) of different sizes (25, 15, 10, 5, and 2 μm). Pretreatment was required to remove solids and prevent fouling of the HRM cartridges, and to prevent PCBs from flushing through the HRM filters by attaching to colloidal material. After treatment, the water went into holding tanks where it could be sampled and analyzed before discharge. At the CTC site, approximately 1.5 million gallons were treated. The treatment system could treat up to 30,000 gallons per day (Abbot 2003; McDonald, C., 301 Environmental, personal communication, 2009).

Based on information from the MYCELX® Company, HRM cartridges are typically used for flow rates ranging from 10 to 40 gpm, but systems handling up to 200 gpm have been built. Typically, the first pre-filtration unit required is a 25- and 5-μm dual media bag filter, and the second unit is 0.35-μm filter. However, for systems with higher flow rates and TSS loading, depth filtration may be necessary. According to the vendor, HRM cartridges have been shown to treat a range of PCB concentrations at its inlet, from less than 500 μg/L to over 1 mg/L and have reached less than 0.065 μg/L at the outlet. Similar to GAC adsorption beds, HRM cartridge filter units are usually installed in a series of two (Greco, P, MYCELX® personal communication, 2009).

Based on information from the MYCELX® Company, HRM cartridges have a high adsorption capacity: 4 pounds of hydrocarbons per pound of medium, whereas other adsorption media exhibit adsorption capacities of less than 1 pound of hydrocarbons per pound of media.

HRM cartridges are rejected as a potential adsorption technology on the basis of reliability, since this technology typically is used for flow rates from 10 to 40 gpm with a maximum reported flow rate of 200 gpm. The flow rate of the groundwater extraction system proposed by Alternative D3 will be approximately 2,100 gpm. Thus, the HRM cartridges have not been demonstrated to be effective at the scale needed to treat the Remelt/Hot Line plume. The HRM cartridges are also judged more susceptible to clogging than GAC and present a potential solid waste disposal problem when the HRM cartridges are replaced. PCBs collected on the GAC beds will be destroyed as spent GAC is regenerated or incinerated.

Description and Evaluation of Post-Adsorption Treatment Technologies

Particle filtration and pH adjustment will be needed following GAC treatment so that system effluent PCB concentrations meet discharge criteria. The pH will likely need to be increased by the addition of a base prior to discharge because of the acid addition in earlier treatment steps. Fine particle filtration will be needed to remove any residual suspended and colloidal solids, since PCBs may be adsorbed to this material, which may prevent treatment system effluent from reaching the PCB PCUL (0.000064 μg/L) established by Ecology for a standard POC.

Residual suspended solids may consist of suspended solids that pass through the GAC bed in addition to GAC fines. For sizing purposes, it is assumed that the size of these particles will be smaller than the final surface filter prior to the GAC bed (5 μm).

It is assumed that surface filters with smaller pore sizes will be practicable and effective for removing suspended solids. Microfiltration and ultrafiltration are eliminated as treatment options based on the reasons stated above. Again, bench- and pilot-scale studies will be needed to finalize the full-scale *ex situ* treatment system design.

5.1.6.3 *Ex Situ* Treatment System Description

As discussed in Section 5.2.2, Alternative D2b consists of three groundwater extraction wells located within the Remelt/Hot Line plume. Based on the modeling results (Appendix E), the total extraction flow rate is expected to be 3.0 MGD. Extraction well locations are shown on Figure 5-6. Each well will be 16 inches in diameter and screened from 90 to 130 feet bgs. The extracted groundwater containing PCBs will be conveyed to an aboveground system for *ex situ* treatment as described below. For the FS, it is assumed that the *ex situ* treatment system will be located in the West Landfill area of the Facility (see Figure 5-6). The initial predicted extracted groundwater concentration is estimated to be 0.040 μg/L (Table 5-4).

To treat the maximum PCB concentration (0.040 μg/L), dissolved solids loading (approximately 210 mg/L), and flow rate that will be extracted from the Remelt/Hot Line plume, it is proposed that four identical treatment trains be used in parallel. Each treatment train would be designed to treat 25 percent of the total flow rate or approximately 500 gpm. The design of the proposed treatment train is based on influent water quality, required effluent PCB concentration (0.000064 μg/L), discussions with vendors, design criteria from literature (Corbitt 1989), and the results of previous bench-scale studies.

A process flow diagram of the *ex situ* treatment system is presented on Figure 5-7. The treatment system is conceptually designed to remove both the dissolved-phase PCBs (through adsorption) and the colloidally adsorbed PCBs (through filtration) using the following processes:

pH adjustment. The addition of acid has shown to improve PCB removal efficiencies (Hart Crowser 2004 and 2005).

Coagulation. The addition of a coagulant will improve removal of colloids and dissolved solids.

Flocculation. Water will travel through tanks at low speeds to allow for floc formation and settling.

Depth Filtration. Water will travel through a depth filtration unit to remove suspended solids and floc down to 50 μm.

Cartridge Filtration. Water will flow through a series of cartridge filters (10 μm, 5 μm) to remove dissolved solids down to 5 μm prior to GAC treatment.

Adsorption. Water will flow through GAC beds arranged in series to remove dissolved PCBs.

Cartridge Filtration. Water will flow through a series of cartridge filters (2 μm, 1 μm, 0.5 μm) to remove dissolved solids and colloids down to 0.5 μm.

pH adjustment. The addition of a base will likely be required to raise pH to a level appropriate for discharge.

Table 5-6 presents details of the equipment quantity and size for the conceptual *ex situ* treatment system.

The equipment will be connected by large-diameter piping to convey extracted groundwater to the treatment system. It is assumed the treatment system will be located in the West Landfill area of the Facility (see Figure 5-6). It is also assumed that most of the piping between wells and the treatment system will be underground to prevent interference with Facility operations. Within the treatment system there will be piping and pumps to convey water through the system components.

Effluent from the treatment system will be conveyed via an underground pipe (to prevent interference with Facility operations) around the north side of the Remelt building and will be discharged into a horizontal infiltration gallery as shown on Figure 5-6. The north side of the Remelt building is a high traffic area. The gallery location noted on Figure 5-6 is an approximate location and may be adjusted in the future. The infiltration gallery will be located approximately 2,900 feet from the Spokane River. The treated water cannot be discharged directly into the river, because the river is a 303d-listed water body and a new point source of PCBs can not be added unless there is a total maximum daily load (TMDL) in place. There is currently not a TMDL for PCBs in place for the Spokane River.

If a conditional POC is granted, the extracted water will be below the PCUL of 0.22 μg/L and below the concentration expected to be protective of the river based on the predicted attenuation that is estimated using the equation described in Section 5.1.4.2. The estimated concentration of PCBs that is expected to be protective of the receptors in the Spokane River at a distance of 2,900 feet is 0.325 μg/L (refer to Appendix E). If a conditional POC is granted, treatment would not be required to protect receptors at locations upland from the Spokane River.

Treatment System Operation and Maintenance

The *ex situ* treatment system will run continuously. Monitoring requirements will include daily monitoring of pressures and flow rates. Equipment and infrastructure will be inspected on a regular basis and maintained, repaired, or replaced as required. Minor maintenance items will include backflushing the depth filters and GAC vessels to remove accumulated solids, and changing surface filter elements when differential pressures indicate excessive solids accumulation (Metcalf & Eddy 2003). Based on the size of the treatment system, it is assumed that one full-time equivalent employee will monitor system operation and perform system maintenance.

5.1.6.4 Expected Performance of Alternative D3

Results from Previous Bench-Scale Evaluations

Bench-scale tests were performed in 2004 and 2005 on groundwater from well HL-MW-5, comparing the effectiveness of PAC and different coagulants/ flocculents for PCB removal under various conditions (Hart Crowser 2004 and 2005). These tests evaluated the impact of various combinations of pH adjustment, coagulants/flocculents, PAC, filtration, and residence times on the amount of PCB mass removed from the groundwater sample. The initial PCB concentration averaged about 0.105 μg/L (Aroclor 1242) in the water treated in the bench-scale tests.

The highest PCB removal (97 percent) was achieved when the water was acidified to pH 4, and PAC and a flocculent (Klaraid PC 1192) were added prior to filtering the sample. Water from the jar tests was filtered through a 2.7-μm glass fiber filter (Hart Crowser 2005). The bench scale studies included up to 5 hours of settling time, which is not practicable in a full-scale treatment system with a 3.0 MGD capacity. A removal efficiency greater than 99.9 percent would have been required by the bench-scale tests to achieve the PCUL concentration for PCBs of 0.000064 μg/L.

PAC was rejected as a potential adsorption technology based on reliability in the FSTM since PAC has not been proven effective at full-scale installations with characteristics similar to the Remelt/Hot Line plume at the Facility. The results of the previous bench-scale studies cannot be used to design a full-scale GAC adsorption system. The information learned from these bench-scale tests has been used for the conceptual design of the *ex situ* treatment system for Alternative D3. Ultimately, additional bench- and pilot-scale tests using GAC would be required to determine whether the *ex situ* treatment system can meet the performance requirements established by Ecology.

Expected Performance of the **Ex Situ** *Groundwater Treatment System*

The *ex situ* treatment system proposed in Section 5.1.6.3 consists of extensive solids removal treatment and GAC adsorption for treatment system effluent to reach PCB PCUL concentration (0.000064 μg/L established by Ecology for a standard POC). Before the treatment system design can be finalized, bench- and pilot-scale studies will be required. Solid removal steps in the proposed *ex situ* treatment system include acid and coagulant addition with flocculation and solids-liquid filtration to 0.5 μm based on previous bench-scale testing and studies to determine the size of particulate and colloidal matter in the Remelt/Hot Line plume (Hart Crowser 2005, 2006). Since the PCB groundwater PCUL concentration is so low, solids removal is important since PCBs adsorb to particulate matter. The system also consists of GAC beds to remove dissolved PCBs, which are expected at relatively low concentrations (less than 0.040 μg/L). GAC adsorption is an EPA presumptive remedy for the removal of soluble organics from groundwater (EPA 1996c).

Estimation of Restoration Time Frame

The assumptions used to estimate the restoration time frame for Alternative D3 are described in Appendix I. If a standard POC is established, the estimated restoration time frame for Alternative D3 to reduce PCB concentrations in the Remelt/Hot Line plume to the modified Method 8082 MDL of 0.0045 μg/L is approximately 170 years; and approximately 350 years to reduce PCB concentrations to below 0.000064 μg/L. If a conditional POC is granted, it is expected to take 4 years for the PCB concentration in the plume to reach the PCUL of 0.22 μg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I).

If the PCUL for a conditional POC is established as 0.000064 µg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 µg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 µg/L by the time the PCBs reach the Spokane River. It is expected to take about 60 years for the PCB concentrations in smear zone soil to decline to these values. The hydraulic containment provided by Alternative D3 will prevent PCBs at concentrations above 0.000064 µg/L from reaching the river.

This alternative assumes an operating period of 30 years for comparison with the other alternatives in this section. Following the same assumptions as described above, approximately 2,300 grams of PCBs (about 5.1 pounds) will be extracted in 30 years. This amounts to approximately 45 percent of the total mass of PCBs in smear zone soil in the Remelt/Hot Line area. Because of the relationship between the concentration in groundwater and the concentration in soil, the percent reduction becomes asymptotic over time. For example, only an additional 25 percent of the mass is reduced from Year 30 to Year 60.

The restoration time frame and removal efficiency is evaluated in Section 5.2.4.2.

5.1.6.5 Monitoring Requirements for Alternative D3

Long-term performance and protection groundwater monitoring, will be conducted and will have the objectives and scope described above for Alternative D1 (Section 5.1.4).

To monitor system performance, sampling between treatment units (e.g., between filters and GAC beds) will be conducted to assess the performance of individual system components. Pressures and flow rates will be monitored to ensure that the system is working properly and to determine when filter change-out is needed. Sampling and chemical analysis of the treatment system effluent will be required to ensure that discharge requirements are met.

Monitoring elements unique to the groundwater extraction and *ex situ* treatment system are summarized in Table 5-7.

5.1.6.6 Alternative D3 Estimated Costs

Alternative D3 capital costs include piping, system equipment, and construction of the *ex situ* treatment system. The costs of the installation of the extraction wells and associated pumps are included under Alternative D2. Annual costs associated with Alternative D3 include electricity costs for running treatment system pumps, maintenance costs for surface filter and GAC change-outs, and labor costs related to system operation, maintenance, and monitoring. Electricity costs for running the groundwater extraction system are included under Alternative D2.

The NPV of implementing Alternative D3 over a 30-year time period is estimated to total approximately $50.2 million (-35 to +50 percent). The portion of this cost that is directly applicable to the operation of the *ex situ* treatment system is estimated to total approximately $28.1 million (refer to Table D-5).

The costs above are based on treatment for 30 years to achieve PCB effluent that meets the PCUL for a standard POC. (0.00064 µg/L). If a conditional POC is granted, the PCB concentration in the extracted water is expected to be below the PCUL (0.22 µg/L) and below the concentration expected to be protective of the Spokane River based on the predicted attenuation that is estimated using the equation described in Section 5.1.4.2. The estimated concentration of PCBs that is expected to be protective of the receptors in the Spokane River at a distance of 2,900 feet is 0.325 µg/L (refer to Appendix E). If a conditional POC is granted, treatment would not be required to protect receptors at locations upland from the river.

A separate cost estimate for a conditional POC was not prepared since the PCB concentration in extracted groundwater would be lower than the PCUL established for a conditional POC.

5.1.7 Alternative D4: Alternative D1 Plus Groundwater Extraction with Ex Situ Treatment

Alternative D4 extracts and treats a portion of the Remelt/Hot Line plume. Alternative D4 was added to this FS at the request of Ecology (Ecology 2011). PCBs from the Remelt/Hot Line plume are not currently reaching the Spokane River at concentrations above 0.0045 µg/L (the MDL for modified Method 8082), and the leading edge of the plume is considered to be stable and located 650 feet from the Spokane River (refer to Section 5.1.2.1). It would not be necessary to hydraulically contain the entire PCB plume if the plume is stable. Alternative D4 was conceived as a means to reduce the concentration of PCBs in the smear zone soils of the Remelt building, based on current information that leads to the conclusion that the leading edge of the Remelt/Hot Line plume is stable.

The future use of proposed EPA Method 1668 to measure ultra-low PCB concentrations may indicate that PCBs reach the river at a concentration below 0.0045 µg/L, and perhaps below a concentration of 0.000064 µg/L. If this outcome occurs, Alternative D4 would not prevent the PCBs in the portion of the Remelt/Hot Line plume that is not extracted and treated from reaching the Spokane River.

One extraction well will be placed as close to the source as possible without being inside the Remelt building (see Figure 5-6). The wells will draw from the shallow portion of the aquifer. A groundwater extraction pump and associated piping will be installed in the well to extract groundwater at a rate of approximately 300,000 gpd. This extraction rate does not result in full containment of the PCB plume and PCBs will continue to move from the smear zone soil in the Remelt area to the groundwater and flow downgradient toward the Spokane River. Natural attenuation processes would keep the PCBs from reaching the river (based on the PCUL resulting from modified Method 8082 MDL of 0.0045 µg/L).

Alternative D4 includes the same treatment components described in Section 5.1.6 for Alternative D3 including pretreatment (coagulation, pH adjustment, flocculation, and filtration), adsorption (GAC, MYCELX®), and post-treatment (coagulation, pH adjustment [if needed], flocculation, and filtration).

The components of this treatment system have never been used to remove colloidal PCBs at the very low concentrations that are present in the Remelt/Hot Line plume. Bench- and pilot-scale testing will be required to determine whether the *ex situ* treatment system will remove soluble and colloidal PCBs to the degree needed to meet the PCULs established by Ecology.

Additional bench- and pilot-scale testing will be required to determine the necessary degree of pH adjustment, the appropriate type of coagulant and flocculent, and to confirm that the type of filtration device(s) selected in this FS to remove colloidal particles and suspended solids will be effective in pretreating influent to the adsorber and polishing effluent.

The characteristics of the Remelt/Hot Line plume and associated smear zone soil is described in Section 5.1.6.2.

5.1.7.1 Extracted Groundwater Characteristics

As described above, the pathways by which PCBs in the Remelt/Hot Line plume and associated smear zone soil can potentially reach receptors are, respectively, the soil to groundwater and the groundwater to surface water pathways. The soil to groundwater pathway assumes that PCBs in smear zone soil could be mobilized into groundwater at concentrations that cause an exceedance of groundwater PCULs. This pathway was determined to have the most impact on the PCULs established for soil at the Facility.

The PCB concentration in groundwater is expected to decrease over time as the PCB mass is extracted by the groundwater flowing through the area. The mass removal rate was estimated as a first-order process. The mass removal rate equation and its derivation are presented in Appendix E. The initial predicted average PCB groundwater concentration in the area of the smear zone soil is estimated to be approximately 0.24 µg/L. At this concentration, an estimated 0.24 gram of PCBs are present in the groundwater that flows through the smear zone soils each day. The list of assumptions implicit in this approach is provided in Appendix E. Since the mass removal rate is a function of the contaminant mass remaining in the smear zone, the removal rate will decrease over time as PCB mass is extracted.

Of the 0.24 gram of PCBs that are in the groundwater, approximately one-third (0.08 gram) will be extracted in the 300,000 gpd that is extracted under Alternative D4 (see Figure E-15 for capture zone). The resulting concentration of the extracted groundwater is estimated to be 0.070 µg/L (refer to Table 5-4). This concentration is assumed to continuously decrease over time as PCB mass is extracted from the smear zone. After 30 years of continuous extraction, the resulting extracted groundwater is estimated to have a PCB concentration of 0.038 µg/L.

As described in Section 5.1.6.2, other extracted groundwater parameters needed to design the *ex situ* treatment system are the concentration of suspended and dissolved solids in the groundwater that will be treated. The average TDS concentration in groundwater from the existing extraction wells at the Facility is approximately 210 mg/L. TSS is typically not detected above the reporting limit of 1 mg/L. The most recent detected TSS concentration was 8 mg/L at WW-EW-2 in 2005 (Kaiser Groundwater Database).

5.1.7.2 *Ex Situ* Treatment System Description

Alternative D4 consists of one groundwater extraction well located just west of the Remelt building within the Remelt/Hot Line plume. The extraction flow rate is 300,000 gpd. The extraction well location is shown on Figure 5-6. The well will be 16 inches in diameter and screened from 90 to 130 feet bgs. The extracted groundwater containing PCBs will be conveyed to an aboveground system for *ex situ* treatment as described below. For this FS, it is assumed that the *ex situ* treatment system will be located in the West Landfill area of the Facility (see Figure 5-6). The initial predicted extracted groundwater concentration from the extraction well is estimated to be 0.085 µg/L (Table 5-4).

To treat the maximum PCB concentration (0.085 µg/L), dissolved solids loading (approximately 210 mg/L), and flow rate that will be extracted from the

Remelt/Hot Line plume, one treatment train is proposed that would designed to treat approximately 210 gpm. The design of the proposed treatment train is based on influent water quality, required effluent concentration to meet the PCB PCUL for a standard POC (0.000064 µg/L), discussions with vendors, design criteria from literature (Corbitt 1989), and the results of previous bench-scale studies.

A process flow diagram of the *ex situ* treatment system is presented on Figure 5-7. The treatment system is conceptually designed to remove both the dissolved-phase PCBs (through adsorption) and the PCBs adsorbed to colloids (through filtration) using the processes described for Alternative D3 in Section 5.1.6.3. Table 5-8 lists equipment details for the conceptual *ex situ* treatment system for Alternative D4.

In addition to the cost of the equipment items listed in Table 5-8, capital costs include the cost of piping, instrumentation, and controllers. The equipment will be connected by large-diameter piping to convey extracted groundwater to the treatment system. It is assumed the treatment system will be located in the West Landfill area of the Facility (see Figure 5-6). It is also assumed that most of the piping between wells and the treatment system will be underground to prevent interference with Facility operations. Within the treatment system there will be piping and pumps to convey water through the system components.

Effluent from the treatment system will be conveyed via an underground pipe (to prevent interference with Facility operations) around the north side of the Remelt building and will be discharged into a horizontal infiltration gallery as shown on Figure 5-6. The north sided of the Remelt building is a high use area. The gallery location indicated on Figure 5-6 is an approximate location and may need to be moved in the future. The infiltration gallery is located approximately 2,900 feet from the Spokane River. The treated water cannot be discharged directly into the river because it is a 303d-listed water body and a new point source of PCBs cannot be added unless there is a TMDL in place. There is currently not a TMDL for PCBs in place for the Spokane River.

If a conditional POC is granted, the extracted water will be below the PCB PCUL of 0.22 µg/L. The estimated concentration of PCBs that is expected to be protective of the receptors in the Spokane River at a distance of 2,900 feet is 0.325 µg/L (refer to Appendix E). If a conditional POC is granted, treatment would not be required to protect receptors at locations upland from the Spokane River.

Treatment System Operation and Maintenance

The *ex situ* treatment system will run continuously. Monitoring requirements will include daily monitoring of pressures and flow rates. Equipment and infrastructure will be inspected on a regular basis and maintained, repaired, or replaced as required. Minor maintenance items will include backflushing the depth filters and GAC vessels to remove accumulated solids, and changing surface filter elements when differential pressures indicate excessive solids accumulation (Metcalf & Eddy 2003).

5.1.7.3 Expected Performance of Alternative D4

The *ex situ* treatment system proposed in Section 5.1.7.2 consists of extensive solids removal treatment and GAC adsorption for treatment system effluent to reach low PCB concentration (0.000064 μg/L). Before the treatment system design can be finalized, bench- and pilot-scale studies will be required. Solid removal steps in the proposed *ex situ* treatment system include acid and coagulant addition with flocculation and solids-liquid filtration to 0.5 μm based on previous bench-scale testing and studies to determine the size of particulate and colloidal matter in the Remelt/Hot Line plume (Hart Crowser 2005, 2006). Since the PCB groundwater PCUL concentration is so low, solids removal is important since PCBs adsorb to particulate matter. The system also consists of GAC beds to remove dissolved PCBs, which are expected at relatively low concentrations (less than 0.085 μg/L).

5.1.7.4 Restoration Time Frame for Alternative D4

The assumptions used to estimate the restoration time frame for Alternative D4 are described in Appendix I. The estimated restoration time frame for Alternative D4 to reduce PCB concentrations in the Remelt/Hot Line plume to the modified Method 8082 MDL of 0.0045 μg/L is approximately 240 years; and approximately 490 years to reach 0.000064 μg/L.

If a conditional POC is granted, it is expected to take 5 years for the PCB concentration in the plume to reach the PCUL of 0.22 μg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I). If the PCUL for a conditional POC is established as 0.000064 μg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 μg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 μg/L by the time the PCBs reach the Spokane River (Appendices E and I). It is expected to take about 80 years for the PCB concentrations in groundwater and smear zone soil to decline to these values.

5.1.7.5 Monitoring Requirements for Alternative D4

Long-term performance and protection groundwater monitoring will be conducted and will have the objectives and scope described above for Alternative D1 (Section 5.1.4). The monitoring of system performance for Alternative D4 is identical to the monitoring described in Section 5.1.6.5 for Alternative D3. The monitoring elements unique to the groundwater extraction and *ex situ* treatment system are summarized in Table 5-7.

5.1.7.5 Alternative D4 Estimated Costs

The NPV of implementing Alternative D4 over a 30-year time period is estimated to total approximately $27.0 million (-35 to +50 percent). The portion of this cost that is directly applicable to the operation of the *ex situ* treatment system is estimated to total approximately $7.2 million (refer to Table D-6).

The costs above are based on treatment for 30 years to achieve PCB effluent that meets the PCUL for a standard POC (0.000064 μg/L). If a conditional POC is granted, the PCB concentration in the extracted water is expected to be below the PCUL (0.22 μg/L) and below the concentration expected to be protective of the Spokane River based on the predicted attenuation that is estimated using the equation described in Appendix E. The estimated concentration of PCBs that is expected to be protective of the receptors in the Spokane River at a distance of 2,900 feet is 0.325 μg/L (refer to Appendix E). If a conditional POC is granted, treatment would not be required to protect receptors at locations upland from the River.

A separate cost estimate for a conditional POC was not prepared since the PCB concentration in extracted groundwater would be lower than the PCUL established for a conditional POC.

5.2 EVALUATION OF REMEDIAL ALTERNATIVES FOR THE REMELT/HOT LINE PCB PLUME AND ASSOCIATED SMEAR ZONE SOIL

Ecology has identified criteria that are used to evaluate remedial technologies and remedial alternatives (WAC 173-340-360). These evaluation criteria are described in Section 2.2.1. The criteria are applied to Alternatives D1 through D4 in Section 5.2.2 through 5.2.5 below. A comparative analysis of alternatives is conducted in Section 5.3 to identify the most appropriate remedial alternative for the PCBs contained in the Remelt/Hot Line smear zone soils and groundwater plume. The FSTM evaluated a wide range of technologies that were potentially applicable to PCBs at the very dilute concentrations detected in the smear zone in the Remelt/Hot Line area (average concentration of 0.07 mg/kg, total quantity of approximately 11.4 pounds (refer to Table 2 of the Remelt/Hot Line PCB Restoration Time Frame memo included in Appendix I).

No full-scale successful applications of these technologies for soil at depths of 68 to 80 feet bgs were identified. Thus, technologies to directly and actively treat smear zone soil in the Remelt/Hot Line area are not evaluated in this FS. However, the technologies included in Alternatives D1 through D4 indirectly affect the PCB mass in smear zone soil through processes occurring in the groundwater that is in contact with the smear zone (such as extraction of PCB-impacted groundwater or natural attenuation processes induced by groundwater flow). These effects on PCBs contained in smear zone soil are kept for consideration in the evaluation of remedial alternatives in this section.

The institutional controls, including physical measures, BMPs, and administrative measures (refer to Section 2.1.1.1) that are now in place at the Remelt complex and planned for implementation (refer to Table 2-2) are aimed at preventing the transport of PCBs to near-surface, vadose zone, and smear zone soils, and ultimately to the Remelt/Hot Line plume.

5.2.1 Remedial Action Objectives for the Remelt/Hot Line PCB Plume and Associated Smear Zone Soil

Remedial action objectives (RAOs) are broad, administrative goals for a cleanup action that address the overall MTCA cleanup process, as summarized in Section 2.2.2. The RAOs for the Remelt/Hot Line plume and associated smear zone soil at the Facility must address the identified COCs for these areas, and the pathways by which these COCs can reach receptors on and off the Facility. PCBs were the only COCs identified for the Remelt/Hot Line plume and associated smear zone soil (refer to Section 6 of the FSTM).

The pathways by which PCBs in the Remelt/Hot Line plume and associated smear zone soil can potentially reach receptors are, respectively, the soil to groundwater and the groundwater to surface water pathways. The soil to groundwater pathway assumes that PCBs in smear zone soil could mobilize into groundwater at concentrations that exceed groundwater SLs. Smear zone SLs for this pathway for saturated soil were derived using the Fixed Parameter 3-Phase Partitioning Model (WAC 173-340-747[4] and MTCA Method B CULs, or MCLs established by the CWA or the SDWA, whichever is lower for groundwater). This pathway was determined to have the most impact on the SLs established for soil at the Kaiser Facility.

The RAOs for the Remelt/Hot Line plume and smear zone soil AOCs are guided by specific MTCA requirements defined in WAC 173-340-740. Specifically, soil and groundwater that are contained as a part of the remedy will be deemed to meet CULs if certain requirements set out in WAC 173-340-740(6)(f) are met, which are defined in Section 2.2.2.

The following RAOs are judged to apply to the Remelt/Hot Line plume and associated smear zone soil AOCs at the Kaiser Facility:

- Meet the overall MTCA threshold requirements under WAC 173-340-360(2)(a);
- Meet threshold requirements for groundwater cleanup actions (WAC 173-340-360[2][c]);
- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent practicable (WAC 173-340-360[3]);
- Provide for a reasonable restoration time frame (WAC 173-340-360[2][b][ii]); and
- Consider public concerns (WAC 173-340-360[2][b][iii]).

The ways in which each remedial alternative will meet these RAOs for the Remelt/Hot Line plume are discussed in Section 5.2.2.

5.2.2 Evaluation of Remedial Alternative D1: Institutional Controls, Monitoring, and MNA

Alternative D1 applies the institutional control, monitoring, and MNA described in Section 5.1.4. The institutional controls include physical measures, for example, fences and controlled access to the Facility; best management practices (BMPs), such as operating practices designed to prevent spills and leaks of chemicals; and administrative measures, such as a restrictive covenant. An extensive groundwater monitoring program at the Facility has been in place for many years. This program contains a wide range of protection and performance monitoring for groundwater at the Facility, and is included as an element of Alternatives D1 through D4 to allow evaluation of whether soil and groundwater concentrations are protective of the soil to groundwater and groundwater to surface water exposure pathways.

An assessment of natural attenuation in groundwater at the Facility is provided in Appendix F. This assessment indicates that PCBs in the Remelt/Hot Line area that enter the aqueous phase may be amenable to bioremediation under both anaerobic and aerobic conditions. This natural attenuation is expected to be concentrated in locations near the source areas of the PCBs. Aerobic degradation is expected to focus on the mono- and di-chlorinated biphenyls, while anaerobic degradation is expected to be focused on tri- and higher chlorinated PCBs (refer to Section 5.1.4 and Appendix F). The capability of Alternative D1 to meet the cleanup requirements established by MTCA is summarized below.

5.2.2.1 Threshold Requirements

Protect Human Health and the Environment

Smear zone soil is in contact with groundwater, allowing the transport of PCBs from soil in these AOCs into groundwater, which can potentially migrate to the Spokane River. Recent groundwater monitoring indicates that the leading edge of the Remelt/Hot Line PCB plume has remained at a location between wells HL-MW-32S and HL-MW-30S, about 650 feet from the Spokane River (see Section 5.1.2). This FS defines the edge of the plume (refer to Section 5.1.2) as located between wells HL-MW-30S and HL-MW-32S, based on groundwater data using the detection limit of the modified Method 8082 of 0.0045 µg/L. The MDL for proposed EPA Method 1668 is expected to be in the 20 pg/L range. Ecology has indicated they will consider the MDL based on proposed Method 1668 in the determination of cleanup levels in the Draft CAP (Ecology 2011b). However, the 1668 Method has not been promulgated by EPA nor has the MTCA been modified to allow use of this method for groundwater and surface water compliance (see WAC 173-340-830[3][c] and [d]). If this were to happen in the future it is not currently known as this FS is being prepared if the weight of evidence collected in the future will show that the PCUL of 0.000064 µg/L is being exceeded over time at the locations where groundwater enters the Spokane River.

COC source control under Alternative D1 relies on physical measures (existing floor slabs and paved surfaces), which would help prevent a future spill or leak from infiltrating into the ground) for smear zone soil and natural attenuation processes for both smear zone soil and the Remelt/Hot Line plume.

As discussed in Section 4 for the petroleum hydrocarbon plumes, the rainfall to soil to groundwater pathway is not considered to be a significant pathway. The PCBs that might be mobilized by rainfall will be mobilized to a much greater extent by contact with groundwater as the water table rises and falls approximately 10 feet per year through the smear zone (Section 4.2, Hart Crowser 2012a). This groundwater fluctuation redistributes PCBs throughout the smear zone, creating a secondary source area of PCBs. Because the source areas in smear zone soil are likely to be present for a long time (refer to Table 5-4) transfer of PCBs from the smear zone into groundwater will be ongoing as groundwater flows through these areas.

Alternative D1 provides source control and ongoing natural attenuation to reduce the concentration of PCBs in smear zone soil and the quantity of PCBs in the plume. PCB concentrations are likely to exceed PCULs for standard POC for a long time. If a conditional POC (0.22 μg/L) is granted by Ecology, concentrations are expected to decline below the PCUL for a conditional POC in approximately 6 years.

Potential risks to the environment remain at the Facility, in that the soil to groundwater exposure pathway persists in the smear zone soil AOC. The risk to receptors in the Spokane River is mitigated under Alternative D1 through natural attenuation causing the edge of the plume (refer to Section 5.1) to be located in the vicinity of well HL-MW-32S, based on the modified Method 8082 with a MDL of 0.0045 μg/L. This well is located approximately 650 feet from the Spokane River. The future use of proposed EPA Method 1668 to measure PCB concentrations may indicate that PCBs reach the river at a concentration below 0.0045 μg/L, and perhaps below a concentration of 0.000064 μg/L. The risk to receptors that may extract and drink Remelt/Hot Line groundwater is controlled by the current practice that prohibits this activity, and by a restrictive covenant that will be put into place to prohibit this activity in the future.

The human direct contact or ingestion pathway to Facility workers and visitors is mitigated because of the depth (greater than 20 feet) of the smear zone soil and groundwater plume AOCs; through implementation of institutional controls; and because the plume does not appear to reach surface water, based on the results of ongoing groundwater monitoring using modified Method 8082. The soil to groundwater exposure pathway remains between smear zone soil and groundwater, but this impact to groundwater is mitigated through the groundwater natural attenuation processes occurring at the Facility that dissipate the plume before it reaches the Spokane River based on PCB concentrations measured using modified Method 8082.

Comply with MTCA Cleanup Standards

The implementation of Alternative D1 will not result in compliance with MTCA cleanup requirements, or with applicable or relevant and appropriate requirements (ARARs) promulgated by state and federal law for a long time if a standard POC is established throughout Facility soil and groundwater. The PCB PCUL (refer to Tables 4-1 and 2-1) for a standard POC have been established by

Ecology as 0.000064 μg/L (adjusted up to 0.0045 μg/L, the MDL for modified Method 8082) for groundwater, and 0.0000199 mg/kg (adjusted up to 0.01 mg/kg, the MDL for standard Method 8082) for soil (Ecology 2010a). These MDLs are currently exceeded in the smear zone soil and Remelt/Hot Line groundwater AOCs identified on Figure 5-1. Alternative D1 relies on source control measures and natural attenuation to reduce the concentration of PCBs that are present in these AOCs to PCULs over long time periods (refer to Appendix I).

However, if a conditional POC is established by Ecology, MTCA standards could be attained under Alternative D1 for the Remelt/Hot Line plume in a shorter time frame. Under a conditional POC, the PCUL is 0.000064 μg/L (adjusted up to 0.0045 μg/L, the MDL based on modified Method 8082) for groundwater at the point at which it flows into the Spokane River and 0.22 μg/L, (adjusted down from the drinking water criterion, 0.44 μg/L, to bring the total cancer risk down to 0.5×10^{-5}) for groundwater everywhere else at the Facility (Ecology 2010a). The corresponding soil concentration is 0.068 mg/kg for PCBs in smear zone soils. PCB concentrations in wells nearest to the Spokane River (e.g., MW-23 and MW-12A) along the centerline of the Remelt/Hot Line plume do not appear to be affected by the Remelt/Hot Line PCB plume. These wells occasionally have detections of PCBs above 0.0045 μg/L but these detections are thought to be from a nearby source that is being further investigated by Kaiser. Thus, the leading edge of the Remelt/Hot Line plume is considered to be stable and located about 650 feet from the Spokane River (refer to Section 5.1.2.1).

The future use of proposed EPA Method 1668 to measure ultra-low PCB concentrations may indicate that PCBs reach the Spokane River at a concentration below 0.0045 μg/L, and perhaps below a concentration of 0.000064 μg/L. However, if Ecology establishes a conditional POC, it is expected to take approximately 6 years for the PCB concentration in the plume to be less than 0.22 μg/L (drinking water PCUL for a conditional POC) (Appendix I).

If the PCUL for a conditional POC is established as 0.000064 μg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 μg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 μg/L by the time the PCBs reach the Spokane River (Appendix E). It is expected to take about 100 years for the PCB concentrations in groundwater and smear zone soil to decline to these values.

Once a POC (WAC 173-340-720[8][c]) is established by Ecology, compliance will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of Alternative D1.

MTCA provides additional requirements for permanent groundwater cleanup actions (WAC 173-340-360[2][c]):

(i) Permanent groundwater cleanup actions are:

> "A permanent cleanup action shall be used to achieve the CULs for ground water in WAC 173-340-720 at the standard point(s) of compliance (see WAC 173-340-720[8])."

It will take a long time for Alternative D1 to reach PCUL for PCBs in groundwater of 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL for modified Method 8082) that has been established by Ecology for a standard POC.

If a conditional POC is established by Ecology, the expected restoration time frame will be reduced substantially. This FS assumes that Ecology would consider the cleanup of groundwater at the Kaiser Facility by Alternative D1 to be an acceptable nonstandard groundwater cleanup action.

(ii) Nonpermanent groundwater cleanups require:

(A) "Treatment or removal of the source of release shall be conducted for liquid wastes, areas contaminated with high concentrations of hazardous substances, highly mobile hazardous substances, or hazardous substances that cannot be reliably contained. This includes removal [of] free product consisting of petroleum and other light non aqueous phase liquid (LNAPL) from the ground water using normally accepted engineering practices."

LNAPL is not present in Remelt/Hot Line smear zone soil. Alternative D1 relies on source control measures and natural attenuation to protect human health and Ecological receptors. PCBs in smear zone soil and in the Remelt/Hot Line plume are not now reaching human or ecological receptors (based on the use of modified Method 8082 to measure groundwater PCB concentrations). Alternative D1 does provide containment (building roof and floor slabs) for nearly the entire footprint of the Remelt area smear zone AOC (refer to Figure 5-1). Aggressive measures to prevent process water in the Remelt complex from leaking or spilling into soil have been implemented, with more similar measures planned (refer to Table 2-2). These measures, together with the other institutional controls and BMPs that are in place at the Facility, will prevent process water from reaching near-surface, vadose zone, or smear zone soils.

(B) "Groundwater containment, including barriers or hydraulic control through ground water pumping, or both, shall be implemented to the maximum extent practicable..."

Alternative D1 does not implement a hydraulic containment system. Ongoing natural attenuation at the Facility has prevented PCBs present in the Remelt/Hot Line groundwater plume and associated smear zone soil from reaching human or ecological receptors (based on the use of modified Method 8082 to measure groundwater PCB concentrations).

Alternative D1 is judged to be protective of human health and the environment. The existing containment (building roof, floor slabs, and other pavement), MNA, and institutional controls provided in Alternative D1 prevent COCs in the smear zone soils and the Remelt/Hot Line plume (based on the use of modified Method 8082 to measure groundwater PCB concentrations) from reaching human or ecological receptors.

However, Alternative D1 does not employ hydraulic containment of the Remelt/Hot Line PCB plume. If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above the PCUL of 0.000064 μg/L, Alternative D1 would not meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

MTCA identifies several expectations for cleanup action alternatives (WAC 173-340-370). These expectations represent the types of cleanup actions that Ecology considers likely results of the remedy selection process described in WAC 173-340-350 through WAC 173-340-360; however, Ecology recognizes that there may be some sites where cleanup actions conforming to these expectations are not appropriate. Per WAC 173-340-370(7), Ecology expects that natural attenuation of hazardous substances may be appropriate at sites where:

(a) Source control has been conducted to the maximum extent practicable;

As discussed in Section 5.1.4, source control is an important component of Alternative D1. The additional source control measures that are feasible in the Remelt Building have been identified (refer to Table 2-2). A plan is in place to implement these source control measures.

(b) *Leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health and the environment;*

As discussed above, Alternative D1 is judged to be protective of human health and the environment (based on the current understanding of the plume).

(c) *There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and*

The leading edge of the Remelt/Hot Line plume appears to be stable (based on the use of modified Method 8082 to measure groundwater PCB concentrations) in the vicinity of well HL-MW-32S, located about 650 feet from the Spokane River. The apparent stability of the plume at this location is evidence that natural attenuation of the plume has occurred and is continuing to occur. While there is considerable indication that the degradation of PCBs that are associated with the Remelt/Hot Line plume is occurring within the initial 500 feet of travel from the Remelt Building (refer to Section 5.1.4), evidence to support this assertion must still be collected and assessed during the pilot testing phase of the cleanup.

(d) *Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.*

Monitoring is a component of Alternative D1 and is described in Section 5.1.4.

If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River from the Remelt/Hot Line plume at concentrations above the PCUL of 0.000064 μg/L, Alternative D1 would not meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. The identified action-specific ARARs for Alternative D1 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These ARARS are judged to be attainable for Alternative D1.

Summary of Ability of Alternative D1 to Meet Threshold Requirements

Alternative D1 is protective of human health and the environment. The existing institutional controls, MNA, and monitoring provided in Alternative D1 prevent PCBs in the Remelt/Hot Line plume and associated smear zone soil from reaching human or ecological receptors (based on the use of modified Method 8082 to measure groundwater PCB concentrations). Thus, the risk to these receptors posed by the Remelt/Hot Line plume and associated smear zone soil has been reduced to acceptable levels by Alternative D1. Alternative D1 complies with applicable state and federal laws, and provides for compliance monitoring. Alternative D1 is judged to meet the threshold requirements established by MTCA.

5.2.2.2 Other Requirements

Other requirements that remedial alternatives must fulfill once they meet threshold requirements are defined by WAC 173-340-360(2)(b) include the use of permanent solutions to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]).

Use of Permanent Solutions to the Maximum Extent Practicable

The use of permanent solutions to the maximum extent practicable is a primary evaluation criterion for the remedial alternatives being considered for the Remelt/Hot Line PCB plume and associated smear zone soil. The specific criteria that must be addressed are specified in WAC 173-340-360(3)(f) and are discussed below.

Protectiveness. Alternative D1 will not reduce the concentration of PCBs to below PCULs for a standard POC in smear zone soil and the Remelt/Hot Line plume AOCs for a long time if a standard POC is established throughout Facility soil and groundwater (refer to Appendix I).

However, if a conditional POC is established by Ecology, MTCA standards are expected to be attained under Alternative D1 for Remelt/Hot Line plume and associated smear zone soils throughout the Facility in approximately 6 years. To reach the PCUL at the Spokane River (0.000064 μg/L) the concentration in the plume would need to be reduced to 60 μg/L based on the predicted attenuation (Appendix E). It is expected to take approximately 100 years to reach this concentration.

Alternative D1 will not break the soil to groundwater exposure pathway at locations downgradient from the Remelt Building. However, natural attenuation has caused the leading edge of the Remelt/Hot Line PCB plume to remain upgradient from wells MW-17S, HL-MW-32S, and HL-MW-23S (based on the use of modified Method 8082 to measure groundwater PCB concentrations). These wells are approximately 650 feet inland from the Spokane River (refer to Section 5.1.2). The direct contact exposure pathway to Facility workers and visitors is mitigated by nature of the depth of the smear zone and groundwater plume AOCs and by the fact that groundwater is not, and will not, be extracted from these AOCs for use as drinking water. Alternative D1 is protective of human health and the environment. The existing containment (building roof, floor slabs, and other pavement), MNA, and institutional controls provided in Alternative D1 prevent PCBs in the smear zone soils and the Remelt/Hot Line plume from reaching human or ecological receptors (based on the use of modified Method 8082 to measure groundwater PCB concentrations).

However, Alternative D1 does not employ hydraulic containment of the Remelt/Hot Line PCB plume. If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River from the Remelt/Hot Line plume at concentrations above the PCUL of 0.000064 µg/L, Alternative D1 would not meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

Permanence. Alternative D1 will reduce the toxicity and volume of PCBs concentrations that can be reduced through natural attenuation processes. However, because these processes proceed at slow rates, it will require a long time to attain the PCUL if a standard POC is established for smear zone soil and groundwater COCs. If a conditional POC is established by Ecology, the restoration time frame will be reduced substantially (Appendix I). Natural attenuation is expected to reduce PCB source area mass in smear zone soil over time. Approximately 30 percent of the mass (3.4 pounds) of PCBs is expected to be removed from the smear zone soil during the initial 30-year operating period of Alternative D1 (Table 5-4). Institutional controls in place at Kaiser help to prevent the release of COCs into the environment by the Facility's industrial activities.

Cost. The NPV of implementing Alternative D1 over a 30-year time period is estimated to total approximately $19.8 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 5.1.4 above and in the cost estimate tables provided in Appendix D.

Effectiveness over the Long Term. It will take a long time for Alternative D1 to reach the PCUL of 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL for modified Method 8082) established for a standard POC. If a conditional POC is established by Ecology, the restoration time frame will be reduced substantially.

Natural attenuation is expected to reduce COC source area mass in smear zone soil over time. Approximately 30 percent of the mass (3.4 pounds) of PCBs is expected to be removed from the smear zone soil and naturally degraded during the initial 30-year operating period of Alternative D1 (Table 5-4). Institutional controls in place at Kaiser help to prevent the release of COCs into the environment by the Facility's industrial activities.

Natural attenuation has caused the leading edge (based on the use of modified Method 8082 to measure groundwater PCB concentrations) of the Remelt/Hot Line plume to remain upgradient from wells MW-17S, HL-MW-32S, and HL-MW-23S, which are about 650 feet inland from the Spokane River (refer to Sections 5.1.2 and 5.1.4.1).

Alternative D1 is expected to be protective over the long term. The existing containment (building roof, floor slabs, and other pavement), MNA, and institutional controls provided in Alternative D1 prevent COCs in the smear zone soils and the Remelt/Hot Line plume from reaching human or ecological receptors (based on the use of modified Method 8082 to measure groundwater PCB concentrations).

Management of Short-Term Risks. Alternative D1 uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create any new or additional risk to human health and the environment.

The short-term risks associated with implementing existing and future institutional controls include:

- Potential exposure of Facility workers and visitors to hazardous materials (e.g., handling items containing hazardous waste as part of executing BMPs); and

- Hazards to workers associated with the industrial activities taking place at locations within the Facility where these institutional controls are being implemented.

Technical and Administrative Implementability. The actions associated with the implementation of Alternative D1 are already in place at the Kaiser Facility.

Restoration Time Frame

The approach used to estimate the restoration time frame for Alternative D1 is discussed in Appendix I and summarized in Section 5.1.4. The estimated restoration time frame for PCBs in Alternative D1 for a standard POC and for a conditional POC (if established by Ecology) are summarized in Appendix I and range from up to 6 years if a conditional POC is established (based on the use of modified Method 8082) to more than 580 years if the standard POC is used by Ecology to establish cleanup criteria.

The factors used to determine whether Alternative D1 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) for PCBs are assessed below:

(i) Potential risks posed by the site to human health and the environment;

The direct contact and ingestion exposure pathways to Facility workers and visitors are mitigated by the depth of the smear zone and groundwater plume AOCs; by the fact that groundwater from within these AOCs is not used as a current drinking water source and will not be used in the future as a drinking water source (via a restrictive covenant); and through natural attenuation, which has kept PCBs from reaching the Spokane River (based on the use of modified Method 8082 to measure groundwater PCB concentrations). However, Alternative D1 does not employ hydraulic containment of the Remelt/Hot Line PCB plume. If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River from the Remelt/Hot Line plume at concentrations above the PCUL of 0.000064 μg/L, Alternative D1 would not meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

(ii) Practicability of achieving shorter restoration time frame;

The expected restoration time frame that Alternative D1 provides is compared to the other restoration time frames of remedial alternatives for the Remelt/Hot Line PCB plume in Section 5.3. These other alternatives have shorter restoration time frames than Alternative D1. An assessment of whether Alternative D1 uses permanent solutions to the maximum extent practicable is provided in Section 5.3.

(iii) Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

Releases from the Facility may pose risks to human and ecological receptors, and may potentially affect groundwater and the Spokane River. Alternative D1 includes physical and administrative controls, BMPs, natural attenuation, and containment of surface soils to reduce the potential for worker exposure to PCBs and to reduce the potential for PCBs in smear zone soil and groundwater to migrate to the Spokane River (based on the use of modified Method 8082 to measure groundwater PCB concentrations). These controls have effectively cut the pathways by which PCBs could reach potential human and ecological receptors.

(iv) Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

A restrictive covenant will limit future uses of the Facility. The Spokane River is likely to continue to be a potential source of receptors for releases from the Facility. PCBs from the Remelt/Hot Line plume do not appear to have been detected in wells near the river at concentrations above PCULs (based on the use of modified Method 8082 to measure groundwater PCB concentrations). An additional investigation of possible PCB sources in the vicinity of the former WDR will be completed in the near future.

(v) Availability of alternative water supplies;

Alternative water supplies are abundant at the Facility. A considerable amount of groundwater exists at the Facility that is outside of the footprint of the existing AOCs at the Facility. Kaiser also has secured access to this groundwater for domestic and industrial use through a water right.

(vi) Likely effectiveness and reliability of institutional controls;

The institutional controls implemented in Alternative D1 (refer to Section 5.1.4) have been shown to be effective and reliable at the Facility. Most of these measures have been successfully used at the Facility for many years.

(vii) Ability to control and monitor migration of hazardous substances from the site;

The groundwater monitoring program at the Facility is governed by a Sampling and Analysis Plan (Hart Crowser 2007a), as amended (Kaiser 2010a), that has been approved by Ecology. A new monitoring plan will be developed to monitor the performance of this alternative if it is selected as the preferred alternative for the Remelt/Hot Line plume and associated smear zone soils at the Facility.

(viii) Toxicity of hazardous substances at the site; and

The toxicity of PCBs depends on their concentration and the duration of exposure to them. The implementation of Alternative D1 is expected to prevent these PCBs from reaching potential human or ecological receptors in the future (based on the use of modified Method 8082).

(ix) Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar conditions.

An assessment of natural attenuation in groundwater at the Facility is provided in Appendix F. This assessment indicates that PCBs in the Remelt/Hot Line area that enter the aqueous phase may be amenable to bioremediation under both anaerobic and aerobic conditions. This natural attenuation is expected to be concentrated in locations near the source areas of the PCBs. Anaerobic degradation is expected to be focused on trichlorinated biphenyls and higher chlorinated PCBs located near the source area (where a negative oxidation-reduction potential [ORP] is present). Anaerobic degradation is expected to eventually convert trichlorinated biphenyls and higher chlorinated PCBs to mono- and bichlorinated biphenyls that can be degraded by aerobic bacteria.

The restoration time frame for Alternative D1 for PCBs is judged to be reasonable as defined by WAC 173-340-360(4) if a conditional POC is established by Ecology.

5.2.3 Evaluation of Remedial Alternative D2: Alternative D1 Plus Containment

Alternative D2 includes the institutional control, monitoring, and MNA elements of Alternative D1, and adds hydraulic containment of the Remelt/Hot Line PCB plume and associated smear zone soil. The Remelt/Hot Line plume and smear zone soil AOCs are shown on Figures 5-1 through 5-4.

The capability of Alternative D2 to meet the cleanup requirements established by MTCA is summarized below.

5.2.3.1 Threshold Requirements

Protect Human Health and the Environment

Alternative D2 provides hydraulic containment of the Remelt/Hot Line PCB plume at the Kaiser Facility. An assessment of plume boundaries in groundwater at the Facility (Section 5.1.4.1) indicates that the leading edge of the Remelt/Hot Line plume has remained approximately 650 feet from the Spokane River. This FS defines the leading edge of the plume (refer to Section 5.1) as located between wells HL-MW-30S and HL-MW-32S, based on modified Method 8082 with a MDL of 0.0045 µg/L. The MDL for proposed EPA Method 1668 is expected to be in the 20 pg/L range. It is not known as this FS is being prepared whether the weight of evidence of future analyses using proposed EPA Method 1668 would show that PCBs from the Remelt/Hot Line plume are reaching the Spokane River at a concentration greater than the PCUL of 0.000064 µg/L.

The combined benefit of hydraulic containment and natural attenuation greatly decreases the probability that PCBs at concentrations above the PCUL of 0.000064 µg/L are reaching the Spokane River. Ongoing groundwater monitoring confirms that PCBs are not migrating beyond the downgradient Kaiser property boundary (Hart Crowser 2012a) based on the modified Method 8082 with a MDL of 0.0045 µg/L.

Because the source area in smear zone soil is likely to be present for a long time, transfer of PCBs from the smear zone into groundwater will be ongoing as groundwater flows through these impacted areas. Most of the Remelt/Hot Line plume and smear zone soil reside beneath the floor slab of the existing building. Alternative D2 does not include additional measures to cut the rainfall to soil to groundwater exposure pathway that could convey PCBs from smear zone soil. This exposure pathway is not considered significant relative to the extent of PCB mobilization into groundwater caused by the seasonal fluctuation of the water table through smear zone soil.

Alternative D2 does not add additional mechanisms (beyond those provided by Alternative D1) to actively reduce the concentration of PCBs in smear zone soil or in the Remelt/Hot Line plume. PCB concentrations are likely to exceed the PCB PCUL for a standard POC for a long time in these AOCs. If a conditional POC is established by Ecology, the restoration time frame would be substantially decreased (Appendix I). Because the soil to groundwater exposure pathway persists in the smear zone soil AOCs, potential risks to the environment remain at the Facility. Alternative D2 controls the risk to Spokane River receptors through the hydraulic containment of PCBs in groundwater, and through natural attenuation that has kept the leading edge of the Remelt/Hot Line plume approximately 650 feet from the Spokane River, based on the modified Method 8082 with a MDL of 0.0045 µg/L.

The risk to receptors that may extract and drink PCB-contaminated groundwater is controlled by the current practice that prohibits this activity, and by a restrictive covenant that will prohibit this activity in the future.

Over time, Alternative D2 will remove PCB mass from the Remelt/Hot Line plume and smear zone soil AOCs through the groundwater recovery and hydraulic containment process. This PCB mass will be transferred to the petroleum hydrocarbon smear zone in the Oil House area through infiltration of the extracted PCB-impacted groundwater. Because PCBs are hydrophobic (Hart Crowser 2012a), and because of their affinity for petroleum hydrocarbons, the PCBs are expected to initially become adsorbed or sequestered by the SVOCs in the smear zone soil.

The PCBs that are presently comingled with SVOCs (approximately 587,000 pounds) and the very small quantities of additional PCBs that will be introduced to the Oil House area in Alternative D2 (approximately 5.1 pounds in 30 years), are expected to be biodegraded by anaerobic and aerobic bacteria (refer to Appendix F).

The FPP and dissolved-phase petroleum concentrations within the Oil House and Wastewater Treatment areas correspond very closely to the negative ORP values in these areas. A negative ORP is the most reliable indicator of favorable conditions for anaerobic degradation and dechlorination processes. These ORP values increase within a short distance from the source area, as the groundwater flux containing high DO concentrations continues to provide electron acceptors to the area (refer to Figure F-2). As the ORP in these areas become positive, anoxic conditions make anaerobic processes less favorable, until positive ORP conditions and other indicators (DO, nitrates, etc.) continue to increase, and eventually only aerobic degradation processes are possible.

PCBs originating from the center of the Oil House area could be dechlorinated under anaerobic conditions as indicated by the ORP values in this area, which are negative. Mono- and dichlorinated biphenyls are more available for biodegradation and are easier to dechlorinate than the trichlorinated biphenyls and more chlorinated PCBs. This should result in a higher ratio of trichlorinated biphenyls and more highly chlorinated PCBs, compared to mono- and dichlorinated biphenyls in this area (refer to Appendix F).

Detected concentrations of PCBs are observed only in areas of negative ORP or anaerobic conditions within the Oil House area, and were not detected at any downgradient locations that had positive ORP values. Based on the groundwater flux through the area, it is not likely that the aerobic bacteria would be capable of providing sufficient degradation to both less and more chlorinated biphenyls in less than a few hundred feet. Since biodegradation of highly chlorinated PCBs is relatively slow, it is reasonable to assume that a much longer PCB plume, similar to the plume in the Remelt Area would be observed in the Oil House area. Since there is no evidence that this plume exists, it suggests the PCBs may be highly sorbed to smear zone soil and FPP in the Oil House area, are not bioavailable, and are not migrating beyond the limited area of a few wells where FPP has been identified, or the PCBs are being degraded as the PCBs partition to the aqueous phase. Bench- and/or pilot-scale tests will be required to develop additional evidence that biodegradation or chemical degradation of PCBs is occurring in the Oil House area.

An additional layer of protection is provided (in Alternative D2) to potential receptors in the Spokane River by the fact that the Oil House area groundwater plume will be contained by the operation of the IRM. Thus, potential receptors in the Spokane River are protected by the ongoing natural attenuation processes that are degrading SVOCs and PCBs; by two levels of hydraulic containment provided: (1) in Alternative D2 for the Remelt/Hot Line plume and (2) by the IRM for the PCBs currently in the Oil House area (approximately 587,000 pounds), and the very small quantity (5.1 pounds over 30 years) of PCBs that are added to the area in Alternative D2); and by the removal of PCBs that are recovered with the FFP.

Natural attenuation of PCBs that has been demonstrated to be occurring at the Facility. The observed attenuation in the Remelt/Hot Line plume was modeled using regression analysis to predict concentrations at the Spokane River based on the empirical data. The curve fit was used to develop an equation that would predict a concentration in the source area that would be protective of receptors in the Spokane River with the knowledge that attenuation is occurring as the groundwater travels from the source area to the river. A PCB concentration of 0.060 µg/L in the Remelt source area (2,300 feet upgradient of the river) was predicted to naturally attenuate to 0.000064 µg/L at the river and protect the receptors that may be present there. This predictive equation provides a conservative estimate of the natural attenuation of the PCBs in the Remelt/Hot Line plume. More information on the equation developed to predict the attenuation of PCBs in the Remelt/Hot Line plume is presented in Appendix E.

The recovered groundwater that would be added to the Oil House area in Alternative D2 is expected to have a PCB concentration of 0.040 µg/L (see Section 5.1.5). The infiltration trench is located approximately 3,300 feet away from the Spokane River. Thus, it is expected that the PCBs added to the Oil

House area by Alternative D2 (approximately 5.1 pounds over 30 years) would not reach the Spokane River at a concentration above 0.000064 µg/L; even if they were not initially sequestered by the SVOCs in the Oil House area and eventually biodegraded as the PCBs entered the aqueous phase.

The human direct contact or ingestion pathway to Facility workers and visitors is mitigated because of the depth (greater than 20 feet) of the smear zone soil and groundwater plume AOCs, through implementation of institutional controls, and because the groundwater plume does not appear to be reaching surface water These observations are based on the results of ongoing groundwater monitoring. The soil to groundwater exposure pathway remains between smear zone soil and groundwater, but this impact to groundwater is mitigated through the groundwater natural attenuation processes occurring at the Facility and by the hydraulic containment provided in Alternative D2 and the existing IRM. Alternative D2 is judged to be protective of human health and the environment.

Comply with MTCA Cleanup Standards

The implementation of Alternative D2 will not result in compliance with MTCA cleanup requirements, or with ARARs promulgated by state and federal law, if a standard POC is established throughout Facility soil and groundwater, for a long time. The PCB PCUL (refer to Table 4-1) for a standard POC has been established by Ecology as 0.000064 µg/L (adjusted up to 0.0045 µg/L the MDL for modified Method 8082) for groundwater, and 0.0000199 mg/kg (adjusted up to 0.01 mg/kg, the MDL for standard Method 8082) for soil. Alternative D2 relies on source control measures, natural attenuation, and containment (of surface soils and groundwater) to reduce the concentration of PCBs that are present in these AOCs to PCULs over long time periods.

However, if a conditional POC is established by Ecology, MTCA standards could be attained under Alternative D2 for Remelt/Hot Line plume in a shorter time period. Under a conditional POC, the PCUL is 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL based on modified Method 8082) for groundwater that flows into the Spokane River and 0.22 µg/L (adjusted down from 0.44 µg/L, the drinking water criterion to bring total cancer risk down to 0.5×10^{-5}) everywhere else. The corresponding soil concentration is 0.068 mg/kg for smear zone soil.

The leading edge of the plume is considered to be stable and located 650 feet from the Spokane River. The future use of proposed EPA Method 1668 to measure ultra-low PCB concentrations may indicate that PCBs reach the river at a concentration below 0.0045 µg/L, and perhaps below a concentration of 0.000064 µg/L. The containment provided by the implementation of Alternative

D2 would prevent these low concentrations of PCBs from reaching the receptors in the Spokane River.

If a conditional POC is established by Ecology, it is expected to take 4 years for the PCB concentration in the plume to reach the PCUL of 0.22 μg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Table 5-4). PCBs are not currently reaching the Spokane River from the Remelt/Hot Line plume at concentrations above the MDL (0.0045 μg/L).

If the PCUL for a conditional POC is established as 0.000064 μg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 μg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 μg/L by the time the PCBs reach the river based on calculations presented in Appendix E. It is expected to take about 60 years for the PCB concentrations in smear zone soil to decline to these values. The hydraulic containment provided by Alternative D2 will prevent PCBs at concentrations above 0.000064 μg/L from reaching the River.

Compliance with CULs established for either a standard POC or a conditional POC will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of Alternative D2.

MTCA provides additional requirements for permanent groundwater cleanup actions under WAC 173-340-360(2)(c)(i) and for nonpermanent groundwater cleanup actions under WAC 173-340-360(2)(c)(ii). These requirements are presented in detail for Alternative D1 in Section 5.2.2.1 and are summarized for Alternative D2 below:

WAC 173-340-360(2)(c)(i). It will take a long time for Alternative D2 to reach the PCUL for PCBs of 0.000064 μg/L (adjusted up to 0.0045 μg/L, the MDL for modified Method 8082) established for a standard POC. If a conditional POC is established by Ecology, the restoration time frame will be reduced substantially. This FS assumes that Ecology would consider the cleanup of groundwater at the Facility by Alternative D2 to be an acceptable nonstandard groundwater cleanup action.

WAC 173-340-360(2)(c)(ii). Alternative D2 implements an extensive series of measures to prevent leaks and spills within the Remelt building (refer to Table 2-2) that could add PCBs to smear zone soil. Alternative D2 prevents PCBs in smear zone soil from reaching human or ecological receptors. Alternative D2 implements hydraulic containment that, together with the ongoing natural attenuation at the Facility, is judged to be an effective treatment and containment system for the PCBs in the Remelt/Hot Line plume and the smear zone soil associated with the plume. The PCB mass contained in the extracted groundwater generated by the hydraulic containment system will be immobilized and contained within the SVOCs in smear zone soil in the Oil House area, and are expected to be attenuated by the natural processes that will anaerobically and aerobically degrade the PCBs as they are released by the SVOCs and enter the aqueous phase. In addition, the Oil House area plume will be contained by the operation of the IRM system, which contains the petroleum plume in the Oil House area.

Since active groundwater restoration and containment technologies that incorporate the pumping of groundwater are integral parts of Alternative D2, compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in Alternative D2 (WAC 173-340-720(9)(c)(vi).

MTCA identifies several expectations for cleanup action alternatives (WAC 173-340-370). These expectations represent the types of cleanup actions that Ecology considers likely results of the remedy selection process described in WAC 173-340-350 through WAC 173-340-360; however, Ecology recognizes that there may be some sites where cleanup actions conforming to these expectations are not appropriate.

Per WAC 173-340-370(7), Ecology expects that natural attenuation of hazardous substances may be appropriate at sites where:

(a) Source control has been conducted to the maximum extent practicable;

As discussed in Section 5.1.4, source control is an important component of Alternative D2. Substantial upgrades to the Remelt building have been completed and additional upgrades planned for the future (refer to Table 2-2). These source control measures will significantly reduce the potential for PCBs to enter smear zone soils.

(b) *Leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health and the environment;*

As discussed above, Alternative D2 is judged to be protective of human health and the environment.

(c) *There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and*

There are many indications that the degradation of PCBs that are associated with the SVOCs in the Oil House and Wastewater Treatment areas has occurred and is occurring (refer to Appendix F). Evidence to support these indications must still be collected and assessed during the pilot testing phase of the cleanup.

(d) *Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.*

Monitoring is a component of Alternative D2 and is described in Section 5.1.4.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. Several action-specific regulations were identified as being potentially applicable or relevant and appropriate to the implementation of Alternative D2 (refer to Appendix G, Tables G-3 and G-4).

Alternative D2 involves recovery of approximately 3.0 MGD from three extraction wells at the midpoint of the plume, west of the Remelt building, to hydraulically contain the Remelt/Hot Line plume (Figure 5-6). The water is extracted from both shallow and deep locations within the aquifer. The extracted groundwater will be conveyed via an underground pipe around the north side of the Remelt building and will be directed into a horizontal infiltration area located in the vicinity of the Oil House area (Figure 5-6). The infiltration area will not contain perforated pipes to distribute the water.

The operation of the existing IRM system continues to provide additional containment of the plume in the Oil House area. The application of potential action-specific ARARs associated with the IRM were discussed in Section 4.2.2.1 and is not repeated here.

Regulation promulgated pursuant to three state statutes are judged to be potentially applicable, or relevant and appropriate, to the implementation of Alternative D2. The WAC citations for these potentially applicable, or relevant and appropriate state regulations are (1) the Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC), (2) the State

Waste Discharge Permit Program (Chapter 173-216 WAC), and (3) the UIC Program (Chapter 173-218 WAC). The UIC and Waste Discharge Permit programs require the use of AKART for discharges governed by their programs. The potential applicability, relevance and appropriateness of these regulations and of AKART to Alternative D2 is discussed below.

Groundwater Quality Standards (Chapter 173-200 WAC). This regulation is designed to protect and preserve the groundwater of the state. This regulation does not apply, nor is it relevant and appropriate, to cleanup actions approved by Ecology under MTCA (WAC 173-200[010][3][c]); rather, groundwater cleanup standards are developed under WAC-173-340-720. The compliance of Alternative D2 with WAC 173-340-720 is discussed above. In addition, the Groundwater Quality Standards include an antidegradation policy designed to preserve current and future beneficial uses of groundwater (WAC 173-200- 030). However, because this regulation explicitly exempts MTCA cleanup actions conducted with Ecology's approval, the antidegradation policy does not apply to MTCA cleanups on the Kaiser Facility.

State Waste Discharge Permit Program (Chapter 173-216 WAC). The purpose of this regulation is to implement a state permit program applicable to the discharge of waste materials from industrial, commercial, and municipal operations *into* ground and surface waters of the state and *into* municipal sewerage systems (emphasis added). Alternative D2 does not discharge *into* the subsurface. All conveyance piping is below ground. The infiltration area will not contain perforated pipes to distribute the water that is infiltrated. The surface of the earth is not pierced by the groundwater that is extracted in Alternative D2. As a result, the State Waste Discharge Program is not applicable to Alternative D2. The program also is not "relevant and appropriate" to Alternative D2 because it does not address problems or situations that are "sufficiently similar to those encountered at the site that [its] use is suited to the particular site (WAC 173-340-710(4). Moreover, the dissolved oxygen distributed with the water actually improves the water quality by enhancing aerobic biodegradation of SVOCs and PCBs.

State Underground Injection Control Program (Chapter 173-218 WAC). The purpose of this statute is to (1) preserve and protect groundwater by preventing the discharge of fluids *into* UIC wells that will endanger groundwater (emphasis added), (2) to require the use of AKART to the discharge of fluids and waste fluids *into* the waters of the state (emphasis added), and (3) to prohibit the injection of fluids through wells except as authorized by this statute.

Groundwater removed from the Remelt/Hot Line plume will be conveyed entirely underground to a horizontal infiltration area located upgradient of the

Oil House area. The infiltration area will not contain perforated pipes to distribute the water that is discharged.

Per WAC 173-218-050(4) infiltration trenches that do not contain perforated pipes are not considered UIC wells and are not regulated under Chapter 173-218 WAC. In addition, the distribution system is not a UIC well because it does not break the surface of the ground. A UIC well is a well that is used to discharge fluids *into* the subsurface (emphasis added). This means that the discharge of fluids must break the surface of the ground to constitute a discharge *into* the waters of the state. The water extracted in Alternative D2 does not pierce the surface of the earth on its journey from the Remelt/Hot Line Plume to the horizontal infiltration area upgradient of the Oil House area. Thus, the horizontal infiltration area is not a UIC well.

For both of these reasons, the State Underground Injection Control Program is not applicable to Alternative D2. The program also is not "relevant and appropriate" to Alternative D2 because it does not address problems or situations that are "sufficiently similar to those encountered at the site that [its] use is suited to the particular site (WAC 173-340-710[4]). In fact, applying the UIC regulations to a system that is specifically exempted from the regulations would defeat the purpose of the exemption.

Use of AKART. The UIC Program, Waste Discharge Program, and Water Quality Standards for Groundwater each specify the need for AKART before a regulated discharge is introduced *into* the subsurface. As explained above, however, none of these programs constitutes an ARAR for Alternative D2 and, therefore, there is no requirement to satisfy AKART. However, even if AKART were deemed to apply, it would not mandate the imposition of additional treatment obligations onto Alternative D2. This is because the Remelt/Hot Line PCB plume is unique in the fact that it contains very low concentrations of PCBs (e.g., parts per trillion and lower) and that it contains PCBs that are attached to colloids. The concentration of PCBs in the groundwater transferred from the plume to an area upgradient of the Oil House area is expected to be approximately 0.040 µg/L.

Additionally, if a conditional POC is established by Ecology, the PCUL for PCBs in groundwater throughout the Facility will be 0.22 µg/L (220 ng/L). Thus, the groundwater that will be introduced upgradient of the Oil House area will contain PCBs at a concentration that is protective of drinking water.

The PCBs in the Remelt/Hot Line plume likely consist of a small fraction of soluble PCBs and a larger fraction of PCBs adsorbed onto colloidal particles (refer to FSTM Section 6.2.1). While treatment with GAC is considered a presumptive remedy for the treatment of *soluble* PCBs, there is no presumptive remedy for the treatment of PCBs attached to colloidal particles. Ecology has acknowledged this fact and has recognized that bench- and pilot-scale tests will be required to demonstrate the effectiveness of the technologies that treat PCBs attached to colloidal particles as proposed by Alternatives D3 and D4.

For a technology to be considered to be AKART, it must be known, available, and reasonable. There is no known treatment method for this dilute colloidal PCB plume. While the individual technical components of the treatment process proposed for Alternatives D3 and D4 are available in some contexts, they have never been used individually or together to capture colloidal PCBs at concentrations in the 0.050 µg/L range. Because the treatment train has never been assembled for this use, it is not currently available. Moreover, the cost of operating such a treatment system is expected to be very high (refer to Sections 5.2.2.3 and 5.2.2.4) and not considered to be practicable (refer to Section 5.3), given the very small quantity of PCBs (5.1 pounds) that will be removed from the environment over a 30-year time period.

The Pollution Control Hearings Board (PCHB) has stated that a public agency could not require an applicant to develop a new technology to advance the art of emission control. The advance must be "known" in the sense that it has been tested and found to control emissions effectively and efficiently. Under this test, the public agency may not insist that an emission source be utilized as a proving ground for an as-yet untried technology (PCHB 85-218). Ecology itself has relied on this PCHB decision in its Water Quality Program Permit Writer's Manual to define AKART (see Ecology 2010c, page IV-36). This ruling by the PCHB, and Ecology's acknowledgment of its applicability in the AKART context, provide further support for the determination that requiring the treatment of the very dilute concentration of colloidal PCBs that are present in the Remelt/Hot Line plume does not constitute AKART.

Summary of ARARs Analysis. The UIC and Waste Discharge Programs are not applicable because there is no discharge *into* the subsurface or *into* waters of the state (emphasis added). Moreover, the infiltration system does not contain perforated pipe, so it is expressly exempt from regulation as a UIC well. Neither of these programs are "relevant and appropriate" because they do not address situations that are "sufficiently similar to those encountered at the site and that their use is well suited to the site." The State Groundwater Quality Standards (Chapter 173-200 WAC) do not apply to cleanup actions approved by Ecology under MTCA (WAC 173-200[010][3][c]); rather, groundwater cleanup standards are developed under WAC 173-340-720. Finally, in accordance with PCHB authority that has been relied upon by Ecology in the AKART context, there are no known, available, and reasonable treatment technologies for the treatment of the very dilute colloidal PCBs that are present in the Remelt/Hot Line plume at the Kaiser Facility.

Summary of Ability of Alternative D2 to Meet Threshold Requirements

Alternative D2 is protective of human health and the environment. The containment (of surface soil and groundwater plumes), MNA, and institutional controls provided in Alternative D2 prevent PCBs in the Remelt/Hot Line plume and associated smear zone soil from reaching human or ecological receptors. Alternative D2 complies with applicable state and federal laws, and provides for compliance monitoring. Alternative D2 is judged to meet the threshold requirements established by MTCA.

Alternative D2 meets the threshold requirement established by WAC 173-340-360 (2)(c)(ii)(A), with which Alternative D1 may not be compliant (if the future use of proposed EPA Method 1668 provides clear evidence that PCBs at concentrations above 0.000064 μg/L are entering the Spokane River from the Remelt/Hot Line plume).

5.2.3.2 Other Requirements

Other requirements that remedial alternatives must fulfill once they meet threshold requirements are defined by WAC 173-340-360(2)(b). These requirements include the use of permanent solutions to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]).

Use of Permanent Solutions to the Maximum Extent Practicable

The use of permanent solutions to the maximum extent practicable is a primary evaluation criterion for the remedial alternatives being considered for the Remelt/Hot Line PCB plume and associated smear zone soils. The specific criteria that must be addressed are specified in WAC 173-340-360(3)(f) and are discussed below.

Protectiveness. Alternative D2 will not reduce the concentration of PCBs to levels below PCULs for a standard POC in smear zone soil and the Remelt/Hot Line plume AOCs for a long time if a standard POC is established throughout Facility for soil and groundwater (Appendix I). However, if a conditional POC is established by Ecology, MTCA standards are expected to be attained under Alternative D2 for the Remelt/Hot Line plume and associated smear zone soils throughout the Facility in approximately 4 years.

Natural attenuation of the Remelt/Hot Line plume has been shown to be occurring at the Facility (Section 5.1.4.1) and is expected to continue. The soil to groundwater exposure pathway remains between smear zone soil and groundwater, but this impact to groundwater is controlled through the hydraulic containment provided in Alternative D2, and through the groundwater natural attenuation processes occurring at the Facility. Attenuation of the PCBs that will be added to the Oil House area in Alternative D2 is also expected (Appendix F).

The human direct contact or ingestion pathway to Facility workers and visitors is mitigated because of the depth of the smear zone soil and groundwater plume AOCs, through implementation of institutional controls, and because the groundwater plumes do not appear to be reaching surface water.

Alternative D2 is protective of human health and the environment because it: (1) mitigates human health direct contact and ingestion pathways by the use of institutional controls, surface containment (building roof, floor slabs, and other pavement), and MNA; (2) allows natural processes to keep the leading edge of the Remelt/Hot Line PCB plume 650 feet or more from the Spokane River (based on the use of modified Method 8082 to measure groundwater PCB concentrations); (3) adds another level of risk control by hydraulically containing the Remelt/Hot Line plume and preventing the plume from reaching receptors in the Spokane River; (4) allows for sequestration and biodegradation of PCBs that are transferred to the Oil House area; and (5) continues the use of the existing IRM system to contain the plume in the Oil House area.

The new hydraulic containment system installed in Alternative D2 will extract groundwater that contains PCBs from the Remelt/Hot Line plume. The extracted groundwater will be infiltrated upgradient of the Oil House area. The small PCB mass (about 5.1 pounds over 30 years) will be immobilized and contained by the SVOCs in the smear zone soil in this area (approximately 587,000 pounds), and is expected to be biodegraded by anaerobic and aerobic bacteria as the PCBs partition from the SVOCs to the aqueous phase over time (refer to Appendix F). In addition, the Oil House area plume will itself be contained by the operation of the IRM system, which currently contains the SVOC plume in this area.

An additional layer of protection is provided by the natural attenuation of PCBs that has been demonstrated to be occurring at the Facility. The observed attenuation in the Remelt/Hot Line plume was modeled using regression analysis to predict concentrations at the Spokane River based on the empirical data. A curve fitting approach was used to develop an equation that would predict a concentration in the source area that would be protective of receptors in the Spokane River with the knowledge that attenuation is occurring as the groundwater travels from the source area to the river. A PCB concentration of 0.060 µg/L in the source area (2,300 feet upgradient of the river) was predicted to naturally attenuate to 0.000064 µg/L at the river and protect the receptors that may be present there. More information on the equation developed to predict the attenuation of PCBs in the Remelt/Hot Line plume is presented in Appendix E.

The recovered groundwater that would be added to the Oil House area by Alternative D2 is expected to have a PCB concentration of 0.040 µg/L (see Section 5.1.5). Thus, it is expected that the PCBs added to the Oil House area by Alternative D2 (approximately 5.1 pounds over 30 years) would not reach the Spokane River at a concentration above 0.000064 µg/L; even if they were not initially sequestered by the SVOCs in the Oil House area and eventually degraded as the PCBs enter the aqueous phase.

Alternative D2 will also protect receptors in the Spokane River if the future use of proposed EPA Method 1668 determines that PCBs are reaching the River from the Remelt/Hot Line plume at concentrations above 0.000064 µg/L.

Alternative D2 is judged to be protective of human health and the environment.

Permanence. Alternative D2 will reduce the toxicity and volume of PCB concentrations that can be reduced through natural attenuation processes. However, because these processes are slow, it will require a long time to attain the PCULs if a standard POC is established for smear zone soil and groundwater. If a conditional POC is established by Ecology, the restoration time frame will be substantially reduced (Appendix I).

The mobility of PCBs in groundwater is reduced by the provision of hydraulic containment, which prevents PCB migration to the Spokane River. The extracted PCB mass (approximately 5.1 pounds over 30 years) will be transferred and initially immobilized by SVOCs and contained within the smear zone in the Oil House soil. Over time, as the PCBs partition from the SVOCs to the aqueous phase, anaerobic and aerobic bacteria are expected to degrade the PCBs. Neither SVOCs nor PCBs have been detected in groundwater directly downgradient from the Oil House petroleum groundwater plume. Institutional controls in place at Kaiser help to prevent the release of PCBs and other COCs into the environment by the Facility's industrial activities.

Cost. The NPV of implementing Alternative D2 over a 30-year time period, and based on a 7 percent discount rate, is estimated to total approximately $23.1 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 5.1.5 above and in the cost tables contained in Appendix D.

Effectiveness over the Long Term. It will take a long time for Alternative D2 to reach the PCUL of 0.000064 μg/L (adjusted up to 0.0045 μg/L, the MDL for modified Method 8082) established for a standard POC. If a conditional POC is established by Ecology, the restoration time frame will be reduced substantially.

Natural attenuation is expected to reduce PCB source area mass in smear zone soil over time. Approximately 45 percent of the mass (5.1 pounds) of PCBs is expected to be removed from smear zone soils below the Remelt building during the initial 30-year operating period of Alternative D2 (Table 5-4) and transferred to the Oil House area to initially be sequestered by SVOCs and biodegraded as the PCBs enter the aqueous phase. Institutional controls in place at Kaiser help to prevent the release of PCBs into the environment by the Facility's industrial activities.

The depth of the Remelt/Hot Line PCB plume and smear zone soil AOCs prevents Facility workers and visitors from directly contacting or ingesting PCBs in these locations.

Alternative D2 is expected to be protective over the long term. The existing containment (building roof, floor slabs, and other pavement), MNA, and institutional controls provided in Alternative D2, plus the new hydraulic containment of the plume and subsequent biodegradation of the PCBs as they are released by the SVOCs in the Oil House area prevent PCBs in the smear zone soils and the Remelt/Hot Line plume from reaching human or ecological receptors in the Spokane River.

The extracted PCB mass (approximately 5.1 pounds over 30 years) is expected to initially be immobilized by SVOCs and contained within the smear zone in the Oil House area. Over time, as the PCBs partition from the SVOCs to the aqueous phase, anaerobic and aerobic bacteria are expected to degrade the PCBs. The smear zone soil in the Oil House area is expected to contain quantities of SVOCs sufficient to immobilize, contain, and promote the biodegradation of PCBs for a long time to come (refer to Table 4-7 and Appendix F). The Oil House area plume is, in turn, contained by the IRM system. Thus, Alternative D2 in effect provides double containment of the PCBs that originate in the Remelt/Hot Line PCB plume.

Management of Short-Term Risks. This alternative will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Short-term risks associated with construction activities in Alternative D2 (for example, installing groundwater extraction wells) will be mitigated by their adherence to the HASP prepared to guide health and safety practices during the construction work.

The short-term risks associated with Alternative D2 include the following:

- Potential exposure of Facility workers and visitors to hazardous materials (e.g., handling items containing hazardous waste as part of executing BMPs); and

- Hazards to workers associated with the industrial activities taking place at locations within the Facility where these institutional controls are being implemented.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place at the Facility. The installation of new groundwater extraction wells has been employed at the Facility in the past and is a practice with which Kaiser is familiar.

Restoration Time Frame

The approach used to estimate the restoration time frame for Alternative D2 is discussed in Appendix I and summarized in Section 5.1.5. The estimated restoration time frame for PCBs in Alternative D2 for a standard POC and for a conditional POC (if a conditional POC is established by Ecology) are provided in Appendix I and range from up to 4 years if a conditional POC is established (based on the use of Method 8082 to measure groundwater PCB concentrations) to more than 340 years if the standard POC is used to establish cleanup criteria.

The factors used to determine whether Alternative D2 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) for PCBs are assessed below:

(i) Potential risks posed by the site to human health and the environment;

The direct contact and ingestion exposure pathways to Facility workers and visitors is mitigated by nature of the depth of the smear zone and groundwater plume AOCs; by the fact that groundwater from these AOCs is not used as a current drinking water source and will not be used in the future as a drinking water source (via a restrictive covenant); through natural attenuation, which has kept PCBs from reaching the Spokane River (based on the use of modified Method 8082 to measure groundwater PCB concentrations); and by the additional hydraulic containment that isolates the Remelt/Hot Line plume from the river and potentially impacting receptors there. If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above the PCUL of 0.000064 µg/L, Alternative D2 would still be able to meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

(ii) Practicability of achieving shorter restoration time frame;

The expected restoration time frame that Alternative D2 provides is compared to the other restoration time frames of remedial alternatives for the Remelt/Hot Line PCB plume in Section 5.3. No other alternative has a shorter restoration time frame than Alternative D2. An assessment of whether Alternative D2 uses permanent solutions to the maximum extent practicable is provided in Section 5.3.

(iii) Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

Releases from the Facility may pose risks to human and ecological receptors, and may potentially affect groundwater and the Spokane River. Alternative D2 includes physical and administrative controls, BMPs, natural attenuation, and containment of surface soil and groundwater to reduce the potential for worker exposure to PCBs and to reduce the potential for PCBs in smear zone soil and groundwater to migrate to the Spokane River. These controls are expected to effectively cut the pathways by which PCBs could reach potential human and ecological receptors.

(iv) Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

A restrictive covenant will limit future uses of the Facility. The Spokane River is likely to continue to be a potential source of receptors for releases from the Facility. PCBs have not been detected in wells near the river from the Remelt/Hot Line plume at concentrations above the MDL (based on the use of modified Method 8082 to measure groundwater PCB concentrations). If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above the PCUL of 0.000064 µg/L, Alternative D2 would still be able to meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

(v) *Availability of alternative water supplies;*

Alternative water supplies are abundant. A considerable amount of groundwater exists at the Facility that is outside of the footprint of the existing AOCs at the Facility. Kaiser also has secured access to this groundwater for domestic and industrial use through a water right.

(vi) *Likely effectiveness and reliability of institutional controls;*

The institutional controls implemented in Alternative D2 (refer to Sections 5.1.5) have been shown to be effective and reliable at the Facility. Most of these measures have been successfully used at the Facility for many years.

(vii) *Ability to control and monitor migration of hazardous substances from the site;*

The groundwater monitoring program at the Facility is governed by a Sampling and Analysis Plan (Hart Crowser 2007a), as amended (Kaiser 2010a), that has been approved by Ecology. A new monitoring plan will be developed to monitor the performance of this alternative if it is selected as the preferred alternative for the Remelt/Hot Line plume and associated smear zone soils at the Facility.

(viii) *Toxicity of hazardous substances at the site; and*

The toxicity of PCBs depends on their concentration and the duration of exposure to them. The implementation of Alternative D2 is expected to prevent these PCBs from reaching potential human or ecological receptors in the future (even if the future use of proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above 0.000064 µg/L.

(ix) *Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar conditions.*

An assessment of natural attenuation in groundwater at the Facility is provided in Appendix F. This assessment indicates that PCBs in the Remelt/Hot Line area that enter the aqueous phase may be amenable to bioremediation under both anaerobic and aerobic conditions. This natural attenuation is expected to be concentrated in locations near the source areas of the PCBs. Anaerobic degradation is expected to be focused on trichlorinated biphenyls and more highly chlorinated PCBs located near the source area (where negative ORPs are present). Anaerobic degradation is expected to eventually convert trichlorinated biphenyls and more highly chlorinated PCBs to mono- and bichlorinated biphenyls that can be degraded by aerobic bacteria. PCBs introduced to the Oil House area will initially be sequestered by the SVOCs that are present there. As these PCBs are released to the aqueous phase over time, the PCBs are expected to be biodegraded by anaerobic and aerobic bacteria.

The restoration time frame for Alternative D2 for PCBs in the Remelt/Hot Line area is judged to be reasonable as defined by WAC 173-340-360(4), if a conditional POC is established by Ecology.

The PCBs that are introduced to the Oil House area are expected to remain associated with FPP and SVOCs. The removal rate of FPP from the smear zone would be a factor in the restoration time frame for comingled PCBs that were originally present in the Oil House area, and the small quantity (5.1 pounds over 30 years) of PCBs that will be introduced to the area in Alternative D2. The presence of FPP would be indicated by the residual saturation default value of 2,000 mg/kg for petroleum hydrocarbons in soil. It can be assumed that comingled PCBs may still be present if the petroleum hydrocarbon concentration in the soil exceeds this default value, and that the estimated restoration time frame for existing comingled PCBs, and PCBs introduced in Alternative D2, may be associated with the time needed for the concentration of petroleum hydrocarbons in soil to decline to this value.

The estimated recovery time for FPP in Alternative C2 is estimated to be approximately 10 years in the Oil House area (refer to Section 4.1.3.4). The restoration time frame for comingled PCBs may be associated with these time frames for the removal of FPP. The PCUL for SVOCs in smear zone soil is 2,000 mg/kg, the default residual saturation value for diesel and heavy oil in soil. The restoration time frame for PCBs comingled with SVOCs may also be associated with the restoration time frame associated with SVOCs in smear zone soil and groundwater of 4 to 28 years. The concentration of SVOCs in smear zone soil is expected to be approximately 2,000 mg/kg at the end of this time period. However, considering the potential for non-recoverable product to remain in the subsurface (even if the concentration of SVOCs declines to below 2,000 mg/kg), the restoration time frame for comingled PCBs, and PCBs introduced in Alternative D2, may be longer.

The available evidence indicates that the estimated restoration time frame for PCBs that are comingled with SVOCs, and for the PCBs introduced in Alternative D2, will be approximately the same as the estimated restoration time frame for SVOCs alone. The restoration time frame for SVOCs was judged to be reasonable (refer to Section 4.2.2). The restoration time frame for PCBs that are introduced in Alternative D2 is also judged to be reasonable.

5.2.4 Evaluation of Remedial Alternative D3: Alternative D2 Plus Groundwater Extraction with Ex Situ Treatment

Alternative D3 adds *ex situ* treatment of the Remelt/Hot Line PCB plume to Alternative D2. Alternative D3 includes institutional controls, MNA, monitoring, hydraulic containment, and groundwater extraction with *ex situ* treatment. The purpose of Alternative D3 is to hydraulically contain the Remelt/Hot Line plume at the Facility, and to extract and treat the PCBs contained in the Remelt/Hot Line plume.

The capability of Alternative D3 to meet the cleanup requirements established by MTCA is summarized below.

5.2.4.1 Threshold Requirements

Protect Human Health and the Environment

The Remelt/Hot Line PCB plume and smear zone soil AOCs are located at depths that prevent Facility workers and visitors from direct contact with COCs in these areas. Institutional controls in place at the Facility include physical and administrative controls and BMPs that are currently being used to reduce the potential for worker exposure to PCBs. Institutional controls also include measures to prevent the potential release of PCBs to the environment through the industrial activities taking place at the Facility.

Operation of the groundwater extraction wells, as described in Section 5.1.5, contains the Remelt/Hot Line plume and prevents PCBs in the plume from reaching the Spokane River. An assessment of natural attenuation processes in groundwater at the Facility (refer to Section 5.1.4.1) indicates that natural attenuation of the PCBs in the Remelt/Hot Line plumes is occurring and that the leading edge of the plume has remained approximately 650 feet from the Spokane River. This FS defines the leading edge of the plume (refer to Section 5.1) as located in the vicinity of well HL-MW-32S, based on modified Method 8082 with a MDL of 0.0045 µg/L. The MDL for proposed EPA Method 1668 is expected to be below 0.0045 µg/L. It is not known as this FS is being prepared whether the weight of evidence of future analyses using proposed EPA Method 1668 (if promulgated and incorporated into the MTCA by Ecology) would show that that the PCUL of 0.000064 µg/L is being exceeded over time at the locations where groundwater enters the Spokane River.

Alternative D3 actively reduces the concentrations of PCBs in the Remelt/Hot Line plume AOC. Approximately 45 percent of the PCBs (5.1 pounds) thought to be present in smear zone soils below the Remelt building are expected to be removed from extracted groundwater by *ex situ* filtration and adsorption processes in 30 years. Used filters will be landfilled at the appropriate facility or incinerated, and spent carbon will be regenerated or incinerated. Typically, spent materials (filters or GAC) will be incinerated if PCB concentrations exceed Toxic Substances Control Act (TSCA) limits. Alternative D3 provides significant source control by capturing and destroying PCBs (through regeneration or incineration) in the Remelt/Hot Line plume.

Risk to human health is mitigated under Alternative D3 because of the depth of the impacted Remelt/Hot Line smear zone soil and groundwater AOCs (greater than 20 feet), the implementation of institutional controls (e.g., BMPs, restrictive covenant). In addition, the containment of the Remelt/Hot Line plume and the reduction in the PCB mass in the Remelt/Hot Line plume that occurs from groundwater extraction and *ex situ* treatment add to the overall reduction in risk. The risk to receptors that may extract and drink PCB-contaminated groundwater is controlled by the current practice that prohibits this activity at the Facility, and by a restrictive covenant that will be implemented to prohibit this activity in the future.

Comply with MTCA Cleanup Standards

The implementation of Alternative D3 will not result in compliance with MTCA cleanup requirements, or with ARARs promulgated by state and federal law, if a standard point of compliance is established throughout Facility soil and groundwater for a long time. The PCB PCUL for a standard POC is currently exceeded in the Remelt/Hot Line plume and smear zone soil AOCs identified on Figure 5-1. Alternative D3 will not directly reduce the concentration of PCBs in these AOCs for a long time.

The assumptions used to estimate the restoration time frame for Alternative D3 are described in Appendix I. If a standard POC is established, the estimated restoration time frame for Alternative D3 to reduce PCB concentrations in the Remelt/Hot Line plume to 0.0045 µg/L is approximately 170 years. It will take approximately 350 years for Alternative D3 to reduce PCB concentrations to below 0.000064 µg/L. If a conditional POC is granted, it is expected to take 4 years for the PCB concentration in the plume to reach the PCUL of 0.22 µg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I).

If the PCUL for a conditional POC is established as 0.000064 µg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 µg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 µg/L by the time the PCBs reach the Spokane River based on calculations presented in Appendices E and I). It is expected to take about 60 years for the PCB concentrations in smear zone soil to decline to these values. The hydraulic containment provided by Alternative D3 will prevent PCBs at concentrations above 0.000064 µg/L from reaching the Spokane River.

PCB concentrations in wells nearest to the river along the centerline of the Remelt/Hot Line PCB plume occasionally have low PCB detections using modified Method 8082. However, these detections are infrequent and recent PCB congener data using proposed EPA Method 1668 analysis in these wells indicate there may be an additional PCB source in the vicinity. This area in being currently investigated and will be included as an addendum to this FS in the future. For the purpose of this FS, the leading edge of the plume is considered to be stable and located 650 feet from the Spokane River.

Once cleanup standards have been established, compliance will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of Alternative D3.

MTCA provides additional requirements for permanent groundwater cleanup actions under WAC 173-340-360(2)(c)(i) and for nonpermanent groundwater cleanup actions under WAC 173-340-360(2)(c)(ii). These requirements are presented in detail for Alternative D1 in Section 5.2.2.1 and are summarized for Alternative D3 below.

WAC 173-340-360(2)(c)(i). It will take a long time for Alternative D3 to reach the PCUL for PCBs in groundwater of 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL for modified Method 8082) established for a standard POC. If a conditional POC is established by Ecology, the restoration time frame will be reduced substantially. This FS assumes that Ecology would consider the cleanup of groundwater at the Facility by Alternative D3 to be an acceptable nonstandard groundwater cleanup action.

WAC 173-340-360(2)(c)(ii). Alternative D3 does not consider the direct treatment of smear zone soil, but does implement an extensive series of measures to prevent leaks and spills within the Remelt complex (refer to Table 2-2) that could add PCBs to smear zone soils. Alternative D3 does prevent PCBs in smear zone soil from reaching human or ecological receptors. Alternative D3 implements hydraulic containment with *ex situ* treatment that, together with the ongoing natural attenuation at the Facility, is judged to be an effective containment system for the PCBs present in the Remelt/Hot Line plume and the smear zone soil associated with the plume.

Alternative D3 is expected to reduce the quantity of PCBs in the Remelt/Hot Line plume AOC by approximately 45 percent in 30 years. Groundwater containment will eliminate the possibility that the PCBs in the Remelt/Hot Line plume could reach the Spokane River. Alternative D3 is not expected to cause the concentration of PCBs in groundwater to fall below the PCB PCUL for a standard POC for a long time (over 340 years). Alternative D3 is judged to meet the threshold requirements established by WAC 173-340-360(2) for the Remelt/Hot Line PCB plume and associated smear zone soil.

Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternative D3, compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in Alternative D3 (WAC 173-340-720[9][c][vi]).

MTCA identifies several expectations for cleanup action alternatives (WAC 173-340-370). These expectations represent the types of cleanup actions that Ecology considers likely results of the remedy selection process described in WAC 173-340-350 through WAC 173-340-360; however, Ecology recognizes that there may be some sites where cleanup actions conforming to these expectations are not appropriate.

Ecology expects that natural attenuation of hazardous substances may be appropriate at sites where:

(a) Source control has been conducted to the maximum extent practicable;

As discussed in Section 5.1.6, source control is an important component of Alternative D3. Substantial upgrades to the Remelt building are underway with additional upgrades planned for the future (refer to Table 2-2). These source control measures will significantly reduce the potential for PCBs to enter smear zone soils. Alternative D3 also removes and treats PCBs from the Remelt/Hot Line plume.

(b) *Leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health and the environment;*

As discussed above, Alternative D3 is judged to be protective of human health and the environment (based on the current understanding of the plume).

(c) *There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and*

The leading edge of the Remelt/Hot Line plume appears to be stable (based on the use of modified Method 8082 to measure groundwater PCB concentrations) in the vicinity of well HL-MW-32-S, located about 650 feet from the Spokane River. The apparent stability of the plume at this location is evidence that natural attenuation of the plume has occurred and is continuing to occur. While there is considerable indication that the degradation of PCBs that are associated with the Remelt/Hot Line plume is occurring within the initial 500 feet of travel from the Remelt Building (refer to Appendix F), evidence to support this assertion must still be collected and assessed during the pilot testing phase of the cleanup.

(d) *Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.*

Monitoring is a component of Alternative D3 and is described in Section 5.1.4.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. Several action-specific ARARs were identified as being potentially applicable or relevant and appropriate to the implementation of Alternative D3 (refer to Appendix G, Tables G-3 and G-4).

Three additional state regulations authorized by state statutes are judged to be potentially applicable or relevant and appropriate to Alternative D3. The WAC citations for these potentially applicable or relevant and appropriate state statutes are (1) the Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC), (2) the State Waste Discharge Permit Program (Chapter 173-216 WAC), and (3) the UIC Program (Chapter 173-218 WAC). The UIC and Waste Discharge Permit programs require the use of AKART for discharges governed by their programs. The applicability, relevance and appropriateness of these regulations and of AKART to Alternative D3 is discussed below.

Groundwater Quality Standards (Chapter 173-200 WAC). This regulation does not apply to cleanup actions approved by Ecology under MTCA (WAC 173-200[010][3][c]); rather, groundwater cleanup standards are developed under WAC-173-340-720. The compliance of Alternative D3 with WAC 173-340-720 is discussed above. Thus, the Water Quality Standards are not applicable or relevant and appropriate to Alternative D3.

State Waste Discharge Permit Program (Chapter 173-216 WAC). The groundwater extracted by Alternative D3 will be treated by an *ex situ* treatment system. The treated effluent will be conveyed via underground piping to a location north of the Remelt building and be re-injected. The effluent discharged by Alternative D3 may be considered a waste material and will be re-injected into the subsurface. Thus, State Waste Discharge Program regulations may be applicable or relevant and appropriate to Alternative D3.

State Underground Injection Control Program (Chapter 173-218 WAC). The purpose of this statute is to (1) preserve and protect groundwater by preventing the discharge of fluids into UIC wells that will endanger groundwater, (2) to require the use of AKART to the discharge of fluids and waste fluids into the waters of the state, and (3) to prohibit the injection of fluids through wells except as authorized by this statute. The infiltration area may contain perforated pipes to distribute the water that is that is re-injected into the subsurface. Thus the State UIC Program may be applicable or relevant and appropriate to Alternative D4.

Use of AKART. The UIC Program, Waste Discharge Program, and Water Quality Standards for Groundwater specify the need for AKART treatment before a regulated discharge is introduced *into* the subsurface. The Remelt/Hot Line PCB plume is unique in the fact that it contains very low concentrations of PCBs and that it contains PCBs that are attached to colloids. The concentration of PCBs in the extracted groundwater is expected to be approximately 0.040 µg/L.

The PCBs in the Remelt/Hot Line plume likely consist of a small fraction of soluble PCBs and a larger fraction of PCBs adsorbed onto colloidal particles (refer to FSTM Section 6.2.1). While treatment with GAC is considered a presumptive remedy for the treatment of soluble PCBs, there is no presumptive remedy for the treatment of PCBs attached to colloidal particles. Ecology has acknowledged this and has recognized that bench- and pilot-scale tests will be required to demonstrate the effectiveness of the technologies that compose Alternative D3.

For a technology to be considered to be AKART, it must be known, available, and reasonable. There is no known treatment method for this dilute colloidal PCB plume. While the individual technical components of the treatment process proposed for Alternative D3 are available, they have never been used individually or together to capture colloidal PCBs at concentrations in the 0.050 µg/L range. Thus, because the treatment train has never been assembled for this use, it is not currently available. Pilot- and bench-scale testing will be required before the technologies are implemented.

Summary of ARARs Analysis. _The State Water Quality Standards (Chapter 173-200 WAC) do not apply to cleanup actions approved by Ecology under MTCA (WAC 173-200[010][3][c]); rather, groundwater cleanup standards are developed under WAC-173-340-720. The discharge under Alternative D3 is expected to need to comply with the substantive requirements of the UIC and Waste Discharge Programs. However, there are no known, available, and reasonable treatment technologies for the treatment of the very dilute colloidal PCBs that are present in the Remelt/Hot Line plume at the Facility. Bench- and pilot-scale studies will be required to determine the effectiveness of the proposed treatment.

Summary of Ability of Alternative D3 to Meet Threshold Requirements

Alternative D3 is protective of human health and the environment. The containment (of surface soil and groundwater plumes), MNA, institutional controls and *ex situ* treatment of PCBs provided in Alternative D3 prevent PCBs in the Remelt/Hot Line plume and associated smear zone soil from reaching human or ecological receptors. Alternative D3 complies with applicable state and federal laws, and provides for compliance monitoring. Alternative D3 is judged to meet the threshold requirements established by MTCA.

Alternative D3 meets the threshold requirement established by WAC 173-340-360 (2)(c)(ii)(A), with which Alternative D1 may not be compliant (if the future use of proposed EPA Method 1668 provides clear evidence that PCBs at concentrations above 0.000064 µg/L are entering the Spokane River from the Remelt/Hot Line plume).

5.2.4.2 Other Requirements

Other requirements that remedial alternatives must fulfill once they meet threshold requirements are defined by WAC 173-340-360(2)(b). These requirements include the use of permanent solutions to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]).

Use of Permanent Solutions to the Maximum Extent Practicable

The use of permanent solutions to the maximum extent practicable is a primary evaluation criterion for the remedial alternatives being considered for the Remelt/Hot Line PCB plume and associated smear zone soil. The specific criteria that must be addressed are specified in WAC 173-340-360(3)(f) and are discussed below.

Protectiveness. Natural attenuation has caused the leading edge of the Remelt/Hot Line plume AOC to remain approximately 650 feet from the Spokane River (based on the use of modified Method 8082 to measure PCB concentrations in groundwater) (see Section 5.1.4.1). Natural attenuation processes are expected to continue (Appendix F). Alternative D3 will actively remove and treat PCB mass in the Remelt/Hot Line groundwater plume. Alternative D3 is expected to remove approximately 2,300 grams (45 percent) of PCBs in 30 years.

Alternative D3 will not reduce the concentration of PCBs to levels below the PCUL in smear zone soil and the Remelt/Hot Line groundwater plume AOCs for a long time if a standard POC is established throughout Facility for soil and groundwater (Appendix I).

If a conditional POC is granted, it is expected to take 4 years for the PCB concentration in the plume to reach the PCUL of 0.22 µg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I).

If the PCUL for a conditional POC is established as 0.000064 µg/l, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 µg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 µg/L by the time the PCBs reach the River per calculations presented in Appendix E and I. It is expected to take about 60 years for the PCB concentrations in smear zone soil to decline to these values. The hydraulic containment provided by Alternative D3 will prevent PCBs at concentrations above 0.000064 µg/L from reaching the River.

The direct contact exposure pathway to Facility workers and visitors is mitigated by nature of the depth of the smear zone and groundwater plume AOCs and by the fact that groundwater from these AOCs will not be used as drinking water. Implementation of institutional controls protects Facility workers and visitors from exposure to PCBs and prevents future releases of PCBs to the environment.

PCBs in groundwater are prevented from reaching the Spokane River through hydraulic containment and because of the PCB removal by the *ex situ* treatment.

The hydraulic containment provided by Alternative D3 will also protect receptors in the Spokane River if the future use of proposed EPA Method 1668 determines that PCBs are reaching the river at concentrations above 0.000064 μg/L.

Permanence. Alternative D3 will reduce the toxicity and volume of PCBs by approximately 45 percent in the Remelt/Hot Line plume and the associated smear zone soil in approximately 30 years through groundwater extraction and *ex situ* treatment. Concentrations of PCBs in the soil and groundwater matrix are not expected to fall below the PCB PCUL for a standard POC a long time (over 340 years) through groundwater extraction. Natural attenuation processes are expected to continue, which will keep the remnant of the PCB plume downgradient of the extraction wells from reaching the Spokane River.

Cost. The NPV of implementing Alternative D3 over a 30-year time period to achieve concentrations for a standard POC is estimated to total approximately $50.2 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 5.1.6 above and in the cost estimate tables provided in Appendix D.

If a conditional POC is granted, the extracted water will be below the PCUL of 0.22 μg/L and below the concentration expected to be protective of the Spokane River based on the predicted attenuation that is estimated using the predictive equation described in Appendix E. The estimated concentration of PCBs that is expected to be protective of the receptors in the Spokane River at a distance of 2,900 feet is 0.325 μg/L (refer to Appendix E). If a conditional POC is granted, treatment would not be required to protect receptors at the river if the effluent from Alternative D3 is injected on the north side of the Remelt building at a distance of 2,900 feet from the river. A separate cost estimate for Alternative D3 designed to meet the PCB effluent concentration associated with a conditional POC was not prepared because the PCB concentration in extracted groundwater would be lower than the PCUL established for a conditional POC.

Effectiveness over the Long Term. Alternative D3 will reduce the concentration of PCBs in smear zone soil AOCs by approximately 45 percent in approximately 30 years. It will take a long time for Alternative D3 to reduce PCB concentrations in the Remelt/Hot Line plume to the PCUL of 0.000064 μg/L (adjusted up to 0.0045 μg/L, the MDL for modified Method 8082) established for a standard POC. If a conditional POC is established by Ecology, the restoration time frame will be reduced substantially.

The operation of the hydraulic containment system prevents the groundwater PCBs from being conveyed to the Spokane River by groundwater flow. The *ex situ* treatment of extracted groundwater removes PCBs in the Remelt/Hot Line plume. PCBs will be removed by filtration or GAC adsorption. Used filters will be disposed of at the appropriate landfill facility or incinerated, and spent GAC will be regenerated or incinerated. Regeneration or incineration will destroy adsorbed PCBs.

Institutional controls will be put into place that prohibit or limit activities that could interfere with the long-term integrity of the hydraulic containment system as well as prevent groundwater in the AOCs from being used as a drinking water source.

Alternative D3 is judged to be effective over the long term.

Management of Short-Term Risks. Short-term risks associated with Alternative D3 include worker exposure to contaminants during the installation of wells, underground piping, and the *ex situ* treatment system. Controls to protect workers will be defined in the HASP and implemented during construction and remediation activities. Short-term risks to construction workers during these activities will be mitigated by their adherence to the HASP.

Additional risks are associated with the storage and handling of coagulants and GAC, the regeneration of spent GAC, and disposal of used filter cartridges. Short-term risks will be mitigated by minimizing the quantities of potentially hazardous materials stored at the Facility and by adherence to the HASP, which is prepared to guide the health and safety aspects of these activities. The regeneration of spent GAC will be undertaken by a vendor permitted to perform this work. Used filter cartridges will be handled using the appropriate personal protective equipment (PPE) and disposed of at a permitted landfill facility.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. Groundwater extraction and *ex situ* treatment techniques have been used to successfully control and reduce risks from PCBs at other similar sites (FRTR 2010). It is expected that the substantive requirements of the UIC and State Waste Discharge programs will be needed to be meet to implement Alternative D3. Bench- and pilot-scale testing will be required for design and implementation of the *ex situ* groundwater treatment system to evaluate its technical implementability and its effectiveness in reducing the PCB concentration in treated groundwater to attain the PCB PCUL concentration.

Restoration Time Frame

The approach used to estimate the restoration time frame for Alternative D3 is discussed in Appendix I. If a standard POC is established, the estimated restoration time frame for Alternative D3 to reduce PCB concentrations in the Remelt/Hot Line plume to the modified Method 8082 MDL of 0.0045 μg/L is approximately 170 years; and approximately 350 years to reduce PCB concentrations to below 0.000064 μg/L. If a conditional POC is granted, it is expected to take 4 years for the PCB concentration in the plume to reach the PCUL of 0.22 μg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I).

If the PCUL for a conditional POC is established as 0.000064 μg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 μg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 μg/L by the time the PCBs reach the Spokane River. It is expected to take about 60 years for the PCB concentrations in smear zone soil to decline to these values. The hydraulic containment provided by Alternative D3 will prevent PCBs from reaching the Spokane River at concentrations above 0.000064 μg/L.

(i) Potential risks posed by the site to human health and the environment;

The direct contact and ingestion exposure pathways to Facility workers and visitors are mitigated by nature of the depth of the smear zone and groundwater plume AOCs; by the fact that groundwater from these AOCs is not used as a current drinking water source and will not be used in the future as a drinking water source (via a restrictive covenant); through natural attenuation, which has kept PCBs from reaching the Spokane River (based on the use of modified Method 8082 to measure groundwater PCB concentrations); by the additional hydraulic containment that isolates the Remelt/Hot Line plume from the river and potentially impacting receptors there; and by the *ex situ* treatment provided by Alternative D3. If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above the PCUL of 0.000064 μg/L, Alternative D3 would still be able to meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

(ii) Practicality of achieving a shorter restoration time frame;

The expected restoration time frame that Alternative D3 provides is compared to the other restoration time frames of remedial alternatives for the Remelt/Hot Line PCB plume in Section 5.3. No other alternative has a shorter restoration time frame than Alternative D3. An assessment of whether Alternative D3 uses permanent solutions to the maximum extent practicable is provided in Section 5.3

(iii) Current use of the site, surrounding area, and associated resources that are, or may be, affected by releases from the site;

Releases from the Facility may pose risks to human and ecological receptors, and may potentially affect groundwater and the Spokane River. Alternative D3 includes physical and administrative controls, BMPs, natural attenuation, and containment of surface soil and groundwater to reduce the potential for worker exposure to PCBs and to reduce the potential for PCBs in smear zone soil and groundwater to migrate to the Spokane River; and the *ex situ* treatment of extracted groundwater. These controls are expected to effectively cut the pathways by which PCBs could reach potential human and ecological receptors.

(iv) Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

A restrictive covenant will limit future uses of the Facility. The Spokane River is likely to continue to be a potential source of receptors for releases from the Facility. Although PCBs have infrequently been detected in wells near the river at low concentrations using modified Method 8082, these detections appear to be from a source near the river and not from the Remelt/Hot Line plume. Thus, the Remelt/Hot Line plume appears to be stable and is not reaching the river at concentrations above MDL based on the use of modified Method 8082 to measure groundwater PCB concentrations. If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above the PCUL of 0.000064 μg/L, Alternative D3 would still be able to meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

(v) Availability of alternative water supplies;

A considerable amount of groundwater exists at the Facility that is outside of the footprint of the Remelt/Hot Line PCB plume and other AOCs at the

Facility. Kaiser also has secured access to this groundwater for domestic and industrial use through a water right.

(vi) Likely effectiveness and reliability of institutional controls;

The institutional controls implemented in Alternative D3 (refer to Sections 2.1.1.1 and 2.1.1.2 and Tables 2-2 and 2-3) have been shown to be effective and reliable at the Kaiser Facility. Most of these measures have been successfully used at the Facility for many years.

(vii) Ability to control and monitor migration of hazardous substances from the site;

The groundwater monitoring program at the Kaiser Facility is governed by a Sampling and Analysis Plan (Hart Crowser 2007a), as amended (Kaiser 2010a) that has been approved by Ecology. A new monitoring plan will be developed to monitor the performance of this alternative if it is selected as the preferred alternative for the Remelt/Hot Line plume and associated smear zone soils at the Facility.

(viii) Toxicity of hazardous substances at the site; and

The toxicity of PCBs will depend on their concentration and the duration of exposure to them. The implementation of Alternative D3 is expected to prevent these PCBs from reaching potential receptors in the Spokane River in the future (even if the future use of proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above 0.000064 µg/L).

(ix) Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions.

Natural attenuation of PCBs by physical processes in the Remelt/Hot Line plume has been under way for many years (see Section 5.1.4.1). An assessment of natural attenuation in groundwater at the Facility is provided in Appendix F. This assessment indicates that PCBs in the Remelt/Hot Line area that enter the aqueous phase may be amenable to bioremediation under both anaerobic and aerobic conditions. This natural attenuation is expected to be concentrated in locations near the source areas of the PCBs. Anaerobic degradation is expected to be focused on trichlorinated biphenyls and more highly chlorinated PCBs located near the source area (where negative ORPs are present). Anaerobic degradation is expected to eventually convert trichlorinated biphenyls and more highly chlorinated

PCBs to mono- and bichlorinated biphenyls that can be degraded by aerobic bacteria.

As a result of this assessment, Alternative D3 is judged to have a reasonable restoration time frame.

5.2.5 Evaluation of Remedial Alternative D4: Alternative D1 Plus Ex Situ Groundwater Extraction with Ex Situ Treatment

Alternative D4 extracts and treats a portion of the Remelt/Hot Line PCB plume. Alternative D4 was added to this FS at the request of Ecology (Ecology 2011). As discussed previously, the leading edge of the plume is considered to be stable and located 650 feet from the Spokane River (refer to Section 5.1.2.1). It would not be necessary to hydraulically contain the entire PCB plume if the plume is stable. Alternative D4 was conceived as a means to reduce the concentration of PCBs in the smear zone soils of the Remelt building, based on current information that leads to the conclusion that the leading edge of the Remelt/Hot Line plume is stable.

The future use of proposed EPA Method 1668 to measure ultra-low PCB concentrations may indicate that PCBs are reaching the Spokane River at a concentration below 0.0045 µg/L, and perhaps below a concentration of 0.000064 µg/L. If this outcome occurs, Alternative D4 would not prevent the PCBs in the portion of the Remelt/Hot Line plume that is not treated from reaching the Spokane River.

The capability of Alternative D4 to meet the cleanup requirements established by MTCA is summarized below.

5.2.4.1 Threshold Requirements

Protect Human Health and the Environment

The Remelt/Hot Line PCB plume and smear zone soil AOCs are located at depths that prevent Facility workers and visitors from direct contact with COCs in these areas. Institutional controls in place at Kaiser include physical and administrative controls and BMPs that are currently being used to reduce the potential for worker exposure to PCBs. Institutional controls also include measures to prevent the potential release of PCBs to the environment through the industrial activities taking place at the Facility.

Smear zone soil is in contact with groundwater, allowing the transport of PCBs from soil in these AOCs into groundwater, which can potentially migrate to the

Spokane River. Recent groundwater monitoring indicates that the leading edge of the Remelt/Hot Line plume has remained at a location between wells HL-MW-32S and HL-MW-30S, about 650 feet from the Spokane River (see Section 5.1.2). PCBs from the Remelt/Hot Line plume have not been detected at the wells closest to the Spokane River at concentrations above the PCUL (refer to Table 4-2) of 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL for modified Method 8082). Additional source investigation is underway near the WDR to determine whether low, infrequent detections of PCBs in some of the vicinity wells are from a nearby source.

Source control under Alternative D4 relies on physical measures (existing floor slabs and paved surfaces, which would help prevent a future spill or leak from infiltrating into the ground) for smear zone soil and natural attenuation processes for both smear zone soil and the Remelt/Hot Line PCB plume.

Potential risks to the environment remain at the Facility, in that the soil to groundwater exposure pathway persists in the smear zone soil AOC. The risk to receptors in the Spokane River is reduced by Alternative D4 through extraction and *ex situ* treatment of a portion of the plume and through natural attenuation that has caused the edge of the plume (refer to Section 5.1) to be located near well HL-MW-32S (based on modified Method 8082 with a MDL of 0.0045 µg/L). PCBs from the Remelt/Hot Line plume have not been detected at monitoring wells near the river using modified Method 8082. The future use of proposed EPA Method 1668 to measure ultra-low PCB concentrations may indicate that PCBs are reaching the river at a concentration below 0.0045 µg/L, and perhaps below a concentration of 0.000064 µg/L. If PCBs are reaching the river at a concentration above 0.000064 µg/L, Alternative D4 would not be protective of receptors in the Spokane River.

Alternative D4 uses *ex situ* treatment to reduce the concentration of PCBs in the Remelt/Hot Line plume AOC. Approximately 12 percent (590 grams, 1.4 pounds) of the PCBs thought to be present in smear zone soils below the Remelt building are expected to be removed from extracted groundwater in Alternative D4 over 30 years. An additional 1190 grams (approximately) are expected to be transferred from smear zone soil to the groundwater and naturally attenuated as this groundwater flows to the Spokane River during this 30-year time period. Used filter cartridges will be landfilled at the appropriate facility or incinerated, and spent carbon will be regenerated or incinerated. Typically, spent materials (filters or GAC) will be incinerated if PCB concentrations exceed TSCA limits.

Risk to human health is mitigated under Alternative D4 because of the depth of the impacted Remelt/Hot Line smear zone soil and groundwater AOCs (greater than 20 feet). Additional actions to mitigate risks include:

- Implementation of institutional controls (e.g., BMPs, restrictive covenant);

- Natural attenuation of the plume that has kept its leading edge at a location approximately 650 feet from the Spokane River (based on the Method 8082 MDL of 0.0045 μg/L); and

- Reduction in the PCB mass in the Remelt/Hot Line plume that occurs as a result of groundwater extraction and *ex situ* treatment.

The risk to receptors that may extract and drink PCB-contaminated groundwater is controlled by the current practice that prohibits this activity, and by a legally binding restrictive covenant that will be implemented to prohibit this activity in the future at the Facility.

Comply with MTCA Cleanup Standards

The implementation of Alternative D4 will not result in compliance with MTCA cleanup requirements, or with ARARs promulgated by state and federal law, if a standard point of compliance is established throughout Facility soil and groundwater for a long time. The PCB PCUL for a standard POC is currently exceeded in the Remelt/Hot Line plume and smear zone soil AOCs identified on Figure 5-1.

However, if a conditional POC is established at the Facility, MTCA standards could be attained under Alternative D4 for groundwater in a shorter time period. This conclusion follows the same rationale that is presented for Alternative D1 in Section 5.2.2.1.

The leading edge of the Remelt/Hot Line plume is considered to be stable and located 650 feet from the Spokane River. The future use of proposed EPA Method 1668 to measure ultra-low PCB concentrations may indicate that PCBs are reaching the river at a concentration below 0.0045 μg/L, and perhaps below a concentration of 0.000064 μg/L. If PCBs are reaching the river at a concentration above 0.000064 μg/L, Alternative D4 would not meet the PCUL for a standard or conditional POC.

If a standard POC is established by Ecology, the estimated restoration time frame for Alternative D4 to reduce PCB concentrations in the Remelt/Hot Line plume to the modified Method 8082 MDL of 0.0045 μg/L is approximately 240 years; and approximately 490 years to reach 0.000064 μg/L.

If a conditional POC is granted, it is expected to take 5 years for the PCB concentration in the plume to reach the PCUL of 0.22 μg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I). If the PCUL for a conditional POC is established as 0.000064 µg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 µg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 µg/L by the time the PCBs reach the Spokane River as presented in calculations presented in Appendices E and I. It is expected to take about 80 years for the PCB concentrations in groundwater and smear zone soil to decline to these values.

Once cleanup standards have been established, compliance will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of Alternative D4.

MTCA provides additional requirements for permanent groundwater cleanup actions under WAC 173-340-360(2)(c)(i) and for nonpermanent groundwater cleanup actions under WAC 173-340-360(2)(c)(ii). These requirements are presented in detail for Alternative D1 in Section 5.2.2.1 and are summarized for Alternative D4 below.

WAC 173-340-360(2)(c)(i). It will take a long time for Alternative D4 to reach the PCUL for PCBs for groundwater of 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL for modified Method 8082) established for a standard POC. If a conditional POC is established by Ecology, the restoration time frame will be reduced substantially. This FS assumes that Ecology would consider the cleanup of groundwater at the Kaiser Facility by Alternative D4 to be an acceptable nonstandard groundwater cleanup action.

WAC 173-340-360(2)(c)(ii). Alternative D4 does not consider the direct treatment of smear zone soil, but does implement an extensive series of measures to prevent leaks and spills within the Remelt complex (refer to Table 2-2) that could add PCBs to smear zone soils. Alternative D4 does prevent PCBs in smear zone soil from reaching human or ecological receptors (based on the use of Method 8082 to measure groundwater PCB concentrations). Alternative D4 implements *ex situ* treatment that, together with the ongoing natural attenuation at the Facility, is judged to be an effective remedy for the PCBs present in the Remelt/Hot Line plume and the smear zone soil associated with the plume (based on the use of modified Method 8082 to measure groundwater PCB concentrations).

Alternative D4 is expected to remove and treat approximately 12 percent (590 grams, 1.4 pounds) of the PCBs in the Remelt/Hot Line plume AOC in 30 years by extraction and treatment of approximately 10 percent of the Remelt/Hot Line plume by volume. Alternative D4 is not expected to cause the concentration of PCBs in groundwater to fall below the PCB PCUL for a long time (over 480 years). Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternative D4, compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in Alternative D4 (WAC 173-340-720(9)(c)(vi).

MTCA identifies several expectations for cleanup action alternatives (WAC 173-340-370). These expectations represent the types of cleanup actions that Ecology considers likely results of the remedy selection process described in WAC 173-340-350 through WAC 173-340-360; however, Ecology recognizes that there may be some sites where cleanup actions conforming to these expectations are not appropriate.

Per WAC 173-340-370(7), Ecology expects that natural attenuation of hazardous substances may be appropriate at sites where:

(a) Source control has been conducted to the maximum extent practicable;

As discussed in Section 5.1.7, source control is an important component of Alternative D4. Substantial upgrades to the Remelt building are underway with additional upgrades planned for the future (refer to Table 2-2). These source control measures will significantly reduce the potential for PCBs to enter smear zone soils.

(b) Leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health and the environment;

As discussed above, Alternative D4 is judged to be protective of human health and the environment (based on the current understanding of the plume).

(c) There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and

The leading edge of the Remelt/Hot Line plume appears to be stable (based on the use of modified Method 8082) in the vicinity of well HL-MW-32-S, located about 650 feet from the Spokane River. The apparent stability of the plume at this location is evidence that natural attenuation of the plume has occurred and is continuing to occur. While there is considerable indication that the degradation of PCBs that are associated with the Remelt/Hot Line plume is occurring within the initial 500 feet of travel from the Remelt Building (refer to Appendix F), evidence to support this assertion must still be collected and assessed.

(d) *Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.*

Monitoring is a component of Alternative D4 and is described in Section 5.1.7.5.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. Several action-specific ARARs were identified as being potentially applicable of relevant and appropriate to the implementation of Alternative D4 (refer to Appendix G, Tables G-3 and G-4).

Alternative D4 involves extraction of approximately 300,000 gpd from one extraction well at the midpoint of the plume, west of the Remelt building. The extracted groundwater will be conveyed via an underground pipe to a treatment plant located in the West Landfill area. Treated effluent is to be injected north of the Remelt building.

Three additional state regulations authorized by state statutes are judged to be potentially applicable or relevant and appropriate to the operation of horizontal infiltration for Alternative D4. The WAC citations for these potentially applicable or relevant and appropriate state regulations are (1) the Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC), (2) the State Waste Discharge Permit Program (Chapter 173-216 WAC), and (3) the UIC Program (Chapter 173-218 WAC). The UIC and Waste Discharge Permit programs require the use of AKART for discharges governed by their programs. The applicability, relevance, and appropriateness of these regulations and of AKART to Alternative D4 is discussed below.

Groundwater Quality Standards (Chapter 173-200 WAC). This regulation is not applicable, nor is it relevant and appropriate, to cleanup actions approved by Ecology under MTCA (WAC 173-200-010[3][c]). Rather, Ecology has already determined that MTCA groundwater cleanup standards (WAC 173-340-720) apply to the implementation of Alternatives D1 through D4. The compliance of Alternative D4 with WAC 173-340-720 is discussed above.

State Waste Discharge Permit Program (Chapter 173-216 WAC). The groundwater extracted by Alternative D4 will be treated by an *ex situ* treatment system. The treated effluent will be conveyed via underground piping to a location north of the Remelt building and be re-injected. The effluent discharged by Alternative D4 may be considered a waste material and will be re-injected into the subsurface. Thus, State Waste Discharge Program regulations may be applicable or relevant and appropriate to Alternative D4.

State Underground Injection Control Program (Chapter 173-218 WAC). The infiltration area may contain perforated pipes to distribute the water that is re-injected into the subsurface. Thus, the State UIC Program regulations may be applicable or relevant and appropriate to Alternative D4.

Use of AKART. The UIC Program, Waste Discharge Program, and Water Quality Standards for Groundwater each specify the need for AKART before a regulated discharge is introduced into the subsurface. The Remelt/Hot Line PCB plume is unique in the fact that it contains very low concentrations of PCBs and that it contains PCBs that are attached to colloids. The concentration of PCBs in the extracted groundwater is expected to be approximately 0.085 μg/L.

The PCBs in the Remelt/Hot Line plume likely consist of a small fraction of soluble PCBs and a larger fraction of PCBs adsorbed onto colloidal particles (refer to FSTM Section 6.2.1). While treatment with GAC is considered a presumptive remedy for the treatment of soluble PCBs, there is no presumptive remedy for the treatment of PCBs attached to colloidal particles. Ecology has acknowledged this and has recognized that bench- and pilot-scale tests will be required to demonstrate the effectiveness of the technologies that compose Alternative D4.

For a technology to be considered to be AKART, it must be known, available, and reasonable. There is no known treatment method for this dilute colloidal PCB plume. While the individual technical components of the treatment process proposed for Alternative D4 are available, they have never been used individually or together to capture colloidal PCBs at concentrations in the 0.050 μg/L range. Thus, the treatment train has never been assembled for this use and is not currently available. Bench- and pilot-scale testing will be required before the technologies are implemented.

Summary of ARARs Analysis. The State Groundwater Quality Standards (Chapter 173-200 WAC) are not applicable, or relevant and appropriate to cleanup actions approved by Ecology under MTCA (WAC 173-200[010][3][c]); rather, groundwater cleanup standards are developed under WAC-173-340-720. The discharge under Alternative D4 may be required to comply with the substantive requirements of the UIC and Waste Discharge Programs. These programs may be applicable or relevant and appropriate to Alternative D4.

There are no known, available, and reasonable treatment technologies for the treatment of the very dilute colloidal PCBs that are present in the Remelt/Hot Line plume at the Kaiser Facility. Bench- and pilot-scale studies will be required to determine the effectiveness of the proposed treatment.

Summary of Ability of Alternative D4 to Meet Threshold Requirements

Alternative D4 is protective of human health and the environment, based on the current understanding of the stability of the Remelt/Hot Line plume. The containment (of surface soil and groundwater plumes), MNA, institutional controls and *ex situ* treatment of PCBs provided in Alternative D4 prevent PCBs in the Remelt/Hot Line plume and associated smear zone soil from reaching human or ecological receptors. Alternative D4 complies with applicable state and federal laws, and provides for compliance monitoring. Alternative D is judged to meet the threshold requirements established by MTCA.

Alternative D4 treats 10 percent of the Remelt/Hot Line plume. The remaining 90 percent of the plume continues to travel toward the Spokane River. Alternative D4 will not meet the threshold requirement established by WAC 173-340-360 (2)(c)(ii)(A), if the future use of proposed EPA Method 1668 to measure PCB concentrations in groundwater provides clear evidence that PCBs at concentrations above 0.000064 µg/L are entering the Spokane River from the Remelt/Hot Line plume.

5.2.4.2 Other Requirements

Other requirements that remedial alternatives must fulfill once they meet threshold requirements are defined by WAC 173-340-360(2)(b). These requirements include the use of permanent solutions to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]).

Use of Permanent Solutions to the Maximum Extent Practicable

The use of permanent solutions to the maximum extent practicable is a primary evaluation criterion for the remedial alternatives being considered for the Remelt/Hot Line PCB plume and associated smear zone soils. The specific criteria that must be addressed are specified in WAC 173-340-360(3)(f) and are discussed below.

Protectiveness. Natural attenuation has caused the leading edge of the Remelt/Hot Line plume AOC to remain approximately 650 feet from the Spokane River (see Section 5.1.4.1). Natural attenuation processes are expected to continue (Appendix F). Alternative D4 will actively remove PCBs in 10 percent of the Remelt/Hot Line plume. Alternative D4 is expected to remove approximately 590 grams (12 percent) of PCBs in the Remelt smear zone in approximately 30 years by groundwater extraction and *ex situ* treatment.

Alternative D4 will not reduce the concentration of PCBs to below the PCUL for a standard POC in smear zone soil and the Remelt/Hot Line plume AOCs for a long time if a standard POC is established throughout Facility for soil and groundwater (Appendix I).

If a conditional POC is granted, it is expected to take 5 years for the PCB concentration in the plume to reach the PCUL of 0.22 μg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I). If the PCUL for a conditional POC is established as 0.000064 μg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 μg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 μg/L by the time the PCBs reach the Spokane River as predicted by calculations in Appendix E and I. It is expected to take about 80 years for the PCB concentrations in groundwater and smear zone soil to decline to these values.

The direct contact exposure pathway to Facility workers and visitors is mitigated by nature of the depth of the smear zone and groundwater plume AOCs and by the fact that groundwater from these AOCs will not be used as drinking water. Implementation of institutional controls protects Facility workers and visitors from exposure to PCBs and prevents future releases of PCBs to the environment. PCBs in groundwater are prevented from reaching the Spokane River through the PCB removal by the *ex situ* treatment system and natural attenuation.

Permanence. Alternative D4 will reduce the toxicity and volume of PCBs by approximately 12 percent in the Remelt/Hot Line plume and the associated smear zone soil in approximately 30 years through groundwater extraction and *ex situ* treatment. Concentrations of PCBs in the soil and groundwater matrix are not expected to fall below the PCB PCUL for a standard POC (0.000064 μg/L) for a long time (over 480 years). Natural attenuation processes are expected to continue, which will keep the groundwater outside of the capture zone from reaching the Spokane River.

Cost. The NPV of implementing Alternative D4 over a 30-year time period to achieve concentrations for a standard POC is estimated to total approximately $27.0 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 5.1.7 above and in the cost estimate tables provided in Appendix D (Table D-6).

If a conditional POC is granted, the extracted water will be below the PCUL of 0.22 µg/L, and below the concentration expected to be protective of the Spokane River based on the predicted attenuation that is estimated using the predictive equation described in Section 5.1.4.2 (0.325 µg/L, refer to Appendix E). If a conditional POC is granted, treatment would not be required to protect receptors at locations upland from the river. A separate cost estimate for a conditional POC was not prepared because the PCB concentration in extracted groundwater would be lower than the PCUL established for a conditional POC.

Effectiveness over the Long Term. It will take a long time for Alternative D4 to reduce the PCB concentration in the Remelt/Hot Line plume to the PCUL of 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL for modified Method 8082) established for a standard POC. If a conditional POC is established by Ecology, the restoration time frame will be reduced substantially.

Alternative D4 will reduce the concentration of PCBs in smear zone soil AOCs by approximately 12 percent in approximately 30 years by extraction and treatment of 300,000 gpd. The *ex situ* treatment of extracted groundwater removes PCBs in the Remelt/Hot Line plume. PCBs will be removed by filtration or GAC adsorption. Used filters will be disposed of at the appropriate landfill facility or incinerated, and spent GAC will be regenerated or incinerated. Regeneration or incineration will destroy adsorbed PCBs.

Institutional controls will be put into place that prohibit or limit activities that could interfere with the long-term integrity of the hydraulic containment system as well as prevent groundwater in the AOCs from being used as a drinking water source.

Management of Short-Term Risks. Short-term risks associated with Alternative D4 include worker exposure to contaminants during the installation of wells, underground piping, and the *ex situ* treatment system. Controls to protect workers will be defined in the HASP and implemented during construction and remediation activities. Short-term risks to construction workers during these activities will be mitigated by their adherence to the HASP.

Additional risks are associated with the storage and handling of coagulants and GAC, the regeneration of spent GAC, and disposal of used filter cartridges. Short-term risks will be mitigated by minimizing the quantities of potentially hazardous materials stored at the Facility and by adherence to the HASP, which is prepared to guide the health and safety aspects of these activities. The regeneration of spent GAC will be undertaken by a vendor permitted to perform this work. Used filter cartridges will be handled using the appropriate PPE and disposed of at a permitted landfill facility.

Technical and Administrative Implementability. BMPs, groundwater monitoring, and institutional controls are already in place at the Kaiser Facility. Groundwater extraction and *ex situ* treatment techniques have been used to successfully control and reduce risks from PCBs at other similar sites (FRTR 2010). It is expected that the substantive requirements of the UIC and State Waste Discharge programs would be applicable or relevant and appropriate to the implementation of Alternative D4. Bench- and pilot-scale testing will be required for design and implementation of the *ex situ* groundwater treatment system to evaluate its technical implementability and its effectiveness in reducing the PCB concentration in treated groundwater to attain the PCB PCUL concentration.

Restoration Time Frame

The approach used to estimate the restoration time frame for Alternative D4 is discussed in Appendix I and summarized in Section 5.1.7.4. The time frame needed in Alternative D4 for remediation to occur through natural attenuation processes and through the operation of a *ex situ* treatment system will be long under a standard POC. The time frame needed for the concentration of PCBs in smear zone soil to fall below PCULs is also expected to be long (greater than 480 years).

If a conditional POC is granted, it is expected to take 5 years for the PCB concentration in the plume to reach the PCUL of 0.22 µg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I). If the PCUL for a conditional POC is established as 0.000064 µg/L, the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 µg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 µg/L by the time the PCBs reach the Spokane River as shown in Appendices E and I. It is expected to take about 80 years for the PCB concentrations in groundwater and smear zone soil to decline to this value.

Compliance with CULs are ultimately determined once the extraction system has been shut off. PCBs are not currently reaching the Spokane River from the Remelt/Hot Line plume at concentrations above the MDL for modified Method 8082 (0.0045 µg/L). The factors used to determine whether Alternative D4 provides for a reasonable restoration time frame (WAC 173-340-360[4][b]) follows:

(i) *Potential risks posed by the site to human health and the environment;*

The direct contact and ingestion exposure pathways to Facility workers and visitors is mitigated by nature of the depth of the smear zone and groundwater plume AOCs; by the fact that groundwater from these AOCs is not used as a current drinking water source and will not be used in the future as a drinking water source (via a restrictive covenant); through natural attenuation, which has kept PCBs from reaching the Spokane River (based on the use of modified Method 8082 to measure groundwater PCB concentrations), and by the *ex situ* treatment provided by Alternative D4. If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above the PCUL of 0.000064 μg/L, Alternative D4 would not be able to meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

(ii) *Practicality of achieving a shorter restoration time frame;*

The expected restoration time frame that Alternative D4 provides is compared to the other restoration time frames of remedial alternatives for the Remelt/Hot Line PCB plume in Section 5.3. Alternatives D2 and D3 have shorter restoration time frames than Alternative D4. An assessment of whether Alternative D4 uses permanent solutions to the maximum extent practicable is provided in Section 5.3.

(iii) *Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;*

Releases from the Kaiser Facility may pose risks to human and ecological receptors, and may potentially affect groundwater and the Spokane River. Alternative D4 includes physical and administrative controls, BMPs, natural attenuation, containment of surface soils to reduce the potential for worker exposure to PCBs and to reduce the potential for PCBs in smear zone soil and groundwater to migrate to the Spokane River (based on the use of modified Method 8082 to measure groundwater PCB concentrations), and the *ex situ* treatment of 10 percent of the Remelt/Hot Line plume. These controls have effectively cut the pathways by which PCBs could reach potential human and ecological receptors.

(iv) *Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;*

A restrictive covenant will limit future uses of the site. The Spokane River is likely to continue to be a potential source of receptors for releases from the

Facility. PCBs from the Remelt/Hot Line plume do not appear to have been detected in wells near the river. However, data from wells near the river appear to indicate a potential nearby source of PCBs that is being currently investigated.

(v) Availability of alternative water supplies;

Alternative water supplies are abundant. A considerable amount of groundwater exists at the Facility that is outside of the footprint of the existing AOCs at the Facility. Kaiser also has secured access to this groundwater for domestic and industrial use through a water right.

(vi) Likely effectiveness and reliability of institutional controls;

The institutional controls implemented in Alternative D4 (refer to Sections 2.1.1.1 and 2.1.1.2 and Tables 2-2 and 2-3) have been shown to be effective and reliable at the Facility. Most of these measures have been successfully used at the Facility for many years.

(vii) Ability to control and monitor migration of hazardous substances from the site;

The groundwater monitoring program at the Facility is governed by a Sampling and Analysis Plan (Hart Crowser 2007a), as amended (Kaiser 2010a) that has been approved by Ecology. A new monitoring plan will be developed to monitor the performance of this alternative if it is selected as the preferred alternative for the Remelt/Hot Line PCB plume and associated smear zone soils at the Facility.

(viii) Toxicity of hazardous substances at the site; and

The toxicity of PCBs depends on their concentration and the duration of exposure to them. The implementation of Alternative D4 is expected to prevent these PCBs from reaching potential human or ecological receptors in the future through extraction and treatment of PCBs and natural attenuation (based on the use of modified Method 8082 to measure groundwater PCB concentrations). If the future use of proposed EPA Method 1668 demonstrates that PCBs are now reaching the Spokane River at concentrations above 0.000064 μg/L, Alternative D4 would not protect the receptors in the river for a long time.

(ix) *Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions.*

Natural attenuation of PCBs by physical processes in the Remelt/Hot Line plume has been under way for many years (see Section 5.1.4.1). An assessment of natural attenuation in groundwater at the Facility is provided in Appendix F. This assessment indicates that PCBs in the Remelt/Hot Line area that enter the aqueous phase may be amenable to bioremediation under both anaerobic and aerobic conditions. This natural attenuation is expected to be concentrated in locations near the source areas of the PCBs. Anaerobic degradation is expected to be focused on tri- and more highly chlorinated biphenyls located near the source area (where negative ORPs are present). Anaerobic degradation is expected to eventually convert trichlorinated biphenyls and more highly chlorinated PCBs to mono- and bichlorinated biphenyls that can be degraded by aerobic bacteria.

As a result, of this assessment, Alternative D4 is judged to have a reasonable restoration time frame.

5.3 COMPARATIVE ANALYSIS OF ALTERNATIVES FOR THE REMELT/HOT LINE PCB PLUME AND ASSOCIATED SMEAR ZONE SOIL

Alternatives D1, D2, D3, and D4 are evaluated individually in Sections 5.2.2 through 5.2.5 using the evaluation criteria that are established by Ecology (WAC 173-340-360). The comparative analysis presented in this section assesses the relative capability of the alternatives for the treatment of PCBs in the Remelt/Hot Line plume and associated smear zone soil to meet threshold requirements; to use permanent solutions to the maximum extent practicable; and to provide a reasonable restoration time frame. A disproportionate cost analysis is used to determine whether a cleanup action uses permanent solutions to the maximum practicable extent. The disproportionate cost analysis procedure is summarized in Section 2.3.1.

Three technology-based remedial alternatives judged to be potentially applicable to PCBs in the Remelt/Hot Line plume and associated smear zone soil were identified, respectively, in Section 4.6.1 (Table 4-22) and in Section 6.4.1 (Table 6-9) of the FSTM (Hart Crowser 2012c).

A fourth remedial alternative, Alternative D4, is also evaluated in this FS. Alternative D4 extracts and treats a portion of the Remelt/Hot Line plume. Alternative D4 was conceived as a means to reduce the concentration of PCBs in the smear zone soils of the Remelt building, based on current information that leads to the conclusion that the leading edge of the Remelt/Hot Line plume is stable. Available data indicate the leading edge of the Remelt/Hot Line plume is considered stable and located 650 feet from the Spokane River (refer to Section 5.1.2.1). It would not be necessary to hydraulically contain the entire PCB plume under MTCA if the plume is stable.

These remedial alternatives are presented in Sections 5.1.4 through 5.1.7 of this FS and are summarized below:

- Alternative D1: Institutional Controls, Monitoring, and MNA;
- Alternative D2: Alternative D1 Plus Containment;
- Alternative D3: Alternative D2 Plus Groundwater Extraction with *Ex Situ* Treatment; and
- Alternative D4: Alternative D1 Plus Groundwater Extraction with *Ex Situ* treatment.

A comparative analysis of alternatives is applied to the PCBs present in the Remelt/Hot Line PCB plume and associated smear zone soil in the following section. The outcome of this comparative assessment of alternatives is summarized in Table 5-9.

5.3.1 Comparative Analysis of Alternatives Applicable to PCBs

Alternatives D1, D2, D3, and D4 are applicable to remediation of the PCB AOCs in the Remelt/Hot Line area and are evaluated in Sections 5.2.2 through 5.2.5. Alternatives D2, D3, and D4 involve the extraction of impacted groundwater, which is typically applied to groundwater treatment only; however, the extraction of groundwater from the PCB plume causes mass transport of PCBs from smear zone soil to groundwater, effectively reducing the mass of PCBs in smear zone soil.

The outcome of the comparative assessment of alternatives applicable to PCBs in the Remelt/Hot Line plume is summarized in Table 5-9. The comparative analysis of alternatives considers the relative ability of the alternatives to meet MTCA threshold requirements (WAC 173-340-360[2][a]), use permanent solutions to the maximum extent practicable (WAC 173-340-360[3]), and provide for a reasonable restoration time frame (WAC 173-340-360[4]). Public concerns (WAC 173-340-360[2][b][iii]) will ultimately be considered during the public comment period for this FS. Public acceptance was not used as a criterion to distinguish among the remediation alternatives evaluated in this FS. Selection of the preferred remediation alternative may be revised based on the results of the public review process. This criterion is not further addressed in this report.

5.3.1.1 Threshold Requirements

The capability of Alternatives D1 through D4 to meet threshold requirements is discussed in this section. MTCA threshold requirements are defined in WAC 173-340-360[2][a] and discussed in Section 2.2.1.1 of this FS.

Protect Human Health and the Environment

The depth of the Remelt/Hot Line PCB plume and associated smear zone soil AOCs (greater than 20 feet) eliminates the risk of direct exposure to these AOCs for Facility workers and visitors. Alternatives D1 through D4 each include physical and administrative controls and BMPs that will reduce worker exposure and potential future releases of PCBs into the environment. PCBs have not been used at the Facility since about 1971 (Hart Crowser 2012a).

PCB source control under Alternatives D1 through D4 relies on physical measures (e.g., existing floor slabs and paved surfaces) which help prevent a future spill or leak from infiltrating into the ground. These physical measures prevent water or chemical spills from reaching impacted soil in the smear zone.

The human direct contact or ingestion pathway to Facility workers and visitors is mitigated by Alternatives D1 through D4 because of the depth (greater than 20 feet) of the smear zone soil and groundwater plume AOCs; through implementation of institutional controls; and because the groundwater plume does not appear to reach surface water, based on the results of ongoing groundwater monitoring using modified Method 8082.

The soil to groundwater exposure pathway remains between smear zone soil and groundwater, but this impact to groundwater is mitigated through the groundwater natural attenuation processes occurring at the Facility that dissipate the plume before it reaches the Spokane River based on PCB concentrations measured using modified Method 8082. The smear zone in the Remelt/Hot Line area contains PCBs at an average concentration of approximately 0.07 mg/kg; or a total quantity of approximately 11.4 pounds of PCBs (refer to Table 1 of the Remelt/Hot Line PCB Restoration Time Frame memo included in Appendix I). Groundwater that flows through this smear zone has mobilized some of these PCBs and created the Remelt/Hot Line PCB plume.

An assessment of plume boundaries in groundwater at the Facility (Section 5.1.4.1) indicates that the leading edge of the Remelt/Hot Line plume has remained more than 650 feet from the Spokane River. This FS defines the leading edge of the plume (refer to Section 5.1) as located between wells HL-MW-30S and HL-MW-32S based on data obtained from modified Method 8082 with a MDL of 0.0045 µg/L. The MDL for proposed EPA Method 1668 (if promulgated) is expected to be in the 20 pg/L range. The proposed EPA Method 1668 has not been finalized under rule for use under the Clean Water Act and has not been incorporated into MTCA, and is under review as this FS is being prepared.

It is not known as this FS is being prepared whether the weight of evidence of future analyses using proposed EPA Method 1668 will show that that the PCUL of 0.000064 µg/L is being exceeded at the locations where groundwater enters the Spokane River. If the PCUL of 0.000064 µg/L is being exceeded over time at the locations where groundwater enters the river from the Remelt/Hot Line plume, only Alternatives D2 and D3 would protect receptors in the river. If the PCUL of 0.000064 µg/L is not being exceeded over time at the locations where groundwater enters the Spokane River from the Remelt/Hot Line plume Alternatives D1 through D4 would each protect receptors in the Spokane River.

The combined benefit of hydraulic containment and natural attenuation in Alternatives D2 and D3 greatly decreases the probability that PCBs at concentrations above the PCUL at the Facility are reaching the Spokane River.

Potential risks to the environment remain at the Facility, in that the soil to groundwater exposure pathway persists in the smear zone soil AOC. However, as described above, natural attenuation processes active at the Facility prevent PCBs from reaching the Spokane River in Alternatives D1 through D4 (based on the current MDL). The bulk of the mass of PCBs in the Remelt/Hot Line PCB plume and nearly all of the smear zone soil are beneath the floor slab of the Remelt building; these alternatives do not include additional measures to cut the rainfall to soil to groundwater exposure pathway that could convey PCBs from smear zone soil. This exposure pathway is not considered a significant pathway relative to the extent of PCB mobilization into groundwater caused by the seasonal fluctuation of the water table through smear zone soil.

Alternative D1 provides source control and ongoing natural attenuation to reduce the concentration of PCBs in smear zone soil and the quantity of PCBs in the plume. Alternative D1 is expected to remove approximately 1,500 grams (3.4 pounds) (30 percent of the mass) of PCBs from smear zone soils over a 30-year time frame. PCB concentrations in the Remelt plume are likely to exceed PCULs for standard POC for a long time. If a conditional POC is granted by

Ecology, concentrations are expected to decline below the PCUL for a conditional POC in approximately 6 years, while it is expected to take approximately 590 years to reduce the concentration of PCBs in the Remelt/Hot Line plume to 0.000064 µg/L.

The additional groundwater flux provided by Alternatives D2 and D3 is expected to remove approximately 2,300 grams (5.1 pounds, equivalent to 45 percent of the mass) of PCBs from smear zone soils over a 30-year time frame. PCB concentrations in the Remelt/Hot Line plume are likely to exceed the PCUL for a standard POC for a long time. If a conditional POC is granted by Ecology, concentrations are expected to decline below the PCULs (0.22 µg/L, 0.068 mg/kg) in approximately 4 years, while it is expected to take approximately 60 years to reduce the concentration of PCBs in the Remelt/Hot Line smear zone soils to 0.019 mg/kg.

Alternative D4 will extract about 10 percent by volume of the groundwater that will be extracted by Alternatives D2 and D3, as a result, Alternative D4 is expected to remove approximately 1,800 grams (3.9 pounds, equivalent to 34 percent of the mass) of PCBs from smear zone soils over a 30-year time frame. About 590 grams will be extracted and treated. If a conditional POC is granted by Ecology, PCB concentrations are expected to decline below the PCULs (0.22 µg/L, 0.068 mg/kg) in approximately 5 years, while it is expected to take approximately 80 years to reduce the concentration of PCBs in the Remelt/Hot Line smear zone soils to 0.019 mg/kg).

Alternatives D3 and D4 will employ *ex situ* treatment to remove PCBs from extracted groundwater, which will involve separation by filtration and adsorption processes. PCBs removed by the filtration and adsorption processes will ultimately either be destroyed (for example, as part of spent GAC regeneration) or will be contained off site in a controlled landfill facility, where spent PCB-containing filters will be disposed of. Alternative D2 will remove PCB mass from the Remelt/Hot Line PCB plume and smear zone soil AOCs at the same rate as in Alternative D3; however, this PCB mass will be transported to the SVOC smear zone in the Oil House area through infiltration of the extracted PCB-impacted groundwater. Because PCBs are hydrophobic (Hart Crowser 2012a) and have an affinity for petroleum hydrocarbons, the PCBs are expected to become adsorbed or sequestered by the SVOCs in the smear zone soil. PCBs may also be adsorbed in FPP and removed from the soil through belt skimming as described in Section 4.

The PCBs that are presently comingled with SVOCs (approximately 587,000 pounds) and the very small quantities of additional PCBs that will be introduced to the Oil House area in Alternative D2 (approximately 5.1 pounds), are expected to be biodegraded by anaerobic and aerobic microbes (refer to Appendix F).

An additional layer of protection is provided (in Alternative D2) to potential receptors in the Spokane River by the fact that the Oil House area groundwater plume will be contained by the operation of the IRM. Thus, potential receptors in the river are protected by:

- The ongoing natural attenuation processes that are degrading SVOCs and PCBs;

- Two levels of hydraulic containment that are provided by (1) the hydraulic containment of the Remelt/Hot Line plume and (2) the continued operation of the IRM to contain the PCBs currently in the Oil House area (approximately 587,000 pounds), and the very small quantity (5.1 pounds over 30 years) of PCBs that are added to the area by Alternative D2; and

- The removal of PCBs that are recovered with the FPP.

Another level of protection is provided by the natural attenuation of PCBs that has been demonstrated to be occurring at the Facility. The observed attenuation was modeled using regression analysis to predict concentrations at the river based on the empirical data. A curve fitting approach was used to develop an equation that would predict a concentration in the source area that would be protective of receptors in the Spokane River with the knowledge that attenuation is occurring as the groundwater travels from the source area to the river. A PCB concentration of 0.060 μg/L in the source area (2,300 feet upgradient of the river) was predicted to naturally attenuate to 0.000064 μg/L at the river and protect the receptors that may be present there. This predictive equation provides a conservative estimate of the natural attenuation of the PCBs in the Remelt/Hot Line plume. More information on the equation developed to predict the attenuation of PCBs in the Remelt/Hot Line plume is presented in Appendix E.

The recovered groundwater that would be added to the Oil House area by Alternative D2 is expected to have a PCB concentration of 0.040 μg/L (see Section 5.1.5). Thus, it is expected that the PCBs added to the Oil House area by Alternative D2 (approximately 5.1 pounds over 30 years) would not reach the Spokane River at a concentration above 0.00064 μg/L; even if they were not initially sequestered by the SVOCs in the Oil House area and eventually biodegraded as the PCBs enter the aqueous phase.

Alternatives D1 through D4 each: 1) include physical and administrative controls and BMPs that will reduce worker exposure and potential future releases of PCBs into the environment; and 2) rely on physical measures (existing floor slabs and paved surfaces, which would help prevent a future spill or leak from infiltrating into the ground) and reaching smear zone soil.

Alternatives D1 and D4 rely on natural attenuation of the Remelt/Hot Line plume that have kept the plume from reaching surface water based on the results of ongoing groundwater monitoring using modified Method 8082.

It is not known as this FS is being prepared whether the weight of evidence of future analyses using proposed EPA Method 1668 will show that that the PCUL of 0.000064 μg/L is being exceeded over time at the locations where groundwater enters the Spokane River. If the PCUL of 0.000064 μg/L is being exceeded over time at the locations where groundwater enters the river from the Remelt/Hot Line plume, only Alternatives D2 and D3 would protect receptors in the river. If the PCUL of 0.000064 μg/L is not being exceeded over time at the locations where groundwater enters the river from the Remelt/Hot Line plume; Alternatives D1 through D4 would each individually protect receptors in the Spokane River.

Alternatives D2 and D3 hydraulically contain the Remelt/Hot Line plume and will protect receptors at the river. Alternative D3 uses a treatment method that has not demonstrated to be effective for the conditions that are present at the Facility (e.g. large flow rates, very dilute concentrations of PCBs, colloidal PCBs). Bench- and pilot-scale tests will be needed to demonstrate that the treatment system can reduce PCB concentrations to the PCUL, and can be effectively operated at the high flow rates (3 MGD) required. Similarly, Alternative D2 hydraulically contains the Remelt/Hot Line plume. The PCBs in the water that is extracted are expected to be biodegraded when they are introduced to the Oil House area. Bench- and pilot-scale tests will be needed to demonstrate that biodegradation of PCBs in the Oil House area is occurring. Alternatives D2 and D3 are judged to be equally protective of human health and the environment.

Comply with MTCA Cleanup Standards

The implementation of Alternatives D1 through D4 will not result in compliance with MTCA cleanup requirements if a standard POC is established throughout Facility soil and groundwater for a long time. The PCB PCULs (refer to Tables 4-1 and 2-1) for a standard POC have been established by Ecology as 0.000064 μg/L (adjusted up to 0.0045 μg/L, the MDL for modified Method 8082) for groundwater and 0.0000199 mg/kg (adjusted up to 0.01 mg/kg, the MDL for standard Method 8082) for soil (Ecology 2010a). These PCULs are currently exceeded in the smear zone soil and Remelt/Hot Line plume AOCs identified on Figure 5-1.

However, if a conditional POC is established by Ecology, MTCA standards could be attained under Alternative D1 through D4 for the Remelt/Hot Line PCB plume in a shorter time frame. Under a conditional POC, the PCUL is 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL based on modified Method 8082) for groundwater at the point at which it flows into the river and 0.22 µg/L (adjusted down from 0.44 µg/L, the drinking water criterion to bring total cancer risk down to 0.5 x 10^{-5}) for groundwater everywhere else at the Facility (Ecology 2010a). The corresponding soil concentration is 0.068 mg/kg for PCBs in smear zone soils. It is expected to take from approximately 4 years (Alternatives D2 and D3) to 6 years (Alternative D1) for the PCB concentration in the plume to be less than 0.22 µg/L and the concentration of PCBs in soil in the Remelt area to decline to 0.068 mg/kg (Appendix I).

Compliance with the final groundwater CULs for Alternatives D2 through D4 will be determined when groundwater characteristics at the Facility are no longer influenced by the active pumping (WAC 173-340-720(9)(c)(vi).

MTCA provides additional requirements for permanent groundwater cleanup actions (WAC 173-340-360[2][c][ii]). This FS assumes that Ecology would consider Alternatives D1 through D4 to be acceptable non-permanent cleanup actions. Non-permanent treatment actions require that:

- *Treatment or removal of the source of release shall be conducted for liquid wastes, areas contaminated with high concentrations of hazardous substances, highly mobile hazardous substances, or hazardous substances that cannot be reliably contained; and*

- *Groundwater containment, including barriers or hydraulic control through ground water pumping, or both, shall be implemented to the maximum extent practicable.*

Alternatives D1 through D4 implement an extensive series of measures to prevent leaks and spills within the Remelt building (refer to Table 2-2) that could add PCBs to smear zone soil and prevent PCBs in smear zone soil from reaching human or ecological receptors. Ongoing natural attenuation at the Facility has prevented PCBs present in the Remelt/Hot Line plume and associated smear zone soil from reaching human or ecological receptors (based on the use of modified Method 8082 to measure groundwater PCB concentrations).

Alternatives D1 through D4 are judged protective of human health and the environment. The existing containment (building roof, floor slabs, and other pavement), MNA, and institutional controls provided prevent COCs in the smear zone soils and the Remelt/Hot Line plume (based on the use of modified Method 8082 to measure groundwater PCB concentrations) from reaching human or ecological receptors.

However, Alternative D1 does not employ hydraulic containment of the Remelt/Hot Line PCB plume, and Alternative D4 contains only 10 percent of the plume. If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above the PCUL of 0.000064 µg/L, Alternatives D1 and D4 would not meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

Alternatives D2 and D3 both implement hydraulic containment. For Alternative D2, hydraulic containment together with the ongoing natural attenuation at the Facility, is judged an effective treatment and containment system for the PCBs in the Remelt/Hot Line plume and the smear zone soil associated with the plume. The PCB mass contained in the extracted groundwater generated by the hydraulic containment system will be immobilized and contained within the SVOCs in smear zone soil in the Oil House area. These PCBs are expected to be attenuated by the natural processes that will anaerobically and aerobically degrade them as they are released by the SVOCs and enter the aqueous phase. In addition, the Oil House area groundwater plume will be contained by the operation of the IRM system, which contains the petroleum groundwater plume in the Oil House area.

Alternative D3 implements hydraulic containment and *ex situ* treatment, once verified during bench- and pilot-scale testing, is judged an effective treatment and containment system for the PCBs in the Remelt/Hot Line groundwater plume and the smear zone soil associated with the plume.

Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternative D2 and D4 , compliance with the final groundwater CULs established in the CAP will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken in the alternatives (WAC 173-340-720[9][c][vi]).

MTCA identifies several expectations for cleanup action alternatives (WAC 173-340-370). These expectations represent the types of cleanup actions that Ecology considers likely results of the remedy selection process described in WAC 173-340-350 through WAC 173-340-360. However, Ecology recognizes there may be some sites where cleanup actions conforming to these expectations are not appropriate.

Ecology (WAC 173-340-370[7]) expects that natural attenuation of hazardous substances may be appropriate at sites where:

(a) *Source control has been conducted to the maximum extent practicable;*

As discussed in Sections 5.1.3 through 5.1.7, source control is an important component of Alternatives D1 through D4. Substantial upgrades to the Remelt building are underway with additional upgrades planned for the future (refer to Table 2-2). These source control measures will significantly reduce the potential for PCBs to enter smear zone soils.

(b) *Leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health and the environment;*

Alternatives D1 through D4 are judged protective of human health and the environment (based on the current understanding of location of the leading edge of the Remelt/Hot Line plume).

(c) *There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site;*

The leading edge of the Remelt/Hot Line plume appears to be stable (based on the use of modified Method 8082 to measure groundwater PCB concentrations) in the vicinity of well HL-MW-32-S, located about 650 feet from the Spokane River. The apparent stability of the plume at this location is evidence that natural attenuation of the plume has occurred and is continuing to occur. While there is considerable indication that the degradation of PCBs that are associated with the Remelt/Hot Line plume is occurring within the initial 500 feet of travel from the Remelt building (refer to Sections 5.1.4 through 5.1.7), evidence to support this assertion must still be collected and assessed.

There are many indications that the degradation of PCBs that are associated with the SVOCs in the Oil House and Wastewater Treatment areas has occurred and is occurring (refer to Appendix F). Evidence to support these indications must still be collected and assessed.

(d) *Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.*

Monitoring is a component of Alternatives D1 through D4 and is described in Sections 5.1.4 through 5.1.7.

Summary of Compliance with MTCA Cleanup Standards. The implementation of Alternatives D1 through D4 will not result in compliance with MTCA cleanup requirements if a standard POC is established throughout Facility soil and groundwater for a long time. However, if a conditional POC is established by Ecology, MTCA standards could be attained under Alternative D1 through D4 for the Remelt/Hot Line PCB plume in a shorter time frame. It is expected to take from approximately 4 years (Alternatives D2 and D3) to 6 years (Alternative D1) for the PCB concentration in the plume to be less than the PCUL (0.22 µg/L) established by Ecology for a conditional POC.

MTCA provides additional requirements for permanent groundwater cleanup actions (WAC 173-340-360[2][c][ii]). This FS assumes that Ecology would consider Alternatives D1 through D4 to be acceptable non-permanent cleanup actions.

However, Alternative D1 does not employ hydraulic containment of the Remelt/Hot Line PCB plume, and Alternative D4 contains only 10 percent of the plume. If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above the PCUL of 0.000064 µg/L, Alternatives D1 and D4 would not meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

Alternatives D1 through D4 rely on natural attenuation as part of their treatment process. WAC 173-340-370(7) requires that there is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the Facility.

Alternatives D1 and D4 rely on the current understanding that the leading edge of the Remelt/Hot Line plume appears to be stable in the vicinity of well HL-MW-32-S, located about 650 feet from the Spokane River (based on the use of modified Method 8082 to measure groundwater PCB concentrations). The apparent stability of the plume at this location is evidence that natural attenuation of the plume has occurred and is continuing to occur. While there is considerable indication that the degradation of PCBs that are associated with the Remelt/Hot Line plume is occurring within the initial 500 feet of travel from the Remelt building (refer to Sections 5.1.4 through 5.1.7), evidence to support this assertion must still be collected and assessed during the pilot testing phase of the cleanup action.

While there are many indications that the degradation of PCBs associated with SVOCs in the Oil House and Wastewater Treatment areas has occurred and is occurring (refer to Appendix F), evidence to support these indications must still be collected and assessed.

Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs, and compliance with these ARARs is discussed above. Several action-specific ARARs were identified as being potentially applicable or relevant and appropriate to the implementation of Alternatives D1 through D4 (refer to Appendix G, Tables G-3 and G-4).

Three additional state regulations authorized by state statutes are judged to be potentially applicable or relevant and appropriate to Alternatives D2 through D4. The applicability of these regulations and of AKART are discussed below.

Groundwater Quality Standards (Chapter 173-200 WAC). This regulation is not applicable, nor is it relevant and appropriate, to cleanup actions approved by Ecology under MTCA (WAC 173-200-010[3][c]). Rather, Ecology has already determined that MTCA groundwater cleanup standards (WAC 173-340-720) apply to the implementation of Alternatives D1 through D4. The compliance with WAC 173-340-720 is discussed above for each alternative.

State Waste Discharge Permit Program (Chapter 173-216 WAC). The purpose of this regulation is to implement a state permit program applicable to the discharge of waste materials from industrial, commercial, and municipal operations into groundwater and surface water of the state and into municipal sewerage systems. The treated effluent produced in Alternatives D3 and D4 may be considered to be a waste material (WAC 173-216-030[19]). Thus, the reinjection of this treated effluent may be subject to a waste discharge permit.

Alternative D2 does not discharge *into* the subsurface. The conveyance piping is below ground. The infiltration area will not contain perforated pipes to distribute the water that is infiltrated. The surface of the earth is not pierced by the groundwater that is extracted in Alternative D2. As a result, the State Waste Discharge Program is not applicable to Alternative D2. The program also is not "relevant and appropriate" to Alternative D2 because it does not address problems or situations that are "sufficiently similar to those encountered at the site that [its] use is suited to the particular site (WAC 173-340-710[4]).

Moreover, the transfer of groundwater with PCB concentrations below the PCUL (0.22 μg/L) does not degrade water quality in the Oil House area. The dissolved oxygen injected with the water actually improves the water quality by enhancing aerobic biodegradation of SVOCs and PCBs.

State Underground Injection Control Program (Chapter 173-218 WAC). The infiltration area in Alternative D2 is not expected to contain perforated pipes to distribute the water that is discharged. Per WAC 173-218-050(4), infiltration trenches that do not contain perforated pipes are not considered UIC wells and are not regulated under WAC 173-218.

A UIC well is a well that is used to discharge fluids *into* the subsurface. This means that the discharge of fluids must break the surface of the ground to constitute a discharge *into* the waters of the state. The water extracted in Alternative D2 does not pierce the surface of the earth on its journey from the Remelt/Hot Line plume to the horizontal infiltration trench in the Oil House area. Thus, the horizontal infiltration area is not a UIC well, and the UIC program is not applicable.

For both of these reasons, the State Underground Injection Control Program is not applicable to Alternative D2. The program also is not "relevant and appropriate" to Alternative D2 because it does not address problems or situations that are "sufficiently similar to those encountered at the site that [its] use is suited to the particular site (WAC 173-340-710[4]). In fact, applying the UIC regulations to a system that is specifically exempted from the regulations would defeat the purpose of the exemption.

The water discharged under Alternatives D3 and D4 will break the surface of the earth to enter the aboveground treatment system and may use perforated pipes to infiltrate the effluent treated by the alternative. The UIC Program may be applicable or relevant and appropriate to Alternatives D3 and D4.

Use of AKART. The UIC Program, Waste Discharge Program, and Water Quality Standards for Groundwater each specify the need for AKART treatment before a regulated discharge is introduced *into* the subsurface. The Remelt/Hot Line PCB plume is unique in the fact that it contains very low concentrations of PCBs and that it contains PCBs that are attached to colloids. The concentration of PCBs in the groundwater extracted is expected to range from 0.040 to 0.085 μg/L.

Additionally, if a conditional POC is established by Ecology, the PCUL for PCBs in groundwater throughout the Facility will be 0.22 μg/L (220 ng/L). Thus, the groundwater that will contain PCBs at a concentration that is protective of drinking water.

The PCBs in the Remelt/Hot Line plume likely consist of a small fraction of soluble PCBs and a larger fraction of PCBs adsorbed onto colloidal particles (refer to FSTM Section 6.2.1). While treatment with GAC is considered a presumptive remedy for the treatment of soluble PCBs, there is no presumptive remedy for the treatment of PCBs attached to colloidal particles. Ecology has acknowledged this and has recognized that bench- and pilot-scale tests will be required to demonstrate the effectiveness of the technologies that compose Alternatives D3 and D4.

For a technology to be considered to be AKART, it must be known, available, and reasonable. There is no known treatment methods for this dilute colloidal PCB plume. While the individual technical components of the treatment process proposed for Alternatives D3 and D4 are available, they have never been used individually or together to capture colloidal PCBs at concentrations in the 0.050 μg/L range. The treatment train has never been assembled for this use and, therefore, it is not currently available. The cost of operating the treatment system is expected to be very high (refer to Sections 5.2.2.3 and 5.2.2.4) and not considered to be practicable (refer to Section 5.3), given the very small quantity of PCBs (5.1 pounds for Alternative D3 and 1.3 pounds for Alternative D4) that will be removed from the environment by the alternatives over a 30-year time period.

The Pollution Control Hearings Board (PCHB) has stated that a public agency could not require an applicant to develop a new technology to advance the art of emission control. The advance must be “known” in the sense that it has been tested and able to control emissions effectively and efficiently. Under this test, the public agency may not insist that an emission source be used as a proving ground for an as yet untried technology (PCHB 85-218). Ecology itself has relied on this PCHB decision in its NPDES Permit Writer's Manual to define AKART (See Manual at IV-36). This ruling by the PCHB, and Ecology's acknowledgment of its applicability in the AKART context, provide further support for the determination that requiring the treatment of the very dilute concentration of colloidal PCBs that are present in the Remelt/Hot Line plume does not represent AKART.

Summary of ARARs Analysis. The State Groundwater Quality Standards (Chapter 173-200 WAC) do not apply to cleanup actions approved by Ecology under MTCA (WAC 173-200[010][3][c]); rather, groundwater cleanup standards are developed under WAC-173-340-720. The UIC and Waste Discharge Programs are not applicable to Alternative D2 because there is no discharge *into* the subsurface or *into* waters of the state. Moreover, the infiltration system does not contain perforated pipe, so it is expressly exempt from regulation as a UIC well. Neither of these programs are "relevant and appropriate" to Alternative D2 because they do not address situations that are "sufficiently similar to those encountered at the site and that their use is well suited to the site." The discharges under Alternatives D3 and D4 may be required to comply with the substantive requirements of the UIC and Waste Discharge Programs. Finally, in accordance with PCHB authority that has been relied on by Ecology in the AKART context, there are no known, available, and reasonable treatment technologies for the treatment of the very dilute colloidal PCBs that are present in the Remelt/Hot Line PCB plume at the Kaiser Facility.

5.3.1.2 Disproportionate Cost Analysis

This disproportionate cost analysis identifies which alternatives use permanent solutions to the maximum extent practicable. Alternatives D1 through D4 meet the threshold requirements established by MTCA (based on the modified Method 8082 MDL of 0.0045 μg/L for PCBs).

Protectiveness

Alternatives D1 through D4 each: 1) include physical and administrative controls and BMPs that will reduce worker exposure and potential future releases of PCBs into the environment; 2) rely on physical measures (existing floor slabs and paved surfaces, which would help prevent a future spill or leak from infiltrating into the ground) and reaching smear zone soil.

Alternatives D1 and D4 rely on natural attenuation of the Remelt/Hot Line PCB plume that have kept the plume from reaching surface water (based on the results of ongoing groundwater monitoring using modified Method 8082).

It is not known as this FS is being prepared whether the weight of evidence of future analyses using proposed EPA Method 1668 will show that that the PCUL of 0.000064 μg/L is being exceeded over time at the locations where groundwater enters the Spokane River. If the PCUL of 0.000064 μg/L is being exceeded over time at the locations where groundwater enters the river from the Remelt/Hot Line plume, only Alternatives D2 and D3 would protect receptors in the river. If the PCUL of 0.000064 μg/L is not being exceeded over time at the locations where groundwater enters the River from the Remelt/Hot Line plume; Alternatives D1 through D4 would each protect receptors in the Spokane River.

Alternatives D2 and D3 hydraulically contain the Remelt/Hot Line plume and will protect receptors at the river. Alternatives D3 and D4 use a treatment method that has not demonstrated to be effective for the conditions that are present at the Facility (e.g. large flow rates, very dilute concentrations of PCBs, colloidal PCBs). Bench- and pilot-scale tests will be needed to demonstrate that the treatment system can reduce PCB concentrations to the PCUL, and can be effectively operated at the high flow rates (3 MGD for Alternative D3) required. Alternative D2 hydraulically contains the Remelt/Hot Line PCB plume. The PCBs in the water that is extracted are expected to be sequestered and biodegraded when they are introduced to the Oil House area. Bench- and pilot-scale tests will be needed to demonstrate that biodegradation of PCBs in the Oil House area is occurring.

Alternative D2 and D3 are judged to be equally protective of human health and the environment followed by Alternatives D4 and D1, in that order.

Permanence

Alternatives D2 through D4 do not directly treat the PCBs within smear zone soil, but the groundwater extraction process will cause mass transfer of PCBs from smear zone soil to groundwater. In 30 years, it is estimated that approximately 2,300 grams of PCBs (approximately 45 percent) will be extracted from smear zone soil in Alternatives D2 and D3. Alternative D4 is expected to extract and treat 590 grams (approximately 12 percent) of the PCBs in 30 years.

Alternatives D3 and D4 will employ *ex situ* treatment to remove PCBs from extracted groundwater, which will involve separation by filtration and adsorption processes. PCBs removed by the filtration and adsorption processes may ultimately either be destroyed (for example, as part of spent GAC regeneration) or will be contained off site in a controlled landfill facility, where spent PCB-containing filters will be disposed of.

Alternative D2 will remove PCB mass from the Remelt/Hot Line plume and smear zone soil AOCs at the same rate as Alternative D3; however, this PCB mass will be transported to the SVOC smear zone in the Oil House area through infiltration of the extracted PCB-impacted groundwater. Because PCBs are hydrophobic (Hart Crowser 2012a) and have an affinity for petroleum hydrocarbons, the PCBs are expected to initially become adsorbed or sequestered by the SVOCs in the smear zone soil. PCBs are expected to biodegrade as they partition from the SVOCs into the dissolved phase (Appendix F). PCBs may also be adsorbed in FPP and removed from the soil through belt skimming as described in Section 4.

Alternatives D2 and D3 hydraulically contain the Remelt/Hot Line plume and will protect receptors at the Spokane River. Alternative D3 uses a treatment method that has not demonstrated to be effective for the conditions that are present at the Kaiser Facility (e.g. large flow rates, very dilute concentrations of PCBs, colloidal PCBs). Bench- and pilot-scale tests will be needed to demonstrate that the treatment system can reduce PCB concentrations to the PCUL, and can be effectively operated at the high flow rates (3 MGD) required.

Similarly, Alternative D2 hydraulically contains the Remelt/Hot Line plume. The PCBs in the water that is extracted are expected to be biodegraded when they are introduced to the Oil House area. Bench- and pilot-scale tests will be needed to demonstrate that biodegradation of PCBs in the Oil House area is occurring.

Alternatives D2 and D3 are expected to remove more PCB mass from the smear zone in the Remelt/Hot Line area over 30 years than Alternatives D4 and D1. Alternatives D2 and D3 are judged to be more permanent than Alternative D4, and Alternative D4 is judged to be more permanent than Alternative D1.

Cost

The NPV of implementing Alternative D1 over a 30-year time period is estimated to total approximately $19.8 million (-35 to +50 percent).

The NPV of implementing Alternative D2 (Scenario D2b) over a 30-year time period is estimated to total approximately $23.1 million (-35 to +50 percent). The incremental cost of the benefit provided by the hydraulic containment system and the enhanced natural attenuation that is expected to result from the transfer of PCBs from the Remelt to the Oil House area presented in Alternative D2 is approximately $3.3 million. The mass of PCBs that will be hydraulically contained in the Remelt/Hot Line plume and transferred to the Oil House area where it will initially be sequestered and degraded as the PCBs partition to the aqueous phase, in 30 years, based on the daily flux of groundwater through the smear zone below the Remelt building, is approximately 2,300 grams (5.1 pounds) (see Section 5.1.6.4). Based on these values, the total cost of Alternative D2 per pound of PCBs removed from the Remelt/Hot Line plume is approximately $4.51 million per pound of PCB degraded.

The NPV of implementing Alternative D3 over a 30-year period is estimated to total approximately $50.2 million (-35 to +50 percent). The incremental costs of the *ex situ* treatment elements of Alternative D3, relative to Alternative D2 as a baseline cost, is $28.1 million. The mass of PCBs that will be disposed of at a lined permitted landfill or destroyed (through GAC regeneration or incineration) in groundwater and associated smear zone soil in this alternative is estimated to be 2,300 grams (5.1 pounds). Alternative D3 costs approximately $9.80 million per pound of PCB treated.

The NPV of implementing Alternative D4 over a 30-year period is estimated to total approximately $27.0 million (-35 to +50 percent). The incremental costs of the *ex situ* treatment elements of Alternative D3, relative to Alternative D1 as a baseline cost, is $7.2 million. The mass of PCBs that will be disposed of at a lined permitted landfill or destroyed (through GAC regeneration or incineration) in groundwater and associated smear zone soil in this alternative is estimated to be 590 grams (1.3 pounds). Alternative D4 costs approximately $20.7 million per pound of PCB treated. The assumptions used to prepare these estimates are described in Section 5.1 and listed in the cost tables contained in Appendix D.

Effectiveness over the Long Term

Alternatives D1 through D4 are expected to be effective over the long term. The existing containment (building roof, floor slabs, and other pavement), MNA, and institutional controls provided by Alternatives D1 through D4, will prevent PCBs in the Remelt/Hot Line PCB plume and smear zone soil from reaching human or ecological receptors in the Spokane River (based on the MDL of 0.0045 µg/L for modified Method 8082).

It will take a long time for Alternatives D1 through D4 to reduce the PCB concentration in the Remelt/Hot Line plume to the PCUL of 0.000064 µg/L under a standard POC. If a conditional POC is established by Ecology, the restoration time frame will be reduced substantially.

Approximately 30 percent of the mass (3.4 pounds) of PCBs is expected to be removed from the smear zone soils below the Remelt building during the initial 30-year operating period of Alternative D1. This mass is expected to be attenuated in the groundwater. Alternatives D2 and D3 are expected to remove approximately 45 percent of the mass (5.1 pounds). Alternative D4 is expected to remove approximately 34 percent of the mass (3.9 pounds) from the smear zone soils during a 30-year operating period. Of the mass transferred into the groundwater in Alternative D4, 1.3 pounds is expected to be extracted and treated, while 2.6 pounds is expected to naturally attenuate.

Alternatives D1 and D4 rely on natural attenuation of the Remelt/Hot Line PCB plume that has kept the plume from reaching surface water (based on the results of ongoing groundwater monitoring using modified Method 8082). Alternative D4 is judged to have a greater degree of long-term effectiveness than Alternative D1, since Alternative D4 uses *ex situ* treatment to destroy 1.3 pounds of PCBs and naturally attenuate 2.6 pounds; while Alternative D1 relies on natural attenuation (including biodegradation) to destroy or attenuate approximately 3.4 pounds of PCBs during a 30-year operating period.

It is not known as this FS is being prepared whether the weight of evidence of future analyses using proposed EPA Method 1668 will show that that the PCUL of 0.000064 µg/L is being exceeded over time at the locations where groundwater enters the Spokane River. If the PCUL of 0.000064 µg/L is being exceeded over time at the locations where groundwater enters the river from the Remelt/Hot Line plume, only Alternatives D2 and D3 would protect receptors in the river. If the PCUL of 0.000064 µg/L is not being exceeded over time at the locations where the groundwater enters the Spokane River from the Remelt/Hot Line plume; Alternatives D1 through D4 would each be expected to be effective over the long term.

Alternatives D2 and D3 hydraulically contain the Remelt/Hot Line plume and will protect receptors at the Spokane River. Alternative D3 includes a large degree of uncertainty that the treatment will be effective as it uses a treatment method that has not demonstrated to be effective for the conditions that are present at the Facility (e.g., large flow rates, very dilute concentrations of PCBs, colloidal PCBs). Bench- and pilot-scale tests will be needed to demonstrate that the *ex situ* treatment system will reduce PCB concentrations to the PCUL, and can be effectively operated at the high flow rates (3 MGD) required. Alternative D2 hydraulically contains the Remelt/Hot Line PCB plume. The PCBs in the groundwater that is extracted from the Remelt/Hot Line plume are expected to be biodegraded when they are introduced to the Oil House area. Bench- and pilot-scale tests will be needed to demonstrate that biodegradation of PCBs in the Oil House area is occurring.

Alternatives D2 and D3 are judged to be equally effective over the long term. Alternatives D2 and D3 add hydraulic containment and treatment (biodegradation, *ex situ* treatment) of the entire Remelt/Hot Line plume. Thus, they provide more long-term effectiveness than Alternatives D4 and D1. Alternative D4 is judged to be more effective over the long term than Alternative D1, since Alternative D4 uses *ex situ* treatment of approximately 10 percent of the Remelt/Hot Line plume to remove additional PCBs from the smear zone soil than would be removed by Alternative D1.

Management of Short-Term Risks

Alternatives D1 through D4 use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. The short-term risks associated with implementing existing and future institutional controls, BMPs and groundwater monitoring include:

- Potential exposure of Facility workers and visitors to hazardous materials (e.g. handling items containing hazardous wastes as part of executing BMPs); and

- Hazards to workers associated with the industrial activities taking place at locations where these institutional control and monitoring practices are taking place.

Short-term risks are associated with constructing the remedial alternatives. Alternatives D2 through D4 involve installation of groundwater extraction wells. Alternatives D3 and D4 present additional short-term risks associated with the construction and operation of the groundwater treatment system, and the handling, transportation, and regeneration or incineration of spent GAC. Alternatives D2 through D4 involve the installation of long runs of underground piping. Short-term risks to construction workers during the installation and/or execution of Alternatives D1 through D4 will be mitigated by their adherence to the HASP prepared to guide the health and safety aspects of this work. An experienced contractor will manage the removal, transportation, and regeneration or incineration of spent GAC.

Alternative D1 poses the fewest short-term risks. Alternative D3 involves the design and operation of a 3 MGD groundwater treatment system over a 30-year time period. Alternative D4 contains the same level of complexity as Alternative D3 but operates at a much smaller volume of 300,000 gpd. Alternative D2 poses fewer short-term risks than Alternatives D3 and D4 since it does not include the long-term operation of an *ex situ* treatment process that contains pH adjustment, coagulation and flocculation tanks, and many filter elements connected in series located before and after a GAC column. The malfunction of any one of these elements could shut down the system.

Alternative D3 presents the highest number and complexity of short-term risks. Alternative D4 presents fewer short-term risks than Alternative D3, but more short-term risk than Alternative D2. Alternative D1 presents the fewest short-term risks.

Technical and Administrative Implementability

Alternatives D1 through D4 include BMPs, groundwater monitoring, and institutional controls, which are already in place at the Facility. The installation of groundwater extraction wells (Alternatives D2 through D4) has been successfully employed at the Facility in the past and is a practice with which Kaiser is familiar. Hydraulic containment is currently being used at the Facility as part of the existing IRM System (see Section 4.1.1) and has been empirically demonstrated to be effective. The hydraulic containment included in Alternative D2 will be similar to the design and installation of the existing IRM system.

It is expected that the substantive requirements of the UIC and State Waste Discharge programs will need to be met to implement Alternatives D3 and D4.

The PCBs in the Remelt/Hot Line plume likely consist of a small fraction of soluble PCBs and a larger fraction of PCBs adsorbed onto colloidal particles (refer to FSTM Section 6.2.1). While treatment with GAC is considered a presumptive remedy for the treatment of soluble PCBs, there is no presumptive remedy for the treatment of PCBs attached to colloidal particles. Ecology has recognized that bench- and pilot-scale tests will be required to demonstrate the effectiveness of the technologies that compose Alternatives D3 and D4.

There is no known treatment method for this dilute colloidal PCB plume. While the individual technical components of the treatment process proposed for Alternatives D3 and D4 are available, they have never been used individually or together to capture colloidal PCBs at concentrations in the 0.050 µg/L range. The treatment train has never been assembled for this use and, therefore, it is not currently available.

Alternatives D1 and D4 are based on the current understanding of the Remelt /Hot Line plume and that the plume appears to be stable (based on the use of modified Method 8082) in the vicinity of well HL-MW-32-S, located about 650 feet from the Spokane River. The apparent stability of the plume at this location is evidence that natural attenuation of the plume has occurred and is continuing to occur. While there is considerable indication that the degradation of PCBs that are associated with the Remelt/Hot Line plume is occurring within the initial 500 feet of travel from the Remelt building (refer to Section 5.1.4), evidence to support this assertion must still be collected and assessed. An assessment of natural attenuation for PCBs is presented in Appendix F.

Alternative D2 transfers approximately 2,300 grams (5.1 pounds) of PCBs from the Remelt/Hot Line plume to the Oil House area where they will be initially comingled with the SVOCs that are present there. As the PCBs partition from the SVOCs to the aqueous phase, the PCBs are expected to be biodegraded by aerobic and anaerobic bacteria. While there are many indications that the degradation of PCBs that are associated with SVOCs in the Oil House and Wastewater Treatment areas has occurred and is occurring (refer to Appendix F), evidence to support these indications still must be collected and assessed.

Alternative D1 poses the fewest technical challenges. Alternative D3 involves the design and operation of a 3 MGD groundwater treatment system over a 30-year time period and poses serious technical issues. The ability of this system to meet MTCA requirements and produce an effluent that will achieve the PCULs for groundwater has not been demonstrated. Alternative D4 contains the same types of complexity as Alternative D3 but operates at 300,000 gpd rather than at 3 MGD.

Alternative D2 poses fewer technical challenges than Alternatives D3 and D4 since it does not include the long-term operation of a treatment system. The technical challenge associated with Alternative D2 relates to the need to conduct bench- and pilot-scale tests to collect evidence to support the presumption that the PCBs in the Oil House and Wastewater Treatment areas will be biodegraded once they partition from the SVOC to the aqueous phase.

Alternative D3 presents the highest number and complexity of technical implementability issues. Alternative D4 presents fewer technical implementability issues than Alternative D3, but more implementability issues than Alternative D2. Alternative D1 presents the fewest technical implementability issues.

Summary of Disproportionate Cost Analysis

Alternatives D1 through D4 meet the threshold requirements established by WAC 173-340-360(2)(a) and are protective of human health and the environment if the Remelt/Hot Line plume is judged to be stable. The current understanding of the plume indicates that PCBs are not reaching the Spokane River from the Remelt/Hot Line plume at concentrations above the PCUL (based on the MDL of 0.0045 μg/L).

The future use of proposed EPA Method 1668 to measure ultra-low PCB concentrations may indicate that PCBs reach the river at a concentration below 0.0045 μg/L, and perhaps above a concentration of 0.000064 μg/L. If the plume is determined to not be stable, Alternatives D1 and D4 would not meet the threshold requirement established by WAC 173-340-360(2)(a)(i)..

Alternatives D1 through D4 provide physical and administrative controls, BMPs, and natural attenuation and monitoring. The hydraulic containment provided in Alternatives D2 and D3 will further reduce the potential for PCBs in the Remelt/Hot Line plume and associated smear zone soil to migrate to the Spokane River if the Remelt/Hot Line plume is judged not to be stable. This reduction in potential risk to receptors in the Spokane River could occur in a short time frame (1 to 3 years) through the installation of the hydraulic containment system. If the PCUL of 0.000064 μg/L is not being exceeded over time at the locations where groundwater enters the Spokane River from the Remelt/Hot Line plume; Alternatives D1 through D4 would also protect receptors in the River.

Alternatives D2 and D3 hydraulically contain the Remelt/Hot Line PCB plume and will protect receptors at the river. Alternative D3 uses a treatment method that has not been demonstrated to be effective for the conditions that are present at the Facility (e.g. large flow rates, very dilute concentrations of PCBs, colloidal PCBs). Bench- and pilot-scale tests will be needed to demonstrate that the treatment system can reduce PCB concentrations to the PCUL and can be effectively operated at the high flow rates (3 MGD) required. Alternative D2 hydraulically contains the Remelt/Hot Line plume. The PCBs in the water that is extracted are expected to be biodegraded when they are introduced to the Oil House area. Bench- and pilot-scale tests will be needed to demonstrate that biodegradation of PCBs in the Oil House area is occurring. Alternatives D2 and D3 are judged to be equally protective of human health and the environment..

Alternatives D2 and D3 are expected to reduce PCB mass in groundwater through extraction over a long time. Alternatives D2 and D3 do not directly treat the PCBs within smear zone soil, but the groundwater extraction process will cause mass transfer of PCBs from smear zone soil to groundwater. In 30 years, it is estimated that approximately 2,300 grams of PCBs (approximately 45 percent) will be extracted from smear zone soil in Alternatives D2 and D3. Alternative D1 is expected to remove approximately 1,500 grams (approximately 30 percent) of PCBs from the Remelt smear zone over 30 years. Alternative D4 is expected to extract and treat 590 grams (approximately 12 percent) of PCBs in 30 years.

Alternatives D2 and D3 are judged to provide an equal degree of permanence . Alternatives D2 and D3 are expected to remove more PCB mass from the smear zone in the Remelt area over 30 years than Alternatives D4 and D1. Alternatives D2 and D3 are judged to be more permanent than Alternative D4, and Alternative D4 is judged to be more permanent than Alternative D1.

Alternatives D2 and D3 are judged to be equally effective over the long term. Alternatives D2 and D3 add hydraulic containment and treatment (biodegradation, *ex situ* treatment) of the entire Remelt/Hot Line plume. Thus, they provide more long-term effectiveness than Alternatives D4 and D1. Alternative D4 is judged to be more effective over the long term than Alternative D1, since Alternative D4 uses *ex situ* treatment of approximately 10 percent of the Remelt/Hot Line plume to remove additional PCBs from the smear zone soil than would be removed by Alternative D1.

Alternative D1 poses the fewest short-term risks. Alternative D3 involves the design and operation of a 3 MGD groundwater treatment system over a 30-year time period. Alternative D4 contains the same level of complexity as Alternative D3 but operates at 300,000 gpd. Alternative D2 poses fewer short-term risks than Alternatives D3 since it does not include the long-term operation of a treatment process that contains pH adjustment, coagulation and flocculation tanks, and many filter elements connected in series located before and after a GAC column.

Alternative D3 presents the highest number and complexity of short-term risks. Alternative D4 presents fewer short-term risks than Alternative D3, but more short-term risk than Alternative D2. Alternative D1 presents the fewest short-term risks.

Alternative D1 poses the fewest technical challenges. Alternative D3 involves the design and operation of a 3 MGD groundwater treatment system over a 30-year time period and poses serious technical issues. The ability of this system to meet MTCA requirements and produce an effluent that will achieve the PCULs for groundwater has not been demonstrated. Alternative D4 contains the same level of complexity as Alternative D3 but operates at 300,000 gpd rather than at 3 MGD. Alternative D2 poses fewer technical challenges than Alternatives D3 and D4 since it does not include the long-term operation of a treatment system. The technical challenge associated with Alternative D2 relates to the need to conduct bench- and pilot-scale tests to collect evidence to support the presumption that the PCBs in the Oil House and Wastewater Treatment areas will be biodegraded once they partition from the SVOC to the aqueous phase.

Alternative D3 presents the highest number and complexity of technical implementability issues. Alternative D4 presents fewer technical implementability issues than Alternative D3, but more implementability issues than Alternative D2. Alternative D1 presents the fewest technical implementability issues.

The benefits of each alternative must be compared to the costs associated with the alternative. The NPV of implementing Alternatives D1 through D4 over a 30-year time period (-35 to +50 percent) is summarized below and is presented in Tables 5-9 and D-1.

Two comparisons of costs and benefits are appropriate for the alternatives evaluated for the Remelt/Hot Line PCB plume;

- A comparison of benefits and costs based on the current understanding that the leading edge of the Remelt/Hot Line plume is stable and located approximately 650 feet from the Spokane River (based on the MDL of 0.0045 µg/L); and

- A comparison of benefits and costs that assumes that the future use of proposed EPA Method 1668 to measure ultra-low PCB concentrations may indicate that PCBs enter the Spokane River at a concentration below 0.0045 µg/L, and perhaps above a concentration of 0.000064 µg/L.

Comparison of Costs and Benefits Based on the Current Understanding of the Remelt/Hot Line Plume. Alternatives D1 through D4 are judged to meet threshold requirements based on the current understanding that the leading edge of the Remelt/Hot Line plume is stable and located approximately 650 feet from the Spokane River (based on the MDL of 0.0045 µg/L). Alternatives D2 and D3 are judged to provide the same degree of protectiveness, permanence, and long-term effectiveness; and to be more protective and provide for greater long-term effectiveness than Alternatives D4 and D1. Alternative D4 is judged to be more be more protective and provide for greater long-term effectiveness than Alternative D1. Alternative D3 is judged to provide the greatest number and complexity of short-term risks to human health and the environment and the greatest number and complexity of technical and administrative challenges; followed by Alternatives D4, D2, and D1, in that order.

Since Alternatives D1 through D4 each meet threshold requirements and are judged to be protective of human health and the environment, the incremental cost of the additional benefits provided by Alternatives D2, D3, and D4 were assessed. Alternatives D2 and D3 are judged to provide the same degree of protectiveness, permanence, and long-term effectiveness, while Alternative D3 provides the greatest number and complexity of short-term risks to human health and the environment and a greater number and complexity of technical and administrative challenges. Yet the incremental cost of Alternative D3 (approximately $ 27 million) is much higher than the incremental cost of Alternative D2 (approximately $ 3.3 million).

The incremental cost of Alternative D3 compared to the incremental cost of Alternative D2 is judged to be disproportionate to the incremental benefits provided by Alternative D3. Both alternatives have similar degrees of permanence, protectiveness, and long-term effectiveness, but Alternative D3 is expected to be more difficult to implement and produce more short-term risks than Alternative D2.

Alternative D4 is judged to be more protective and to provide for greater long-term effectiveness than Alternative D1. Alternative D4 is judged to provide a greater number and complexity of short-term risks to human health and the environment and a greater number and complexity of technical and administrative challenges than Alternative D1. Alternative D4 is judged to provide more permanence than Alternative D1. The incremental cost of Alternative D4 (approximately $ 7.2 million) is much higher than the incremental cost of Alternative D1 (the base case). The incremental cost of Alternative D4 compared to the baseline cost of Alternative D1 is judged to be disproportionate to the benefits that Alternative D4 provides.

Alternative D2 provides substantial additional benefits compared to Alternative D1, at an incremental cost of approximately $3.3 million. Based on current regulatory conditions and available Facility data, the benefits of Alternative D2 do not provide for any additional protection to the receptors on the Facility or to potential receptors in the Spokane River and the additional costs associated with the implementation of Alternative D2 are judged to be disproportionate to these benefits of Alternative D1.

However, because of the uncertainty associated with a possible PCB source near the river (being investigated), uncertainty in the PCB standard that may be applied to groundwater at the Facility in the future, and the uncertainty in the continued stability of the PCB plume, Alternative D2 is selected as the remedial alternative for Remelt/Hot Line plume at the Kaiser Facility based on our current understanding of the Remelt/Hot Line plume.

Comparison of Costs and Benefits if Proposed EPA Method 1668 is Used in the Future. If the PCUL of 0.000064 µg/L is being exceeded over time at the locations where groundwater enters the Spokane River from the Remelt/Hot Line plume, only Alternatives D2 and D3 would meet MTCA threshold requirements and protect receptors in the river.

As discussed above, the incremental cost of Alternative D3 compared to the incremental cost of Alternative D2 is judged to be disproportionate to the additional benefits that Alternative D3 provides. Alternative D2 is selected as the remedial alternative that uses permanent solutions to the maximum extent practicable, for the Remelt/Hot Line plume and its associated smear zone soil if the future use of proposed EPA Method 1668 to measure ultra-low PCB concentrations indicates that PCBs reach the Spokane River at a concentration above 0.000064 µg/L.

5.3.1.3 Restoration Time Frame

Remedial alternatives must provide for a reasonable restoration time frame per WAC 173-340-360(2)(b)(ii). A number of factors are considered to determine whether an alternative provides for a reasonable restoration time frame (WAC 173-340-360[4][b]), which are individually assessed for Alternatives D1 though D4 in Sections 5.2.2 through 5.2.5. Restoration time frame calculations are described in more details in Appendix I.

For a standard POC, the alternatives are expected to take a long time to reduce the concentration of PCBs the Remelt/Hot Line plume to a PCUL of 0.000064 μg/L.

If a conditional POC is granted, the concentration of PCBs remaining in the source area below the Remelt building is expected to be reduced to below 0.068 mg/kg; and the PCB concentration in the groundwater plume is expected to be below the PCUL (0.22 μg/L) in approximately 4 (Alternatives D2 and D3) to 6 (Alternative D1) years.

Based on predicted attenuation (Appendix E), the concentration in the Remelt/Hot Line plume at the Remelt building that would be protective of 0.000064 μg/L at the Spokane River is estimated to be 0.060 μg/L. It is expected to take approximately 100 and 80 years for Alternatives D1 and D4, respectively, to reduce the concentration of the plume in the Remelt building to 0.060 μg/L. (Appendix I). It is expected to take approximately 60 years for Alternatives D2 and D3 to reduce the concentration of PCBs in the Remelt/Hot Line plume at the Remelt building to 0.060 μg/L. During this time, the containment system provided in Alternatives D2 and D3 will prevent PCBs from reaching the Spokane River at concentrations above the 0.000064 μg/L.

Alternatives D2 and D3 are expected to reduce the PCB concentration in the Remelt/Hot Line plume to a PCB PCUL of 0.000064 μg/L in groundwater approximately 40 years faster than Alternative D1 and 20 years faster than Alternative D4. If a conditional POC is granted, and the PCUL for groundwater in the plume is established at a PCUL 0.22 μg/L, Alternatives D1 through D4 are each expected to take less than 10 years to reduce PCB concentration in the plume to this PCUL.

5.3.1.4 Summary of the Comparison of Remedial Alternatives for the Remelt/Hot Line PCB Plume

If the Remelt/Hot Line PCB plume is considered to be stable, Alternatives D1 through D4 are each judged to meet threshold requirements established by

MTCA. Although Alternative D1 was judged to be the alternative that used permanent solutions to the maximum extent practicable, it is not selected as the best alternative for the Remelt/Hot Line PCB plume at the Facility. Alternative D2 provides more certainty in that this alternative actively contains the groundwater PCB plume while Alternative D1 does not. For example, if the leading edge of the Remelt/Hot Line plume is determined to be unstable and enters the Spokane River at concentrations that are not protective of the potential receptors, only Alternatives D2 and D3 will meet MTCA threshold requirements. In such a case, Alternative D2 is judged to be the alternative that used permanent solutions to the maximum extent practicable for this case. Since the implementation of Alternatives D2 and D3 result in the same expected restoration time frame, Alternative D2 is judged to be the most appropriate alternative based on the presumption that the future use of proposed EPA Method 1668 will result in a PCUL of 0.000064 μg/L and that groundwater is reaching the Spokane River from the Remelt/Hot Line plume at concentrations higher than the PCUL.

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Table 5-1 - PCB Results for Groundwater near Leading Edge of PCB Plume

Sample ID	Date	Units	Aroclor-1016	Aroclor-1016/1242	Aroclor-1016/1242/1248	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1242/1248	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
HL-MW-30S	7/24/2007	ng/L	4.8 U			9.6 U	4.8 U	160 JP		4.8 U	4.8 U	4.8 U			160 JP
HL-MW-30S	10/24/2007	ng/L	4.8 U			9.6 U	4.8 U	110 P		4.8 U	4.8 U	4.8 U			110
HL-MW-30S	1/25/2008	ng/L	4.9 U			9.8 U	4.9 U	120		4.9 U	4.9 U	4.9 U			120
HL-MW-30S	4/23/2008	ng/L	5 U			9.9 U	5 U	100 JP		5 U	5 U	5 U			100 JP
HL-MW-30S	7/24/2008	ng/L	4.9 U			9.8 U	4.9 U	150		4.9 U	4.9 U	4.9 U			150
HL-MW-30S	10/19/2008	ng/L	5 U			10 U	5 U	120 JP		5 U	5 U	5 U			120 JP
HL-MW-30S	1/21/2009	ng/L	5 U			10 U	5 U	140		5 U	5 U	5 U			140
HL-MW-30S	4/22/2009	ng/L	5 U			10 U	5 U	170		5 U	5 U	5 U			170
HL-MW-30S	7/23/2009	ng/L	5 U			10 U	5 U	140		5 U	5 U	5 U	5 U	5 U	140
HL-MW-30S	10/19/2009	ng/L	5 U			9.9 U	5 U	110		5 U	5 U	5 U			110
HL-MW-30S	2/4/2010	ng/L	5 U			10 U	5 U	190		5 U	5 U	5 U			190
HL-MW-30S	4/22/2010	ng/L	5 U			10 U	5 U	180		5 U	5 U	5 U	5 U	5 U	180
HL-MW-30S	5/20/2010	ng/L	4.9 U			9.8 U	4.9 U	220		4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	220
MW-17S	9/12/2001	ng/L	5 U			5 U	5 U	5 U		5 U	5 U	5 U			5 U
MW-17S	12/5/2001	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-17S	3/19/2002	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-17S	6/25/2002	ng/L	5.2 U			11 U	5.2 U	17		5.2 U	5.2 U	5.2 U			17
MW-17S	9/25/2002	ng/L	5.1 U			11 U	5.1 U	5.1 U		5.1 U	5.1 U	5.1 U			11 U
MW-17S	12/18/2002	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-17S	5/13/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-17S	9/2/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-17S	10/22/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-17S	3/4/2004	ng/L	4.9 U			9.7 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.7 U
MW-17S	6/29/2004	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-17S	10/25/2004	ng/L	5 U			17 U	5 U	5 U		5 U	5 U	5 U			17 U
MW-17S	7/28/2005	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-17S	10/26/2005	ng/L	4.9 U			9.7 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.7 U
MW-17S	1/25/2006	ng/L	4.9 U			9.7 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.7 U
MW-17S	4/21/2006	ng/L	11 U			15 U	23 U	14 U		12 U	4.9 U	4.9 U			23 U
MW-17S	7/18/2006	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-17S	10/27/2006	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-17S	2/1/2007	ng/L	4.9 U			9.7 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.7 U
MW-17S	4/17/2007	ng/L	4.8 U			9.6 U	4.8 U	23 JP		4.8 U	4.8 U	4.8 U			23 JP
MW-17S	7/24/2007	ng/L	4.8 U			9.6 U	4.8 U	12		4.8 U	4.8 U	4.8 U			12
MW-17S	10/23/2007	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-17S	1/25/2008	ng/L	5 U			9.9 U	5.3 U	5 U		5 U	5 U	5 U			9.9 U
MW-17S	4/22/2008	ng/L	5.6 U			9.8 U	10 U	9.3 U		5.4 U	4.9 U	4.9 U			10 U
MW-17S	7/24/2008	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-17S	10/21/2008	ng/L	5 U			10 U	5 U	13 U		5 U	5 U	5 U			13 U
MW-17S	1/21/2009	ng/L	5 U			10 U	5 U	11 JP		5 U	5 U	5 U			11 J
MW-17S	4/22/2009	ng/L	5 U			10 U	5 U	5.7 U		9.8 U	5 U	5 U			10 U
MW-17S	7/23/2009	ng/L	5 U			10 U	5 U	4.1 T		5 U	5 U	5 U	5 U	5 U	4.1 T
MW-17S	10/19/2009	ng/L	5 U			10 U	5 U	5.6 U		5 U	7.1 U	5 U			10 U
MW-17S	2/3/2010	ng/L	5 U			10 U	5.4 U	5 U		5 U	5 U	5 U			10 U
MW-17S	4/21/2010	ng/L	5 U			10 U	5 U	7.9		5 U	5 U	5 U	5 U	5 U	7.9
MW-17S	5/20/2010	ng/L	4.9 U			9.8 U	4.9 U	9.9		4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	9.9

Table 5-1 - PCB Results for Groundwater near Leading Edge of PCB Plume

Sample ID	Date	Units	Aroclor-1016	Aroclor-1016/1242	Aroclor-1016/1242/1248	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1242/1248	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
HL-MW-32S	10/22/2009	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
HL-MW-32S	2/3/2010	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
HL-MW-32S	4/21/2010	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U	5 U	5 U	10 U
HL-MW-32S	5/20/2010	ng/L	4.9 U			9.7 U	4.9 U	10		4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	10
HL-MW-23S	4/21/2006	ng/L	4.9 U			9.7 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.7 U
HL-MW-23S	7/20/2006	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-23S	10/26/2006	ng/L	4.8 U			9.6 U	4.8 U	6.9		4.8 U	4.8 U	4.8 U			6.9
HL-MW-23S	2/1/2007	ng/L	4.8 U			9.6 U	4.8 U	14		4.8 U	4.8 U	4.8 U			14
HL-MW-23S	4/17/2007	ng/L	4.8 U			9.6 U	4.8 U	6.9 JP		4.8 U	4.8 U	4.8 U			6.9 JP
HL-MW-23S	7/24/2007	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-23S	10/24/2007	ng/L	4.8 U			9.6 U	4.8 U	5.1		4.8 U	4.8 U	4.8 U			5.1
HL-MW-23S	1/25/2008	ng/L	5 U			9.9 U	7.1 U	5 U		5 U	5 U	5 U			9.9 U
HL-MW-23S	4/22/2008	ng/L	6.9 U			9.9 U	5 U	5 U		5 U	5 U	5 U			9.9 U
HL-MW-23S	7/24/2008	ng/L	5.9 U			13 U	16 U	18 U		5 U	5 U	5 U			18 U
HL-MW-23S	10/24/2008	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
HL-MW-23S	1/21/2009	ng/L	5 U			10 U	5 U	6.7 JP		5 U	5 U	5 U			6.7 J
HL-MW-23S	4/22/2009	ng/L	5 U			10 U	5 U	5.9 U		12 U	5 U	5 U			12 U
HL-MW-23S	7/23/2009	ng/L	5 U			10 U	5 U	17 JP		5 U	5 U	5 U	5 U	5 U	17 J
HL-MW-23S	10/19/2009	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
HL-MW-23S	2/3/2010	ng/L	5 U			10 U	5 U	7.1 U		5.6 U	5 U	5 U			10 U
HL-MW-23S	4/21/2010	ng/L	4.9 U			9.7 U	4.9 U	10		4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	10
HL-MW-23S	5/20/2010	ng/L	5 U			10 U	5 U	12		5 U	5 U	5 U	5 U	5 U	12
MW-25S	9/12/2001	ng/L	5 U			5 U	5 U	5 U		5 U	5 U	5 U			5 U
MW-25S	12/5/2001	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-25S	3/19/2002	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-25S	6/25/2002	ng/L	5.1 U			11 U	5.1 U	5.1 U		5.1 U	5.1 U	5.1 U			11 U
MW-25S	9/25/2002	ng/L	5.2 U			11 U	5.2 U	5.2 U		5.2 U	5.2 U	5.2 U			11 U
MW-25S	12/17/2002	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-25S	5/12/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-25S	9/2/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-25S	10/22/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-25S	6/29/2004	ng/L	5 U			28 Ui	5 U	5 U		5 U	5 U	5 U			28 U
MW-25S	10/26/2004	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-25S	7/28/2005	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-25S	10/26/2005	ng/L	4.9 U			9.7 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.7 U
MW-25S	1/24/2006	ng/L	4.9 U			9.8 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.8 U
MW-25S	4/21/2006	ng/L	4.9 U			9.8 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.8 U
MW-25S	7/18/2006	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-25S	10/27/2006	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-25S	2/1/2007	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-25S	4/17/2007	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-25S	7/24/2007	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-25S	10/25/2007	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-25S	1/25/2008	ng/L	4.9 U			9.8 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.8 U
MW-25S	4/22/2008	ng/L	4.9 U			9.8 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.8 U
MW-25S	7/24/2008	ng/L	5 U			9.9 U	5 U	5 U		5 U	5 U	5 U			9.9 U
MW-25S	10/22/2008	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-25S	1/21/2009	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-25S	4/22/2009	ng/L	5 U			9.9 U	5 U	5 U		5 U	5 U	5 U			9.9 U

Table 5-1 - PCB Results for Groundwater near Leading Edge of PCB Plume

Sample ID	Date	Units	Aroclor-1016	Aroclor-1016/1242	Aroclor-1016/1242/1248	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1242/1248	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
MW-25S	7/23/2009	ng/L	5 U			10 U	5 U	4.4 T		5 U	5 U	5 U	5 U	5 U	4.4 T
MW-25S	10/19/2009	ng/L	5 U			9.9 U	5 U	5 U		5 U	5 U	5 U			9.9 U
MW-25S	2/3/2010	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-25S	4/21/2010	ng/L	5 U			9.9 U	5 U	5 U		5 U	5 U	5 U	5 U	5 U	9.9 U
MW-15	2/17/1998	ng/L	21 U			52 U	52 U	21 U		21 U	21 U	21 U			52 U
MW-15	5/5/1998	ng/L	22 U			55 U	55 U	22 U		22 U	22 U	22 U			55 U
MW-15	9/15/1998	ng/L	21 UJ			53 UJ	53 UJ	21 UJ		21 UJ	21 UJ	21 UJ			53 UJ
MW-15	12/15/1998	ng/L	22 U			55 U	55 U	22 U		22 U	22 U	22 U			55 U
MW-15	3/23/1999	ng/L	20 U			50 U	50 U	20 U		20 U	20 U	20 U			50 U
MW-15	6/9/1999	ng/L	20 U			49 U	49 U	20 U		20 U	20 U	20 U			49 U
MW-15	9/21/1999	ng/L	19 U			48 U	48 U	19 U		19 U	19 U	19 U			48 U
MW-15	12/30/1999	ng/L	20 U			50 U	50 U	20 U		20 U	20 U	20 U			50 U
MW-15	6/28/2000	ng/L	20 U			20 U	20 U	20 U		20 U	20 U	20 U			20 U
MW-15	10/3/2000	ng/L	20 U			20 U	20 U	20 U		20 U	20 U	20 U			20 U
MW-15	12/28/2000	ng/L	20 U			50 U	50 U	20 U		20 U	20 U	20 U			50 U
MW-15	4/17/2001	ng/L	5 U			5 U	5 U	5 U		5 U	5 U	5 U			5 U
MW-15	6/19/2001	ng/L	5.1 U			5.1 U	5.1 U	5.1 U		5.1 U	5.1 U	5.1 U			5.1 U
MW-15	9/11/2001	ng/L	4.8 U			4.8 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			4.8 U
MW-15	12/3/2001	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-15	3/18/2002	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-15	6/24/2002	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-15	9/24/2002	ng/L	5.2 U			11 U	5.2 U	5.2 U		5.2 U	5.2 U	5.2 U			11 U
MW-15	12/16/2002	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-15	5/12/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-15	9/2/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-15	6/29/2004	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-15	10/25/2004	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-15	7/29/2005	ng/L	4.9 U			9.7 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.7 U
MW-15	10/24/2005	ng/L	4.9 U			9.7 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.7 U
MW-15	4/21/2006	ng/L	4.9 U			9.7 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.7 U
MW-15	10/27/2006	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-15	2/1/2007	ng/L	4.9 U			9.7 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.7 U
MW-15	4/17/2007	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-15	7/25/2007	ng/L	4.8 U			9.6 U	4.8 U	1.9 T		4.8 U	4.8 U	4.8 U			1.9 T
MW-15	10/24/2007	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-15	1/25/2008	ng/L	4.9 U			9.8 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.8 U
MW-15	4/23/2008	ng/L	5 U			9.9 U	5 U	5 U		5 U	5 U	5 U			9.9 U
MW-15	7/23/2008	ng/L	5 U			9.9 U	5 U	5 U		5 U	5 U	5 U			9.9 U
MW-15	10/21/2008	ng/L	5 U			10 U	5 U	7.7 U		5 U	5 U	5 U			10 U
MW-15	1/21/2009	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-15	4/23/2009	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-15	7/22/2009	ng/L	5 U			9.9 U	5 U	5 U		5 U	5 U	5 U	5 U	5 U	9.9 U
MW-15	10/19/2009	ng/L	5 U			9.9 U	5 U	5 U		5 U	5 U	5 U			9.9 U
MW-15	2/3/2010	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-15	4/19/2010	ng/L	4.9 U			9.8 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	9.8 U

Table 5-1 - PCB Results for Groundwater near Leading Edge of PCB Plume

Sample ID	Date	Units	Aroclor-1016	Aroclor-1016/1242	Aroclor-1016/1242/1248	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1242/1248	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
MW-12A	3/23/1999	ng/L	20 U			49 U	49 U	20 U		19 J	20 U	20 U			19 J
MW-12A	6/10/1999	ng/L	20 U			49 U	49 U	20 U		13 J	20 U	20 U			13 J
MW-12A	9/21/1999	ng/L	19 U			48 U	48 U	19 U		19 U	19 U	19 U			48 U
MW-12A	12/30/1999	ng/L	20 U			50 U	50 U	20 U		20 U	20 U	20 U			50 U
MW-12A	6/28/2000	ng/L	20 U			20 U	20 U	20 U		20 U	20 U	20 U			20 U
MW-12A	10/4/2000	ng/L	20 U			20 U	20 U	20 U		20 U	20 U	20 U			20 U
MW-12A	12/28/2000	ng/L	20 U			50 U	50 U	20 U		20 U	20 U	20 U			50 U
MW-12A	4/18/2001	ng/L	5 U			5 U	5 U	5 U		5 U	5 U	5 U			5 U
MW-12A	6/19/2001	ng/L	5 U			5 U	5 U	5 U		5 U	5 U	5 U			5 U
MW-12A	9/12/2001	ng/L	5 U			5 U	5 U	5 U		5 U	5 U	5 U			5 U
MW-12A	12/4/2001	ng/L	5 U			10 U	15 U	6.6 U		5 U	7.2 U	5 U			15 U
MW-12A	3/18/2002	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-12A	6/25/2002	ng/L	5.1 U			11 U	5.1 U	57		5.1 U	5.1 U	5.1 U			57
MW-12A	9/24/2002	ng/L	5.2 U			11 U	5.2 U	5.2 U		5.2 U	5.2 U	5.2 U			11 U
MW-12A	12/17/2002	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-12A	5/12/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-12A	9/2/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-12A	10/22/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-12A	3/5/2004	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-12A	6/29/2004	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-12A	10/25/2004	ng/L	5 U			37 U	5 U	5 U		5 U	5 U	5 U			37 U
MW-12A	7/28/2005	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-12A	10/26/2005	ng/L	4.9 U			9.7 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.7 U
MW-12A	4/21/2006	ng/L	17 U			9.7 U	28 U	20 U		6.8 U	4.9 U	4.9 U			28 U
MW-12A	10/27/2006	ng/L	4.8 U			9.6 U	4.8 U	7.7		4.8 U	4.8 U	4.8 U			7.7
MW-12A	2/1/2007	ng/L	4.9 U			9.7 U	4.9 U	42		4.9 U	4.9 U	4.9 U			42
MW-12A	4/17/2007	ng/L	4.8 U			9.6 U	4.8 U	95		4.8 U	4.8 U	4.8 U			95
MW-12A	7/25/2007	ng/L	4.8 U			9.6 U	4.8 U	5.4 JP		4.8 U	4.8 U	4.8 U			5.4 JP
MW-12A	10/23/2007	ng/L	5 U			9.6 U	7.3 U	4.8 U		5.5 U	4.8 U	4.8 U			9.6 U
MW-12A	1/25/2008	ng/L	5.9 U			9.9 U	5 U	7.3 U		5 U	5 U	5 U			9.9 U
MW-12A	4/24/2008	ng/L	4.9 U			9.8 U	4.9 U	14 JP		4.9 U	4.9 U	4.9 U			14 JP
MW-12A	7/23/2008	ng/L	13 U			23 U	17 U	30 U		5 U	5 U	5 U			30 U
MW-12A	10/21/2008	ng/L	5 U			9.9 U	5 U	5 U		4.7 T	5 U	5 U			4.7 T
MW-12A	1/21/2009	ng/L	5 U			10 U	5 U	45		5 U	5 U	5 U			45
MW-12A	4/23/2009	ng/L	4.9 U			9.8 U	4.9 U	52		4.9 U	4.9 U	4.9 U			52
MW-12A	7/23/2009	ng/L	5 U			10 U	5 U	5.1 U		5 U	5 U	5 U	5 U	5 U	10 U
MW-12A	10/19/2009	ng/L	5 U			10 U	6 U	5 U		5 U	5 U	5 U			10 U
MW-12A	2/3/2010	ng/L	12 U			11 U	7.6 U	13 U		8.9 U	5 U	5 U			13 U
MW-12A	4/22/2010	ng/L	5 U			9.9 U	5 U	64		5 U	5 U	5 U	5 U	5 U	64
MW-12A	5/20/2010	ng/L	4.9 U			9.8 U	4.9 U	77		4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	77
MW-23S	9/11/2001	ng/L	5 U			5 U	5 U	5 U		5 U	5 U	5 U			5 U
MW-23S	12/4/2001	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-23S	3/18/2002	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-23S	6/25/2002	ng/L	5.2 U			11 U	5.2 U	5.2 U		5.2 U	5.2 U	5.2 U			11 U
MW-23S	9/24/2002	ng/L	5.2 U			11 U	5.2 U	5.2 U		5.2 U	5.2 U	5.2 U			11 U
MW-23S	12/16/2002	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-23S	5/12/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-23S	9/2/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-23S	10/22/2003	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U

Table 5-1 - PCB Results for Groundwater near Leading Edge of PCB Plume

Sample ID	Date	Units	Aroclor-1016	Aroclor-1016/1242	Aroclor-1016/1242/1248	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1242/1248	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
MW-23S	3/5/2004	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-23S	6/29/2004	ng/L	5 U			30 Ui	5 U	5 U		5 U	5 U	5 U			30 U
MW-23S	10/25/2004	ng/L	5 U			19 U	5 U	5 U		5 U	5 U	5 U			19 U
MW-23S	7/28/2005	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-23S	10/24/2005	ng/L	5 U			9.9 U	5 U	5 U		5 U	5 U	5 U			9.9 U
MW-23S	4/21/2006	ng/L	20 U			23 U	23 U	18 U		5.3 U	4.9 U	4.9 U			23 U
MW-23S	10/27/2006	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-23S	2/1/2007	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-23S	4/17/2007	ng/L	4.8 U			9.6 U	4.8 U	25		4.8 U	4.8 U	4.8 U			25
MW-23S	7/25/2007	ng/L	4.8 U			9.6 U	4.8 U	6.9		4.8 U	4.8 U	4.8 U			6.9
MW-23S	10/24/2007	ng/L	4.8 U			9.6 U	4.8 U	4.8 U		4.8 U	4.8 U	4.8 U			9.6 U
MW-23S	1/25/2008	ng/L	4.9 U			9.8 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.8 U
MW-23S	4/24/2008	ng/L	4.9 U			9.8 U	4.9 U	4.9 U		4.9 U	4.9 U	4.9 U			9.8 U
MW-23S	7/23/2008	ng/L	5 U			9.9 U	5 U	5 U		5 U	5 U	5 U			9.9 U
MW-23S	10/21/2008	ng/L	5 U			9.9 U	5 U	8.8 U		5 U	5 U	5 U			9.9 U
MW-23S	1/21/2009	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-23S	4/23/2009	ng/L	5 U			9.9 U	5 U	19 JP		5 U	5 U	5 U			19 J
MW-23S	7/23/2009	ng/L	5 U			10 U	5 U	5.4 U		5 U	5 U	5 U	5 U	5 U	10 U
MW-23S	10/19/2009	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-23S	2/3/2010	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U			10 U
MW-23S	4/19/2010	ng/L	5 U			10 U	5 U	5 U		5 U	5 U	5 U	5 U	5 U	10 U
MW-23S	5/20/2010	ng/L	5 U			9.9 U	5 U	10		5 U	5 U	5 U	5 U	5 U	10

Data Qualifiers

D = Result from a diluted sample.
J = Estimated value.
P = The GC confirmation criteria were exceeded.
T = Reported result below associated quantitation limit but above the method detection limit.
U = Not detected at the detection limit noted.
Ui = Not detected at the detection limit noted. Detection limit elevated due to chromatographic interference.
ng/L = nanograms per liter

Table 5-2 - Statistical Summary for Groundwater Samples near Leading Edge of PCB Plume

Station	Analyte	Detection Frequency	Minimum Detection in ng/L	Maximum Detection in ng/L	Maximum Detection Date	Mean Detection in ng/L	Median Detection in ng/L	Minimum RL in ng/L	Maximum RL in ng/L
HL-MW-23S	Aroclor-1016	0/18						4.8	6.9
HL-MW-23S	Aroclor-1221	0/18						9.6	13
HL-MW-23S	Aroclor-1232	0/18						4.8	16
HL-MW-23S	Aroclor-1242	8/18	5.1	17	7/23/2009	9.8	8.5	4.8	18
HL-MW-23S	Aroclor-1248	0/18						4.8	12
HL-MW-23S	Aroclor-1254	0/18						4.8	5
HL-MW-23S	Aroclor-1260	0/18						4.8	5
HL-MW-23S	Aroclor-1262	0/3						4.9	5
HL-MW-23S	Aroclor-1268	0/3						4.9	5
HL-MW-23S	Total PCBs	8/18	5.1	17	7/23/2009	9.8	8.5	9.6	18
HL-MW-30S	Aroclor-1016	0/13						4.8	5
HL-MW-30S	Aroclor-1221	0/13						9.6	10
HL-MW-30S	Aroclor-1232	0/13						4.8	5
HL-MW-30S	Aroclor-1242	13/13	100	220	5/20/2010	146.9	140	NA	NA
HL-MW-30S	Aroclor-1248	0/13						4.8	5
HL-MW-30S	Aroclor-1254	0/13						4.8	5
HL-MW-30S	Aroclor-1260	0/13						4.8	5
HL-MW-30S	Aroclor-1262	0/3						4.9	5
HL-MW-30S	Aroclor-1268	0/3						4.9	5
HL-MW-30S	Total PCBs	13/13	100	220	5/20/2010	146.9	140	NA	NA
HL-MW-32S	Aroclor-1016	0/4						4.9	5
HL-MW-32S	Aroclor-1221	0/4						9.7	10
HL-MW-32S	Aroclor-1232	0/4						4.9	5
HL-MW-32S	Aroclor-1242	1/4	10	10	5/20/2010	10	10	5	5
HL-MW-32S	Aroclor-1248	0/4						4.9	5
HL-MW-32S	Aroclor-1254	0/4						4.9	5
HL-MW-32S	Aroclor-1260	0/4						4.9	5
HL-MW-32S	Aroclor-1262	0/2						4.9	5
HL-MW-32S	Aroclor-1268	0/2						4.9	5
HL-MW-32S	Total PCBs	1/4	10	10	5/20/2010	10	10	10	10
MW-12A	Aroclor-1016	0/40						4.8	20
MW-12A	Aroclor-1221	0/40						5	50
MW-12A	Aroclor-1232	0/40						4.8	50
MW-12A	Aroclor-1242	10/40	5.4	95	4/17/2007	45.9	48.5	4.8	30
MW-12A	Aroclor-1248	3/40	4.7	19	3/23/1999	12.2	13	4.8	20
MW-12A	Aroclor-1254	0/40						4.8	20
MW-12A	Aroclor-1260	0/40						4.8	20
MW-12A	Aroclor-1262	0/3						4.9	5
MW-12A	Aroclor-1268	0/3						4.9	5
MW-12A	Total PCBs	13/40	4.7	95	4/17/2007	38.1	42	5	50

Table 5-2 - Statistical Summary for Groundwater Samples near Leading Edge of PCB Plume

Station	Analyte	Detection Frequency	Minimum Detection in ng/L	Maximum Detection in ng/L	Maximum Detection Date	Mean Detection in ng/L	Median Detection in ng/L	Minimum RL in ng/L	Maximum RL in ng/L
MW-15	Aroclor-1016	0/41						4.8	22
MW-15	Aroclor-1221	0/41						4.8	55
MW-15	Aroclor-1232	0/41						4.8	55
MW-15	Aroclor-1242	1/41	1.9	1.9	7/25/2007	1.9	1.9	4.8	22
MW-15	Aroclor-1248	0/41						4.8	22
MW-15	Aroclor-1254	0/41						4.8	22
MW-15	Aroclor-1260	0/41						4.8	22
MW-15	Aroclor-1262	0/2						4.9	5
MW-15	Aroclor-1268	0/2						4.9	5
MW-15	Total PCBs	1/41	1.9	1.9	7/25/2007	1.9	1.9	4.8	55
MW-17S	Aroclor-1016	0/33						4.8	11
MW-17S	Aroclor-1221	0/33						5	17
MW-17S	Aroclor-1232	0/33						4.8	23
MW-17S	Aroclor-1242	7/33	4.1	23	4/17/2007	12.1	11	4.8	14
MW-17S	Aroclor-1248	0/33						4.8	12
MW-17S	Aroclor-1254	0/33						4.8	7.1
MW-17S	Aroclor-1260	0/33						4.8	5.2
MW-17S	Aroclor-1262	0/3						4.9	5
MW-17S	Aroclor-1268	0/3						4.9	5
MW-17S	Total PCBs	7/33	4.1	23	4/17/2007	12.1	11	5	23
MW-23S	Aroclor-1016	0/31						4.8	20
MW-23S	Aroclor-1221	0/31						5	30
MW-23S	Aroclor-1232	0/31						4.8	23
MW-23S	Aroclor-1242	4/31	6.9	25	4/17/2007	15.2	14.5	4.8	18
MW-23S	Aroclor-1248	0/31						4.8	5.3
MW-23S	Aroclor-1254	0/31						4.8	5.2
MW-23S	Aroclor-1260	0/31						4.8	5.2
MW-23S	Aroclor-1262	0/3						5	5
MW-23S	Aroclor-1268	0/3						5	5
MW-23S	Total PCBs	4/31	6.9	25	4/17/2007	15.2	14.5	5	30
MW-25S	Aroclor-1016	0/31						4.8	5.2
MW-25S	Aroclor-1221	0/31						5	28
MW-25S	Aroclor-1232	0/31						4.8	5.2
MW-25S	Aroclor-1242	1/31	4.4	4.4	7/23/2009	4.4	4.4	4.8	5.2
MW-25S	Aroclor-1248	0/31						4.8	5.2
MW-25S	Aroclor-1254	0/31						4.8	5.2
MW-25S	Aroclor-1260	0/31						4.8	5.2
MW-25S	Aroclor-1262	0/2						5	5
MW-25S	Aroclor-1268	0/2						5	5
MW-25S	Total PCBs	1/31	4.4	4.4	7/23/2009	4.4	4.4	5	28

NA = Not applicable. All samples had detected values.
RL = Analytical reporting limit.
ng/L = Nanograms per liter.

Table 5-3 - PCB Analytical Results for Deep Groundwater

Sample ID	Date	Units	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
HL-MW-5	8/29/1995	ng/L	20 U	50 U	50 U	20 U	20 U	20 U	20 U			50 U
HL-MW-5	10/4/1995	ng/L	21 U	52 U	52 U			21 U	21 U			26
HL-MW-5	10/1/1997	ng/L	21 U	52 U	52 U	21 U	75	21 U	21 U			75
HL-MW-5	12/17/1997	ng/L	21 U	52 U	52 U	21 U	56	21 U	21 U			56
HL-MW-5	2/19/1998	ng/L	21 U	52 U	52 U	21 U	43	21 U	21 U			43
HL-MW-5	5/4/1998	ng/L	21 U	52 U	52 U	21 U	50	21 U	21 U			50
HL-MW-5	9/16/1998	ng/L	21 U	52 U	52 U	21 U	170	21 U	21 U			170
HL-MW-5	12/16/1998	ng/L	22 U	22 U	55 U	22 U	77	22 U	22 U			77
HL-MW-5	4/18/2001	ng/L	20 U	20 U	20 U	70	20 U	20 U	20 U			70
HL-MW-5	6/19/2001	ng/L	19 U	38 U	19 U	53	19 U	19 U	19 U			53
HL-MW-5	9/10/2001	ng/L	4.9 U	4.9 U	4.9 U	91	4.9 U	4.9 U	4.9 U			91
HL-MW-5	12/5/2001	ng/L	5 U	10 U	5 U	54	5 U	5 U	5 U			54
HL-MW-5	3/20/2002	ng/L	5 U	10 U	5 U	82	5 U	5 U	5 U			82
HL-MW-5	6/26/2002	ng/L	5.4 U	11 U	5.4 U	130	5.4 U	5.4 U	5.4 U			130
HL-MW-5	9/25/2002	ng/L	5.2 U	11 U	5.2 U	110	5.2 U	5.2 U	5.2 U			110
HL-MW-5	12/18/2002	ng/L	5 U	10 U	5 U	92	5 U	5 U	5 U			92
HL-MW-5	5/14/2003	ng/L	85 Ui	74 Ui	130 Ui	120	46 Ui	5 U	5 U			120
HL-MW-5	9/3/2003	ng/L	5 U	10 U	5 U	86	5 U	5 U	5 U			86
HL-MW-5	10/23/2003	ng/L	5 U	10 U	5 U	180	5 U	5 U	5 U			180
HL-MW-5	3/4/2004	ng/L	4.9 U	9.7 U	4.9 U	90	4.9 U	4.9 U	4.9 U			90
HL-MW-5	6/30/2004	ng/L	5 U	10 U	5 U	100	5 U	5 U	5 U			100
HL-MW-5	10/29/2004	ng/L	5 U	10 U	5 U	110 JP	5 U	5 U	5 U			110 JP
HL-MW-5	7/26/2005	ng/L	4.8 U	9.6 U	4.8 U	85	4.8 U	4.8 U	4.8 U			85
HL-MW-5	10/26/2005	ng/L	4.9 U	9.7 U	4.9 U	100	4.9 U	4.9 U	4.9 U			100
HL-MW-5	4/22/2006	ng/L	4.9 U	9.8 U	4.9 U	120	4.9 U	4.9 U	4.9 U			120
HL-MW-5	7/18/2006	ng/L	4.8 U	9.6 U	4.8 U	140 J	4.8 U	4.8 U	4.8 U			140 J
HL-MW-5	10/27/2006	ng/L	4.8 U	9.6 U	4.8 U	93	4.8 U	4.8 U	4.8 U			93
HL-MW-5	4/15/2007	ng/L	4.8 U	9.6 U	4.8 U	150	4.8 U	4.8 U	4.8 U			150
HL-MW-5	7/25/2007	ng/L	4.8 U	9.6 U	4.8 U	140	4.8 U	4.8 U	4.8 U			140 U
HL-MW-5	10/25/2007	ng/L	4.8 U	9.6 U	4.8 U	84	4.8 U	4.8 U	4.8 U			84
HL-MW-5	1/25/2008	ng/L	5 U	9.9 U	5 U	110	5 U	5 U	5 U			110
HL-MW-5	4/22/2008	ng/L	4.9 U	9.8 U	4.9 U	100	4.9 U	4.9 U	4.9 U			100
HL-MW-5	7/23/2008	ng/L	5 U	10 U	5 U	200	5 U	5 U	5 U			200
HL-MW-5	10/20/2008	ng/L	5 U	10 U	5 U	130	5 U	5 U	5 U			130
HL-MW-5	1/21/2009	ng/L	5 U	9.9 U	5 U	160	5 U	5 U	5 U			160
HL-MW-5	4/26/2009	ng/L	4.9 U	9.8 U	4.9 U	130	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	130
HL-MW-5	7/23/2009	ng/L	5 U	10 U	5 U	230	5 U	5 U	5 U	5 U	5 U	230
HL-MW-5	10/20/2009	ng/L	4.8 U	9.6 U	4.8 U	120	4.8 U	4.8 U	4.8 U			120
HL-MW-5	4/22/2010	ng/L	4.9 U	9.8 U	4.9 U	140	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	140

Table 5-3 - PCB Analytical Results for Deep Groundwater

Sample ID	Date	Units	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
HL-MW-11D	9/13/2001	ng/L	5.1 U	5.1 U	5.1 U	5.1 U	5.1 U	5.1 U	5.1 U			5.1 U
HL-MW-11D	12/5/2001	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-11D	3/21/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-11D	6/26/2002	ng/L	5.2 U	11 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U			11 U
HL-MW-11D	9/25/2002	ng/L	5.2 U	11 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U			11 U
HL-MW-11D	12/18/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-11D	5/12/2003	ng/L	12 Ui	63 Ui	34 Ui	16 Ui	12 Ui	5 U	5 U			63 U
HL-MW-11D	9/3/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-11D	10/24/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-11D	6/30/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-13DD	10/23/2003	ng/L	5 U	10 U	5 U	84	5 U	5 U	5 U			84
HL-MW-13DD	3/4/2004	ng/L	4.9 U	9.7 U	4.9 U	66	4.9 U	4.9 U	4.9 U			66
HL-MW-13DD	6/30/2004	ng/L	5 U	10 U	5 U	55	5 U	5 U	5 U			55
HL-MW-13DD	10/26/2004	ng/L	44 U	71 U	110 U	61	5 U	5 U	5 U			61
HL-MW-13DD	7/27/2005	ng/L	4.8 U	9.6 U	4.8 U	23	4.8 U	4.8 U	4.8 U			23
HL-MW-13DD	10/24/2005	ng/L	4.9 U	9.7 U	4.9 U	88	4.9 U	4.9 U	4.9 U			88
HL-MW-13DD	1/23/2006	ng/L	4.9 U	9.7 U	4.9 U	43	4.9 U	4.9 U	4.9 U			43
HL-MW-13DD	4/20/2006	ng/L	4.8 U	9.6 U	4.8 U	64	4.8 U	4.8 U	4.8 U			64
HL-MW-13DD	7/18/2006	ng/L	4.8 U	9.6 U	4.8 U	80 J	4.8 U	4.8 U	4.8 U			80 J
HL-MW-13DD	10/26/2006	ng/L	4.8 U	9.6 U	4.8 U	68	4.8 U	4.8 U	4.8 U			68
HL-MW-13DD	4/15/2007	ng/L	4.8 U	9.6 U	4.8 U	94	4.8 U	4.8 U	4.8 U			94
HL-MW-13DD	10/23/2007	ng/L	4.8 U	9.6 U	4.8 U	130	4.8 U	4.8 U	4.8 U			130
HL-MW-13DD	4/21/2008	ng/L	5 U	10 U	5 U	100	5 U	5 U	5 U			100
HL-MW-13DD	10/19/2008	ng/L	5 U	10 U	5 U	84	5 U	5 U	5 U			84
HL-MW-13DD	4/26/2009	ng/L	4.9 U	9.8 U	4.9 U	120	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	120
HL-MW-13DD	10/22/2009	ng/L	5 U	10 U	5 U	120	5 U	5 U	5 U			120
HL-MW-13DD	4/20/2010	ng/L	5 U	10 U	5 U	120	5 U	5 U	5 U	5 U	5 U	120
HL-MW-15DD	10/23/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-15DD	3/4/2004	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-15DD	6/30/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-15DD	10/26/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-15DD	7/26/2005	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-15DD	10/26/2005	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
HL-MW-15DD	4/22/2006	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
HL-MW-15DD	10/26/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-15DD	4/15/2007	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
HL-MW-15DD	10/25/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-15DD	4/22/2008	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
HL-MW-15DD	10/20/2008	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
HL-MW-15DD	4/26/2009	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	9.8 U
HL-MW-15DD	10/20/2009	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
HL-MW-15DD	4/22/2010	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U	9.6 U

Table 5-3 - PCB Analytical Results for Deep Groundwater

Sample ID	Date	Units	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
HL-MW-24DD	4/21/2006	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
HL-MW-24DD	7/19/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-24DD	10/26/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-24DD	1/31/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-24DD	4/15/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-24DD	10/23/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-24DD	4/21/2008	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
HL-MW-24DD	10/24/2008	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
HL-MW-24DD	4/23/2009	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
HL-MW-24DD	10/21/2009	ng/L	4.9 U	9.7 U	8.4 U	5 U	4.9 U	4.9 U	4.9 U			9.7 U
HL-MW-24DD	4/20/2010	ng/L	5.1 U	11 U	5.1 U	5.1 U	5.1 U	5.1 U	5.1 U	5.1 U	5.1 U	11 U
HL-MW-27D	4/22/2006	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
HL-MW-27D	7/19/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-27D	10/27/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-27D	1/31/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-27D	4/16/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-27D	10/24/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-27D	4/21/2008	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
HL-MW-27D	10/21/2008	ng/L	5 U	10 U	5 U	8.5 U	5 U	5 U	5 U			10 U
HL-MW-27D	4/23/2009	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-27D	10/20/2009	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-27D	4/21/2010	ng/L	5.2 U	11 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U	11 U
HL-MW-28DD	10/26/2006	ng/L	4.8 U	9.6 U	4.8 U	96 P	4.8 U	4.8 U	4.8 U			96 JP
HL-MW-28DD	1/31/2007	ng/L	4.8 U	9.6 U	4.8 U	74	4.8 U	4.8 U	4.8 U			74
HL-MW-28DD	4/15/2007	ng/L	4.9 U	9.8 U	4.9 U	160	4.9 U	4.9 U	4.9 U			160
HL-MW-28DD	7/24/2007	ng/L	4.8 U	9.6 U	4.8 U	74	4.8 U	4.8 U	4.8 U			74
HL-MW-28DD	10/23/2007	ng/L	4.8 U	9.6 U	4.8 U	180	4.8 U	4.8 U	4.8 U			180
HL-MW-28DD	1/24/2008	ng/L	4.9 U	9.8 U	4.9 U	150	4.9 U	4.9 U	4.9 U			150
HL-MW-28DD	4/21/2008	ng/L	5 U	10 U	5 U	160	5 U	5 U	5 U			160
HL-MW-28DD	10/19/2008	ng/L	5 U	10 U	5 U	170	5 U	5 U	5 U			170
HL-MW-28DD	4/26/2009	ng/L	5 U	9.9 U	5 U	170	5 U	5 U	5 U	5 U	5 U	170
HL-MW-28DD	10/22/2009	ng/L	5 U	10 U	5 U	210	5 U	5 U	5 U			210
HL-MW-28DD	4/20/2010	ng/L	5.1 U	11 U	5.1 U	210	5.1 U	5.1 U	5.1 U	5.1 U	5.1 U	210
HL-MW-8D	9/12/2001	ng/L	5 U	5 U	5 U	51	5 U	5 U	5 U			51
HL-MW-8D	12/6/2001	ng/L	5 U	10 U	5 U	48	5 U	5 U	5 U			48
HL-MW-8D	3/21/2002	ng/L	5 U	10 U	5 U	42	5 U	5 U	5 U			42
HL-MW-8D	6/26/2002	ng/L	5 U	10 U	5 U	75	5 U	5 U	5 U			75
HL-MW-8D	9/26/2002	ng/L	5.2 U	11 U	5.2 U	50	5.2 U	5.2 U	5.2 U			50
HL-MW-8D	12/18/2002	ng/L	5 U	10 U	5 U	53	5 U	5 U	5 U			53
HL-MW-8D	5/14/2003	ng/L	40 Ui	150 Ui	92 Ui	56 Ui	71 Ui	5 U	5 U			50 U
HL-MW-8D	9/3/2003	ng/L	5 U	10 U	5 U	33	5 U	5 U	5 U			33

Table 5-3 - PCB Analytical Results for Deep Groundwater

Sample ID	Date	Units	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
HL-MW-8D	10/23/2003	ng/L	5 U	10 U	5 U	100	5 U	5 U	5 U			100
HL-MW-8D	3/5/2004	ng/L	5 U	10 U	5 U	58	5 U	5 U	5 U			58
HL-MW-8D	6/30/2004	ng/L	5 U	10 U	5 U	80	5 U	5 U	5 U			80
HL-MW-8D	10/26/2004	ng/L	41 U	57 U	88 U	57	5 U	5 U	5 U			57
HL-MW-8D	7/28/2005	ng/L	4.9 U	9.7 U	4.9 U	27	4.9 U	4.9 U	4.9 U			27
HL-MW-8D	10/26/2005	ng/L	4.9 U	9.7 U	4.9 U	83	4.9 U	4.9 U	4.9 U			83
HL-MW-8D	4/22/2006	ng/L	4.9 U	9.8 U	4.9 U	96	4.9 U	4.9 U	4.9 U			96
HL-MW-8D	10/26/2006	ng/L	4.8 U	9.6 U	4.8 U	52	4.8 U	4.8 U	4.8 U			52
HL-MW-8D	4/15/2007	ng/L	4.8 U	9.6 U	4.8 U	74	4.8 U	4.8 U	4.8 U			74
HL-MW-8D	10/23/2007	ng/L	4.8 U	9.6 U	4.8 U	59	4.8 U	4.8 U	4.8 U			59
HL-MW-8D	4/21/2008	ng/L	5 U	10 U	5 U	49	5 U	5 U	5 U			49
HL-MW-8D	10/19/2008	ng/L	5 U	10 U	5 U	35	5 U	5 U	5 U			35
HL-MW-8D	4/26/2009	ng/L	4.9 U	9.8 U	4.9 U	57	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	57
HL-MW-8D	10/22/2009	ng/L	5 U	10 U	5 U	39	5 U	5 U	5 U			39
HL-MW-8D	4/20/2010	ng/L	5.2 U	11 U	5.2 U	41	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U	41
HL-MW-9D	9/12/2001	ng/L	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U			5.2 U
HL-MW-9D	12/5/2001	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-9D	3/21/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-9D	6/26/2002	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
HL-MW-9D	9/26/2002	ng/L	5.2 U	11 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U			11 U
HL-MW-9D	12/18/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-9D	5/14/2003	ng/L	28 Ui	44 Ui	88 Ui	39 Ui	5 U	5 U	5 U			88 U
HL-MW-9D	9/3/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-9D	10/24/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-9D	3/5/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-9D	6/30/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-9D	10/26/2004	ng/L	8.1 U	80 U	22 U	25 U	5 U	5 U	5 U			80 U
HL-MW-9D	7/27/2005	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-9D	10/26/2005	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
HL-MW-9D	4/22/2006	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
HL-MW-9D	10/27/2006	ng/L	4.8 U	9.6 U	4.8 U	7.2	4.8 U	4.8 U	4.8 U			7.2
HL-MW-9D	4/15/2007	ng/L	4.8 U	9.6 U	5.7 U	7.9 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-9D	10/25/2007	ng/L	4.8 U	9.6 U	6.2 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
HL-MW-9D	4/22/2008	ng/L	5 U	10 U	5.3 U	5 U	5 U	5 U	5 U			10 U
HL-MW-9D	10/19/2008	ng/L	5 U	10 U	5 U	8.8 JP	5 U	5 U	5 U			8.8 JP
HL-MW-9D	4/22/2009	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
HL-MW-9D	10/22/2009	ng/L	5 U	10 U	5 U	5.2 U	5 U	5 U	5 U			10 U
HL-MW-9D	4/20/2010	ng/L	5 U	10 U	5 U	6.8	5 U	5 U	5 U	5 U	5 U	6.8

Table 5-3 - PCB Analytical Results for Deep Groundwater

Sample ID	Date	Units	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
MW-18D	9/12/2001	ng/L	5 U	5 U	5 U	5 U	5 U	5 U	5 U			5 U
MW-18D	12/5/2001	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-18D	3/19/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-18D	9/25/2002	ng/L	5.1 U	11 U	5.1 U	5.1 U	5.1 U	5.1 U	5.1 U			11 U
MW-18D	12/18/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-18D	5/13/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-18D	9/2/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-18D	10/22/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-18D	3/4/2004	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
MW-18D	6/29/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-18D	10/25/2004	ng/L	5.4 U	33 U	5 U	18 U	5 U	5 U	5 U			33 U
MW-18D	7/29/2005	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-18D	10/26/2005	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
MW-18D	4/21/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-18D	10/27/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-18D	4/17/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-18D	10/26/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-18D	4/22/2008	ng/L	5 U	9.9 U	16 U	11 U	5 U	5 U	5 U			16 U
MW-18D	10/21/2008	ng/L	5 U	9.9 U	5 U	11 U	5 U	5 U	5 U			11 U
MW-18D	4/22/2009	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-18D	10/19/2009	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-18D	4/21/2010	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	10 U
MW-20D	9/12/2001	ng/L	5 U	5 U	5 U	5 U	5 U	5 U	5 U			5 U
MW-20D	12/4/2001	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-20D	3/19/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-20D	6/26/2002	ng/L	5.2 U	11 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U			11 U
MW-20D	9/25/2002	ng/L	5.2 U	11 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U			11 U
MW-20D	12/17/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-20D	5/13/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-20D	9/2/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-20D	6/29/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-20D	4/17/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-20D	10/24/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-20D	4/23/2008	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-20D	10/21/2008	ng/L	5 U	10 U	5 U	5.7 U	5 U	5 U	5 U			10 U
MW-20D	4/23/2009	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
MW-20D	10/20/2009	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-20D	4/20/2010	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	10 U

Table 5-3 - PCB Analytical Results for Deep Groundwater

Sample ID	Date	Units	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
MW-22D	9/11/2001	ng/L	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			4.8 U
MW-22D	12/3/2001	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-22D	3/18/2002	ng/L	8 U	16 U	8 U	8 U	8 U	8 U	8 U			16 U
MW-22D	6/24/2002	ng/L	5.1 U	11 U	5.1 U	5.1 U	5.1 U	5.1 U	5.1 U			11 U
MW-22D	9/24/2002	ng/L	5.2 U	11 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U			11 U
MW-22D	12/16/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-22D	5/12/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-22D	9/2/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-22D	6/29/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-22D	10/27/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-22D	4/17/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-22D	10/24/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-22D	4/23/2008	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
MW-22D	10/23/2008	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-22D	4/23/2009	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
MW-22D	10/19/2009	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-22D	4/19/2010	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	9.9 U
MW-24D	9/11/2001	ng/L	5 U	5 U	5 U	5 U	5 U	5 U	5 U			5 U
MW-24D	12/4/2001	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-24D	3/18/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-24D	6/25/2002	ng/L	5.1 U	11 U	5.1 U	5.1 U	5.1 U	5.1 U	5.1 U			11 U
MW-24D	9/24/2002	ng/L	5.2 U	11 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U			11 U
MW-24D	12/16/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-24D	5/12/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-24D	9/2/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-24D	10/22/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-24D	3/5/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-24D	6/29/2004	ng/L	4.8 U	55 Ui	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			55 U
MW-24D	10/25/2004	ng/L	5.3 U	45 U	20 U	14 U	5 U	5 U	5 U			45 U
MW-24D	7/28/2005	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-24D	10/24/2005	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
MW-24D	4/21/2006	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
MW-24D	10/27/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-24D	2/1/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-24D	4/17/2007	ng/L	4.8 U	9.6 U	4.8 U	3.8 J	4.8 U	4.8 U	4.8 U			3.8 J
MW-24D	7/25/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-24D	10/24/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-24D	1/25/2008	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
MW-24D	4/24/2008	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
MW-24D	7/23/2008	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
MW-24D	10/21/2008	ng/L	4.9 U	9.8 U	4.9 U	7.1 U	4.9 U	4.9 U	4.9 U			9.8 U

Table 5-3 - PCB Analytical Results for Deep Groundwater

Sample ID	Date	Units	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
MW-24D	1/21/2009	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-24D	4/23/2009	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
MW-24D	7/23/2009	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	10 U
MW-24D	10/19/2009	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
MW-24D	4/19/2010	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	10 U
MW-26D	9/12/2001	ng/L	5 U	5 U	5 U	5 U	5 U	5 U	5 U			5 U
MW-26D	12/5/2001	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-26D	3/19/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-26D	6/25/2002	ng/L	5.2 U	11 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U			11 U
MW-26D	9/25/2002	ng/L	5.2 U	11 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U			11 U
MW-26D	12/17/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-26D	5/12/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-26D	9/2/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-26D	10/22/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-26D	6/29/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-26D	10/26/2005	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
MW-26D	4/21/2006	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
MW-26D	10/27/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-26D	4/17/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-26D	10/25/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
MW-26D	4/22/2008	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
MW-26D	10/22/2008	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-26D	4/22/2009	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-26D	10/19/2009	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-26D	4/21/2010	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	9.9 U
MW-2D	9/11/2001	ng/L	5 U	5 U	5 U	5 U	5 U	5 U	5 U			5 U
MW-2D	12/4/2001	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-2D	3/19/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-2D	6/25/2002	ng/L	5.1 U	11 U	5.1 U	5.1 U	5.1 U	5.1 U	5.1 U			11 U
MW-2D	9/24/2002	ng/L	5.2 U	11 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U			11 U
MW-2D	12/16/2002	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-2D	5/12/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-2D	9/2/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-2D	6/30/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-2D	10/25/2004	ng/L	5 U	16 U	5 U	5 U	5 U	5 U	5 U			16 U
MW-2D	7/28/2005	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
MW-2D	10/24/2005	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
MW-2D	4/21/2006	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
MW-2D	10/27/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U

Table 5-3 - PCB Analytical Results for Deep Groundwater

Sample ID	Date	Units	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total PCBs
RM-MW-2D	10/23/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
RM-MW-2D	3/4/2004	ng/L	4.8 U	9.5 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.5 U
RM-MW-2D	6/30/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
RM-MW-2D	10/27/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
RM-MW-2D	7/25/2005	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
RM-MW-2D	10/28/2005	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
RM-MW-2D	4/18/2006	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
RM-MW-2D	10/24/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
RM-MW-2D	4/18/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
RM-MW-2D	10/22/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
RM-MW-2D	4/20/2008	ng/L	4.9 U	9.8 U	4.9 U	7.5 U	4.9 U	4.9 U	4.9 U			9.8 U
RM-MW-2D	10/22/2008	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
RM-MW-2D	4/25/2009	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	9.8 U
RM-MW-2D	10/21/2009	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
RM-MW-2D	4/21/2010	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	9.9 U
RM-MW-4D	10/23/2003	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
RM-MW-4D	3/4/2004	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
RM-MW-4D	6/30/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
RM-MW-4D	10/27/2004	ng/L	5 U	10 U	5 U	5 U	5 U	5 U	5 U			10 U
RM-MW-4D	7/25/2005	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
RM-MW-4D	10/26/2005	ng/L	4.9 U	9.7 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U			9.7 U
RM-MW-4D	4/18/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
RM-MW-4D	10/24/2006	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
RM-MW-4D	4/19/2007	ng/L	4.8 U	9.6 U	5.4 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
RM-MW-4D	10/24/2007	ng/L	4.8 U	9.6 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U			9.6 U
RM-MW-4D	4/20/2008	ng/L	5 U	10 U	6.2 U	5 U	5 U	5 U	5 U			10 U
RM-MW-4D	10/23/2008	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U			9.9 U
RM-MW-4D	4/25/2009	ng/L	4.9 U	9.8 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	4.9 U	9.8 U
RM-MW-4D	10/21/2009	ng/L	4.9 U	9.8 U	5.6 U	4.9 U	4.9 U	4.9 U	4.9 U			9.8 U
RM-MW-4D	4/21/2010	ng/L	5 U	9.9 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	9.9 U

Data Qualifiers

D = Result from a diluted sample.
J = Estimated value.
P = The GC confirmation criteria were exceeded.
T = Reported result below associated quantitation limit but above the method detection limit.
U = Not detected at the detection limit noted.
Ui = Not detected at the detection limit noted. Detection limit elevated due to chromatographic interference.
ng/L = nanograms per liter

Table 5-4 - Estimated PCB Mass Removal for the Remelt/Hot Line Plume

AOC	Time in Years	Mass of PCB-Impacted Smear Zone Soil in grams [a]	Avg. PCB Concentration in Smear Zone Soil in mg/kg [a]	Predicted Groundwater Concentration (based on K_d) in ng/L [b]	Groundwater Flow Rate through Smear Zone in gpd [c]	PCB Mass Removal Rate in Grams/Day [d]	% PCBs Removed	Estimated Extracted Groundwater Concentration in ng/L [e]
Scenario D1	0	5,175	0.07	239	220,071	0.20	0%	NA
	30	3,645	0.043	140	220,071	0.12	30%	NA
Scenario D2a	0	5,175	0.07	239	352,114	0.32	0%	23
	30	2,953	0.035	114	352,114	0.15	43%	11
Scenario D2b	0	5,175	0.07	239	374,121	0.34	0%	29
	30	2,852	0.034	110	374,121	0.16	45%	14
Scenario D3	0	5,175	0.07	239	374,121	0.34	0%	29
	30	2,852	0.034	110	374,121	0.16	45%	14
Scenario D4 [f]	0	5,175	0.07	239	264,085	0.24	0%	70
	30	3,398	0.040	131	264,085	0.13	34%	38

Notes:
(a) Initial mass (time = 0) from Appendix I. Mass after 30 years calculated from Equation 11 in Appendix E.
(b) $C_w = K_d * C_s$ (See Appendix E). Where Kd = 310 L/kg from Ecology's CLARC database.
(c) Groundwater flow rate through 10-foot smear zone. See Appendix E for groundwater flux.
(d) Mass removal rate from smear zone soil based on mass transfer to groundwater. Calculated as the product of the predicted groundwater concentration and the groundwater flow rate through the smear zone.
(e) Estimated extracted groundwater concentration calculated by dividing the predicted mass removal rate by the groundwater extraction rate. Scenario D2a extracted flow rate: 3.7 MGD. Scenario D2b and D3 extracted flow rate: 3.0 MGD. Scenario D4 extracted flow rate: 300,000 gpd.
(f) It is assumed that only 1/3 of the mass transferred from the soil to the groundwater will be extracted based on width of capture zone (Appendix I).

Table 5-5 - Summary of Monitoring Requirements for Remedial Alternative D2: Institutional Controls, Monitoring, MNA, and Containment [a]

Monitoring Type and Location	Medium	Frequency	Parameters	Comment	Evaluation Criteria
Protection Monitoring					
Dust monitoring	Air	Daily, during extraction well installation.	Visual inspection of dust generation.	Air monitoring takes place during ground-disturbing activities, as required by the HASP.	TBD in HASP
Performance Monitoring					
Hydraulic containment system	NA	Weekly	Flow rates, equipment condition (maintenance needs), plume boundaries [b].	As required by the O&M Plan.	TBD
Early warning monitoring well	Groundwater	Quarterly	PCBs.	Conducted to determine whether the operation of the extraction wells is drawing impacted groundwater from the shallow aquifer into the deep aquifer.	TBD in SAP

Notes:

(a) Monitoring requirements for elements unique to Alternative D2 only. In addition to these requirements, Alternative D2 includes the monitoring requirements of Alternative A1 (see Table 2-3).

(b) Monitoring the performance of the hydraulic containment system (i.e., assessing the status of the PCB plume boundaries over time) will be included as part of the regular groundwater monitoring schedule at the Facility (see Table 2-3).

NA - Not applicable.

TBD - To be determined.

Table 5-6 - Alternative D3 - *Ex Situ* Treatment System for the Remelt/Hot Line Plume per 500 gpm [a]

Unit Operation	Type of Equipment Needed	(Number) and size of equipment for costing purposes per 500 gpm [a,b]
Acid and coagulant addition	Rapid mixing tank	(1) 1,000-gallon tank with impeller
Flocculation	Flocculation tanks	(2) 21,000-gallon flocculation tanks in series
Depth filtration	Sand filters	(1) Sand filter train [c]
10-µm surface filtration	Cartridge filter	(1) Cartridge filter vessel that holds twenty 40-in-long, 25-µm cartridge filters [d]
5-µm surface filtration	Cartridge filter	(1) Cartridge filter vessel that holds twenty 40-in-long, 10-µm cartridge filters [d]
GAC adsorption	GAC beds	(2) 10,000-lb GAC beds in series
2-µm surface filtration	Cartridge filter	(1) Cartridge filter vessel that holds twenty 40-in-long, 2-µm cartridge filters [d]
1-µm surface filtration	Cartridge filters	(1) Cartridge filter vessel that holds twenty 40-in-long, 1-µm cartridge filters [d]
0.5-µm surface filtration	Cartridge filters	(1) Cartridge filter vessel that holds twenty 40-in-long, 0.5-µm cartridge filters [d]
pH adjustment (base addition)	Rapid mixing tank	(1) 1,000-gallon tank with impeller

Notes:
(a) Based on total extraction flow rate of approximately 3.0 MGD; four treatment trains in parallel will be needed.
(b) Equipment sizing information provided by vendor (Baker) with the exception of rapid mixing tanks.
Size of rapid mixing tanks based on two-minute hydraulic retention time (Corbitt 1989).
(c) Sand filter train consists of four 130-cf sand filter beds in series.
(d) Each cartridge filter vessel will be equipped with spare vessel in parallel so system can continue running during filter change-out.

Table 5-7 - Summary of Monitoring Requirements for Remedial Alternatives D3 and D4: Groundwater Extraction with *Ex Situ* Treatment for the Remelt/Hot Line PCB Plume [a]

Locations	Medium	Frequency	Parameters	Comment	Evaluation Criteria
Performance Monitoring					
Sample points along treatment train	Water	Monthly	PCBs, TSS, TDS	To determine effectiveness of individual system components. As required by the *ex situ* treatment system O&M plan and discharge permits.	TBD
Treatment system pressures and flow rates	Water	Daily	Pressure, Flow rate.	As required by the *ex situ* treatment system O&M plan.	TBD
Conveyance pipe	NA	Weekly	Visual signs of deterioration (e.g., abrasion, leaks) to be recorded.	As required by the *ex situ* treatment system O&M plan. Leaks will need to be repaired.	TBD
Treatment system effluent	Water	Weekly	PCBs, TSS, TDS	As required by the *ex situ* treatment system O&M plan and discharge permits (if applicable).	TBD

Notes:

(a) This table presents an overview of monitoring requirements unique to the *ex situ* treatment portions of Alternatives D3 and D4. In addition to these requirements, Alternatives D3 and D4 include the requirements of Alternatives D1 and D2 (see Tables 2-3 and 5-5).

TBD - To be determined.

Table 5-8 - Alternatvie D4 - *Ex Situ* Treatment System Summary

Unit Operation	Type of Equipment Needed	(Number) and size of equipment for costing purposes [a]
Acid and coagulant addition	Rapid mixing tank	(1) 500-gallon tank with impeller
Flocculation	Flocculation tanks	(2) 21,000-gallon flocculation tanks in series
Depth filtration	Sand filters	(1) Sand filter train that consists of three 130-cf sand filter beds in series
10-µm surface filtration	Cartridge filter	(1) Cartridge filter vessel that holds twenty 40-in-long, 25-µm cartridge filters [d]
5-µm surface filtration	Cartridge filter	(1) Cartridge filter vessel that holds twenty 40-in-long, 10-µm cartridge filters [d]
GAC adsorption	GAC beds	(2) 10,000-lb GAC beds in series
2-µm surface filtration	Cartridge filter	(1) Cartridge filter vessel that holds twenty 40-in-long, 2-µm cartridge filters [d]
1-µm surface filtration	Cartridge filters	(1) Cartridge filter vessel that holds twenty 40-in-long, 1-µm cartridge filters [d]
0.5-µm surface filtration	Cartridge filters	(1) Cartridge filter vessel that holds twenty 40-in-long, 0.5-µm cartridge filters [d]
pH adjustment (base addition)	Rapid mixing tank	(1) 500-gallon tank with impeller

Notes:
(a) Equipment sizing information provided by vendor (Baker) with the exception of rapid mixing tanks.
Size of rapid mixing tanks based on two-minute hydraulic retention time (Corbitt 1989).
(d) Each cartridge filter vessel will be equipped with spare vessel in parallel so system can continue running during filter change-out.

Table 5-9 - Summary of Detailed Analysis of Alternatives Applicable to PCBs in the Remelt/Hot Line Groundwater Plume and Associated Smear Zone Soil at the Kaiser Facility

	Criteria	Alternative D1 Institutional Controls, Monitoring, and MNA	Alternative D2 Alternative D1 Plus Hydraulic Containment	Alternative D3 Alternative D2 Plus *Ex Situ* Treatment	Alternative D4 Alternative D1 Plus Limited *Ex Situ* Treatment
Threshold Requirements	Overall Protection of Human Health and the Environment	PCB source control under Alternative D1 relies on physical measures (e.g., existing floor slabs and paved surfaces) which help prevent a future spill or leak from infiltrating into the ground. These physical measures prevent water or chemical spills from reaching impacted soil in the smear zone. The human direct contact or ingestion pathway to Facility workers and visitors is mitigated by Alternatives D1 because of the depth (greater than 20 feet) of the smear zone soil and groundwater plume AOCs; through implementation of institutional controls; and because the groundwater plume does not appear to reach surface water, based on the results of ongoing groundwater monitoring using modified Method 8082. Groundwater natural attenuation processes occurring at the Facility dissipate the plume before it reaches the Spokane River based on PCB concentrations measured using modified Method 8082. Based on this information it can be concluded that Alternative D1 is protective of human health and the environment. If the PCUL of 0.000064 µg/L is being exceeded over time at the locations where groundwater enters the river from the Remelt/Hot Line plume, Alternative D1 would not protect receptors in the River. Alternative D1 is less protective than Alternatives D2 through D4.	Alternative D2 includes the institutional controls, monitoring, and MNA provided by Alternative D1. The combined benefit of hydraulic containment and natural attenuation in Alternative D2 greatly decreases the possibility that groundwater PCBs at concentrations above the PCUL are reaching the Spokane River. Groundwater extraction is estimated to remove approximately 2,300 grams (5.1 pounds) or about 45 percent of PCBs from Remelt smear zone soil in 30 years. PCB-impacted extracted groundwater will be conveyed to a location upgradient of the Oil House area and infiltrated into the soil column, where PCBs will initially be sequestered by the SVOCs in the smear zone soil in the Oil House area and eventually biodegraded as the PCBs enter the aqueous phase. The SVOC groundwater plume in the Oil House area is containeed by the existing IRM system. It is concluded that Alternative D2 is protective of human health and the environment. Alternative D2 is equally protective as Alternative D3 but more protective than Alternatives D1 and D4.	Alternative D3 includes the institutional controls, monitoring, and MNA provided by Alternative D1. Alternative D3 actively extracts and treats approximately 100 percent of the Remelt/Hot Line plume. PCBs will be removed from extracted groundwater by filtration or GAC adsorption and disposed of off site, or destroyed as GAC is regenerated. Extraction of groundwater is estimated to remove and treat approximately 2,300 grams (5.1 pounds) or about 45 percent of PCBs in Remelt smear zone soil in 30 years. Alternative D3 includes operation of a hydraulic containment system (Alternative D2), which is expected to prevent migration of PCBs to the Spokane River during the course of *ex situ* treatment, and natural attenuation processes are expected to continue to occur during this time. Alternative D3 is judged to be equally protective as D2 and more protective than Alternatives D1 and D4.	Alternative D4 includes the institutional controls, monitoring, and MNA provided by Alternative D1. Alternative D4 actively extracts and treats approximately 10 percent of the Remelt/Hot Line plume by volume. PCBs will be removed from extracted groundwater by filtration or GAC adsorption and disposed of off site or destroyed as GAC is regenerated. Extraction of groundwater is estimated to remove and treat approximately 590 grams (1.3 pounds) or about 12 percent of PCBs in Remelt smear zone soil in 30 years. Natural attenuation processes are expected to continue to occur during this time. Alternative D4 is judged to be more protective than Alternatives D1 but less protective than Alternatives D2 and D3.
	Comply with Cleanup Standards	The implementation of Alternative D1 will not result in compliance with MTCA cleanup standards for a long time if a standard POC is established throughout Facility. If a conditional POC is established by Ecology, MTCA standards could be attained under Alternative D1 for the Remelt/Hot Line plume in a shorter time frame. If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above the PCUL of 0.000064 µg/L, Alternative D1 would not meet cleanup standards.	The implementation of Alternative D2 will not result in compliance with MTCA cleanup standards for a long time if a standard POC is established throughout Facility. If a conditional POC is established by Ecology, the PCUL is 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL based on modified Method 8082) for groundwater at the point at which it flows into the Spokane River, and 0.22 µg/L for groundwater everywhere else at the Facility (Ecology 2010a). The corresponding soil concentration is 0.068 mg/kg for PCBs in smear zone soils. It is expected to take from approximately 4 years for the PCB concentrations to decline to these levels.	The implementation of Alternative D3 will not result in compliance with MTCA cleanup standards for a long time if a standard POC is established throughout Facility. If a conditional POC is established by Ecology, the PCUL is 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL based on modified Method 8082) for groundwater at the point at which it flows into the Spokane River, and 0.22 µg/L for groundwater everywhere else at the Facility . The corresponding soil concentration is 0.068 mg/kg for PCBs in smear zone soils. It is expected to take from approximately 4 years for the PCB concentrations to decline to these levels.	The implementation of Alternative D4 will not result in compliance with MTCA cleanup standards for a long time if a standard POC is established throughout Facility. If a conditional POC is established by Ecology, the PCUL is 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL based on modified Method 8082) for groundwater at the point at which it flows into the Spokane River, and 0.22 µg/L for groundwater everywhere else at the Facility. The corresponding soil concentration is 0.068 mg/kg for PCBs in smear zone soils. It is expected to take from approximately 5 years for the PCB concentrations to decline to these levels. If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above the PCUL of 0.000064 µg/L, Alternative D4 would not meet cleanup standards.
	Comply with Applicable State and Federal Law	The identified action-specific ARARs for Alternative D1 consist of requirements associated with implementation of the alternative (see Appendix G, Table G-3). These ARARS are judged to be attainable for Alternative D1.	The UIC and Waste Discharge Programs are not "relevant and appropriate" because they do not address situations that are "sufficiently similar to those encountered at the site and that their use is well suited to the site." The State Groundwater Quality Standards (Chapter 173-200 WAC) do not apply to cleanup actions approved by Ecology under MTCA (WAC 173-200[010][3][c]); rather, groundwater cleanup standards are developed under WAC-173-340-720. There is no AKART for the treatment of the very dilute colloidal PCBs that are present in the Remelt/Hot Line plume at the Facility.	The State Water Quality Standards (WAC 173-200) do not apply to cleanup actions approved by Ecology under MTCA (WAC 173-200[010][3][c]); rather, groundwater cleanup standards are developed under WAC-173-340-720. The treated effluent from Alternative D3 is expected to need to comply with the substantive requirements of the UIC and Waste Discharge Programs. There is no AKART for the treatment of the very dilute colloidal PCBs that are present in the Remelt/Hot Line plume at the Facility. Bench- and pilot-scale studies will be required to determine the effectiveness of the proposed treatment process.	The State Water Quality Standards (WAC 173-200) do not apply to cleanup actions approved by Ecology under MTCA (WAC 173-200[010][3][c]); rather, groundwater cleanup standards are developed under WAC-173-340-720. The treated effluent from Alternative D4 is expected to need to comply with the substantive requirements of the UIC and Waste Discharge Programs. There is no AKART for the treatment of the very dilute colloidal PCBs that are present in the Remelt/Hot Line plume at the Facility. Bench- and pilot-scale studies will be required to determine the effectiveness of the proposed treatment process.
	Provide for Compliance Monitoring	Alternative D1 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative D2 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative D3 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.	Alternative D4 provides for compliance monitoring as per WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760.

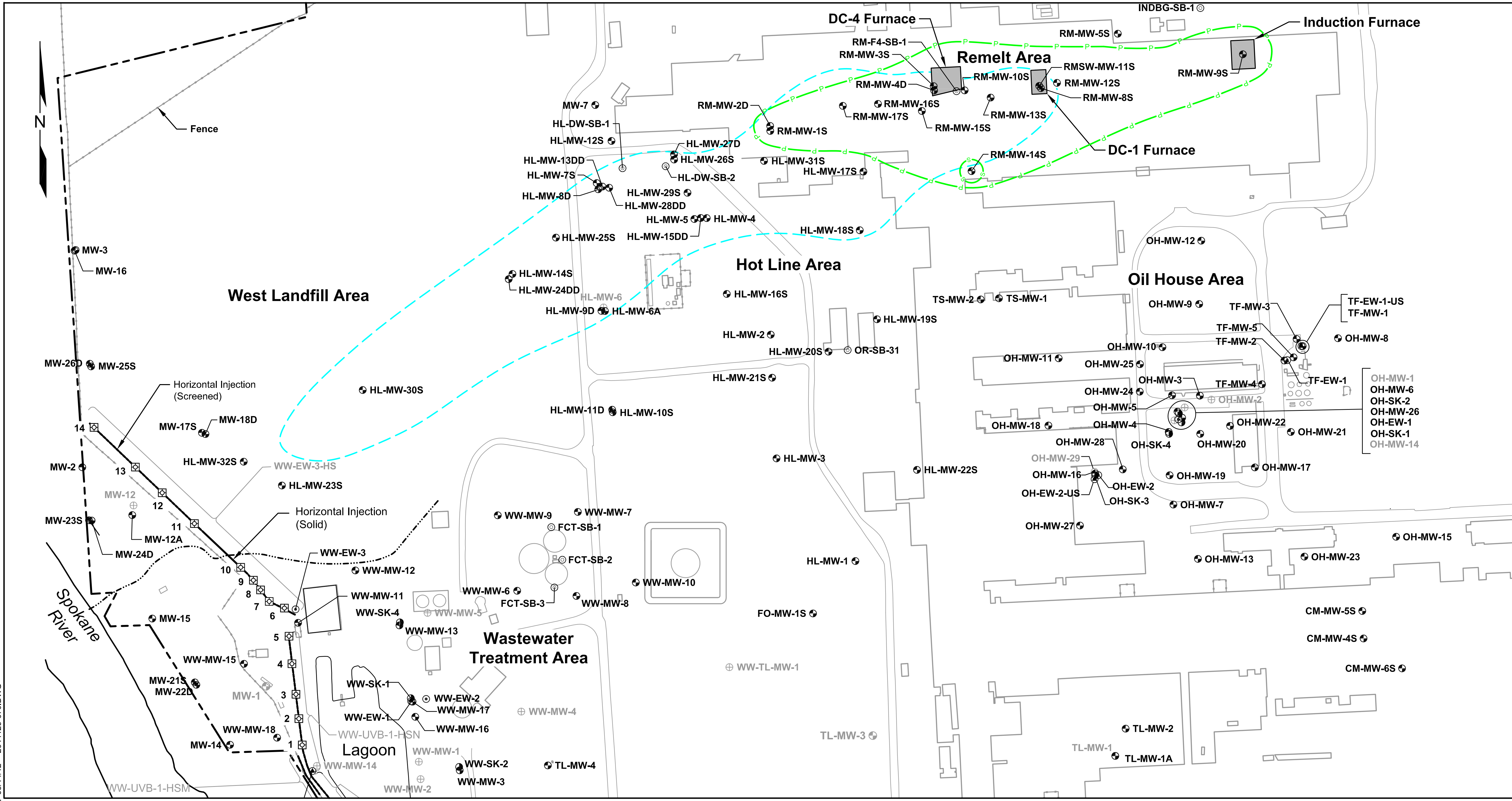
Table 5-9 - Summary of Detailed Analysis of Alternatives Applicable to PCBs in the Remelt/Hot Line Groundwater Plume and Associated Smear Zone Soil at the Kaiser Facility

		Alternative D1	Alternative D2	Alternative D3	Alternative D4
	Criteria	Institutional Controls, Monitoring, and MNA	Alternative D1 Plus Hydraulic Containment	Alternative D2 Plus *Ex Situ* Treatment	Alternative D1 Plus Limited *Ex Situ* Treatment
Disproportionate Cost Analysis	Protectiveness	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.	See "Overall Protection of Human Health and the Environment" above.
	Permanence	Alternative D1 will reduce the toxicity and volume of PCBs through natural attenuation processes and is expected to remove approximately 1500 grams or about 30 percent of tthe PCBs in Remelt smear zone soil in 30 years. Institutional controls and BMPs in place at Kaiser help to prevent the release of PCBs into the environment. Alternative D1 is judged to be less permanent than Alternatives D2, D3, and D4.	In 30 years, it is estimated that the flux provided by extraction wells will remove approximately 2,300 grams (5.1 pounds) of PCBs from Remelt smear zone soil. The extracted PCB mass will be immobilized and contained within the smear zone in the Oil House soil, or will be attenuated by the natural processes that have caused the petroleum groundwater plume (that contains PCBs comingled with SVOCs) in the Oil House area to shrink over time. The Oil House SVOC plume is, in turn, contained by the IRM system that operates at the Facility. Alternative D2 provides the same degree of permanence as Alternative D3 and provides greater permanence than Alternatives D1 and D4.	In 30 years, it is estimated that the flux provided by extraction wells will remove approximately 2,300 grams (5.1 pounds) of PCBs from Remelt smear zone soil. PCBs will be removed from the extracted groundwater through filtration or adsorption onto GAC. PCBs collected by the filters will be disposed of off site at a lined, permitted landfill. PCBs adsorbed on the GAC will be destroyed as the spent GAC is regenerated or incinerated as part of the *ex situ* treatment process. Alternative D3 provides the same degree of permanence as Alternative D2 and provides greater permenance than Alternatives D1 and D4.	Alternative D4 is expected to remove approximately 1800 grams (3.9 pounds) of PCBs from the Remelt smear zone soils during a 30-year operating period. Of the mass transferred into the groundwater in Alternative D4, 1.3 pounds are expected to be extracted and treated; while 2.6 pounds are expected to naturally attenuate. PCBs will be removed from the extracted groundwater through filtration or adsorption onto GAC. PCBs collected by the filters will be disposed of off site at a lined, permitted landfill. PCBs adsorbed on the GAC will be destroyed as the spent GAC is regenerated or incinerated as part of the *ex situ* treatment process. Alternative D4 is judged to be less permanent that Alternative D2 and D3, but more permanent than Alternative D1.
	Effectiveness over the Long Term	The existing containment (building roof, floor slabs, and other pavement), MNA, and institutional controls provided by Alternatives D1 through D4, will prevent PCBs in the smear zone soils and the Remelt/Hot Line plume from reaching human or ecological receptors in the Spokane River (based on the MDL of 0.0045 µg/L for modified Method 8082). Approximately 30 percent of the mass (3.4 pounds) of PCBs is expected to be removed from the smear zone soils below the Remelt building during the initial 30-year operating period of Alternative D1. Alternatives D1 relies on natural attenuation of the Remelt/Hot Line plume that has kept the plume from reaching surface water (based on the results of ongoing groundwater monitoring using modified Method 8082). Alternative D1 is expected to be be less effective over the long term than Alternatives D2, D3, and D4.	Alternatives D2 hydraulically contain the Remelt/Hot Line PCB plume and will protect receptors at the Spokane River. In 30 years, it is estimated that the flux provided by extraction wells will remove approximately 2,300 grams (5.1 pounds) or about 45 percent of PCBs from Remelt smear zone soil. The PCBs in the groundwater that is extracted from the Remelt/Hot Line plume are expected to be biodegraded when they are introduced to the Oil House area. Bench- and pilot-scale tests will be needed to demonstrate that biodegradation of PCBs in the Oil House area is occurring. The Oil House plume is, in turn, contained by the IRM system that operates at the Facility. Alternative D2, in effect, provides double containment of the PCBs in the Remelt/Hot Line plume. Alternative D2 provides an equal degree of long-term effectiveness as Alternative D3, and greater long-term effectiveness than Alternatives D1 and D4.	Alternative D3 hydraulically contains the Remelt/Hot Line plume and will protect receptors at the Spokane River. In 30 years, it is estimated that the flux provided by extraction wells will remove approximately 2,300 grams (5.1 pounds) or about 45 percent of PCBs from Remelt smear zone soil. PCBs will be removed from the extracted groundwater through filtration or adsorption onto GAC. PCBs collected by the filters will be disposed of off site at a lined, permitted landfill. PCBs adsorbed on the GAC will be destroyed as the spent GAC is regenerated or incinerated as part of the ex situ treatment process. Alternative D3 uses a treatment method that has not demonstrated to be effective for the conditions that are present at the Facility (e.g. large flow rates, very dilute concentrations of PCBs, colloidal PCBs). Bench- and pilot-scale tests will be needed to demonstrate that the *ex situ* treatment system will reduce PCB concentrations to the PCUL, and can be effectively operated at the high flow rates (3 MGD) required. Alternative D3 is judged to be equally effectiveover the long term as Alternative D2 , and more effective over the long term than Alternatives D1 and D4.	Alternative D4 uses an *ex situ* process to treat an estimated 590 grams (1.3 pounds) of PCBs over 30 years. Natural attenuation processes are expected to continue for the PCBs in the Remelt/hot Line plume that are not extracted and treated. Alternative D4 uses a treatment method that has not demonstrated to be effective for the conditions that are present at the Facility (e.g. large flow rates, very dilute concentrations of PCBs, colloidal PCBs). Bench- and pilot-scale tests will be needed to demonstrate that the *ex situ* treatment system will reduce PCB concentrations to the PCUL, and can be effectively operated at the high flow rates (300,000 gpd) required. Alternative D4 is judged to be less effective over the long term than Alternatives D2 and D3; and more effective over the long term than Alternative D1.
	Management of Short-Term Risks	Alternative D1 uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring, and does not create any new or additional risk to human health and the environment. The short-term risks that are associated with implementation of institutional controls include industrial hazards that are present in locations where the institutional controls are being implemented. Short-term risks to construction workers during the installation and/or execution of Alternatives D1 through will be mitigated by their adherence to the HASP prepared to guide the health and safety aspects of this work. Alternative D1 poses fewer short-term risks than Alternatives D2, D3, and D4.	Alternative D2 uses existing procedures to implement institutional controls, BMPs, and groundwater monitoring. The short-term risks that are associated with implementing institutional controls include industrial hazards that are present in the locations where the institutional controls are implemented. Additional short-term risks are associated with the construction of new groundwater extraction wells and long runs of underground piping.. Alternative D2 poses more short-term risks than Alternative D1, but fewer short-term risks than Alternatives D3 and D4.	This alternative will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Additional short-term risks to workers result from installing and operating the *ex situ* treatment system. These risks will be mitigated by adherence to the HASP and O&M plan specific to the *ex situ* treatment system. An experienced contractor will manage the removal, transportation, and regeneration or incineration of spent carbon. Alternative D3 produces more short-term risks than Alternatives D1, D2, and D4.	This alternative will use existing procedures to implement institutional controls, BMPs, and groundwater monitoring. Additional short-term risks to workers result from installing and operating the *ex situ* treatment system. These risks will be mitigated by adherence to the HASP and O&M plan specific to the *ex situ* treatment system. An experienced contractor will manage the removal, transportation, and regeneration or incineration of spent carbon. Alternative D4 presents similar risks as Alternative D3 but treats a smaller volume. Alternative D4 produces less short-term risks than Alternative D3, but more short-term risks than Alternatives D1 and D2.

Table 5-9 - Summary of Detailed Analysis of Alternatives Applicable to PCBs in the Remelt/Hot Line Groundwater Plume and Associated Smear Zone Soil at the Kaiser Facility

	Criteria	Alternative D1 Institutional Controls, Monitoring, and MNA	Alternative D2 Alternative D1 Plus Hydraulic Containment	Alternative D3 Alternative D2 Plus *Ex Situ* Treatment	Alternative D4 Alternative D1 Plus Limited *Ex Situ* Treatment
Disproportionate Cost Analysis	Technical and Administrative Implementability	Alternative D1 includes BMPs, groundwater monitoring, and institutional controls, which are already in place at the Kaiser Facility. While there is considerable indication that the degradation of PCBs that are associated with the Remelt/Hot Line plume is occurring within the initial 500 feet of travel from the Remelt building (refer to Appendix F), evidence to support this assertion must still be collected and assessed. Alternative D1 is more implementable than Alternatives D2, D3, and D4.	The installation of groundwater extraction wells and long runs of underground piping have been employed at the Facility in the past and is a practice with which Kaiser is familiar. It is expected that the substantive requirements of the UIC and State Waste Discharge programs will not need to be met to implement Alternative D2. While there are many indications that the degradation of PCBs that are associated with SVOCs in the Oil House and Wastewater Treatment areas has occurred and is occurring (refer to Appendix F), evidence to support these indications still must be collected and assessed. Alternative D2 is more implementable than Alternatives D3 and D4, but less implementable than Alternative D1.	There is no known treatment method for this dilute colloidal PCB plume. While the individual technical components of the treatment process proposed for Alternatives D3 are available, they have never been used individually or together to capture colloidal PCBs at concentrations in the 0.050 µg/L range, so the treatment train is not currently available, in that it has never been assembled for this use. Bench- and pilot-scale testing will be required to determine the implementability of the treatment system. It is expected that the substantive requirements of the UIC and State Waste Discharge programs need to be met to implement Alternative D3. Alternative D3 is less implementable than Alternatives D1, D2, and D4.	There is no known treatment method for this dilute colloidal PCB plume. While the individual technical components of the treatment process proposed for Alternatives D4 are available, they have never been used individually or together to capture colloidal PCBs at concentrations in the 0.050 µg/L range, so the treatment train is not currently available, in that it has never been assembled for this use. Bench- and pilot-scale testing will be required to determine the implementability of the treatment system. It is expected that the substantive requirements of the UIC and State Waste Discharge programs need to be met to implement Alternative D4. Alternative D4 contains the same types of complexity as Alternative D3 but operates at 300,000 gpd rather than at 3 MGD. Alternative D4 is more implementable than Alternative D3, but less implementable than Alternatives D1 and D2.
	Consideration of Public Concerns	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.	This criterion will be addressed during the public comment period for the FS.
	Conceptual-Level Cost (NPV -35/+50 percent)	$19.8 million	$23.1 million	$50.2 million	$27.0 million
	Total Cost per Pound of COC Treated or Contained	Not estimated -- Existing baseline condition.	$4.51 million per pound of PCB contained	$9.8 million per pound of PCB treated	$20.7 million per pound of PCB treated
	Restoration Time Frame	The estimated restoration time frame for PCBs in Alternative D1 are summarized in Appendix I and range from up to 6 years if a conditional POC is established (based on the use of modified Method 8082) to more than 580 years if the standard POC is used by Ecology to establish cleanup criteria. Alternative D1 has the longest restoration time frame.	The estimated restoration time frame for PCBs in Alternative D2 are provided in Appendix I and range from up to 4 years if a conditional POC is established (based on the use of Method 8082 to measure groundwater PCB concentrations) to more than 340 years if the standard POC is used to establish cleanup criteria. Alternative D2 has a restoration time frame equal to D3 and shorter than Alternatives D1 and D4.	The estimated restoration time frame for PCBs in Alternative D3 are provided in Appendix I and range from up to 4 years if a conditional POC is established (based on the use of Method 8082 to measure groundwater PCB concentrations) to more than 340 years if the standard POC is used to establish cleanup criteria. Alternative D3 has a restoration time frame equal to Alternative D2 and shorter than Alternatives D1 and D4.	The estimated restoration time frame for PCBs in Alternative D4 are provided in Appendix I and range from up to 5 years if a conditional POC is established (based on the use of Method 8082 to measure groundwater PCB concentrations) to more than 490 years if the standard POC is used to establish cleanup criteria. The restoration time frame for Alternative D4 is greater than Alternatives D2 and D3 but less than Alternative D1.

Site Plan - Remelt/Hot Line PCB Groundwater Plume and Associated Smear Zone Soil AOC



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Source: Base map from 2007 ALTA Survey by Adams & Clark, provided by Kaiser.

OH-EW-1 ⊙	Extraction Well Location and Number
HL-MW-26S	Monitoring Well Location and Number
WW-MW-5 ⊕	Abandoned Monitoring Well Location and Number
WW-SK-4 ◑	Skimming Well Location and Number
TF-EW-1-US	Upper Screen Well Location and Number
OR-SB-31 ◎	Soil Boring Location and Number
11 ⊠	Horizontal Injection Well Stickup Location and Number

— — (cyan dashed)	Inferred Extent of PCB Concentrations in Groundwater ≥ 5 ng/L (ppt)
—— (green)	Smear Zone Soil
—P—	PCB Area of Screening Level Exceedance in Smear Zone Soil
—S—	SVOC (Heavy Oil) Area of Screening Level Exceedance in Smear Zone Soil

Note: PCB groundwater plume location based on April 2010 analytical data (see Figure 5-4).

0 250 500
Scale in Feet

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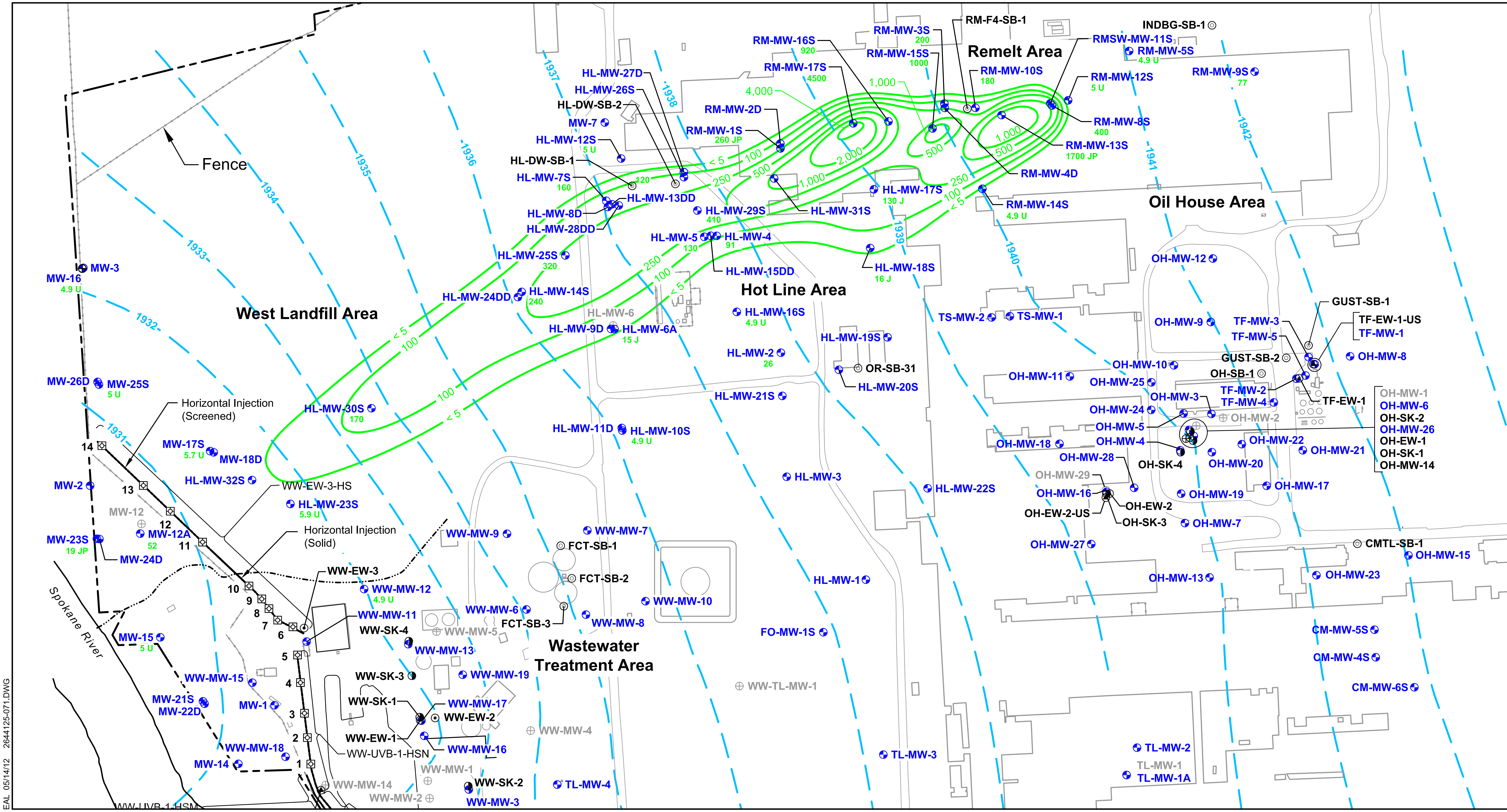
Figure 5-1

April 2009 Groundwater Elevation and PCB Concentration Contour Map



Source: Base map from 2007 ALTA Survey by Adams & Clark, provided by Kaiser.

HL-MW-26S — Monitoring Well Location and Number
200 — PCB Concentration in ng/L (ppt)
U — Not Detected Above Reporting Limits
P — GC Confirmation Criteria Was Exceeded
J — Estimated Value

OH-EW-1 — Extraction Well Location and Number
WW-MW-5 — Abandoned Monitoring Well Location and Number
WW-SK-4 — Skimming Well Location and Number
TF-EW-1-US — Upper Screen Well Location and Number
OR-SB-31 — Soil Boring Location and Number
11 — Horizontal Injection Well Stickup Location and Number

1932 — Groundwater Elevation Contour in Feet (NAVD88)
100 — PCB Concentration Contour in ng/L (ppt) (Based on Shallow Wells Only)
West Discharge Ravine

0 250 500
Scale in Feet
Vertical Datum in NAVD88

N

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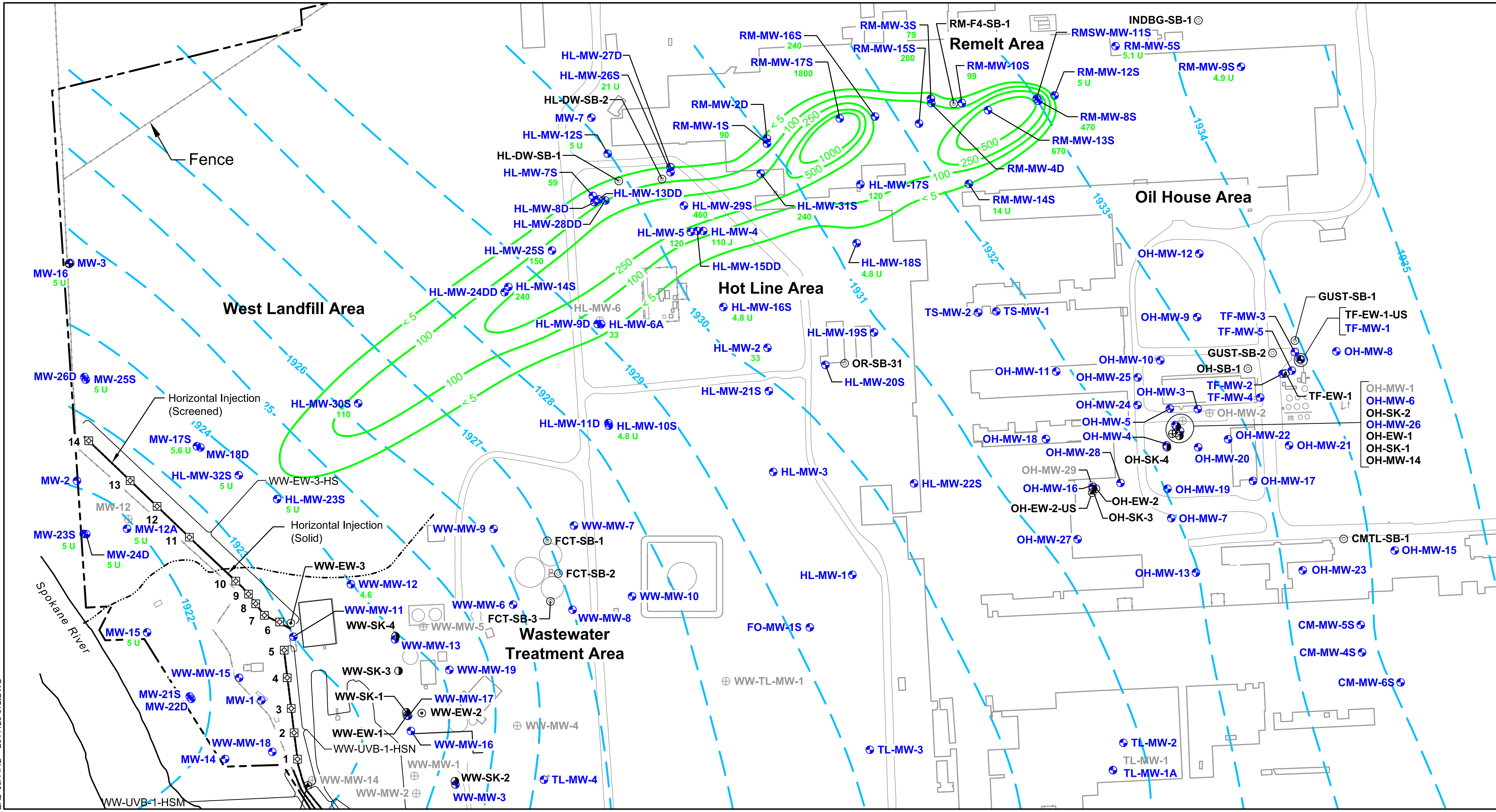
Figure 5-2

October 2009 Groundwater Elevation and PCB Concentration Contour Map



EAL 05/14/12 2644125-072.DWG

Source: Base map from 2007 ALTA Survey by Adams & Clark, provided by Kaiser.

HL-MW-26S	Monitoring Well Location and Number
200	PCB Concentration in ng/L (ppt)
U	Not Detected Above Reporting Limits
J	Estimated Value
OH-EW-1	Extraction Well Location and Number
WW-MW-5	Abandoned Monitoring Well Location and Number
WW-SK-4	Skimming Well Location and Number
TF-EW-1-US	Upper Screen Well Location and Number
OR-SB-31	Soil Boring Location and Number
11	Horizontal Injection Well Stickup Location and Number
1932	Groundwater Elevation Contour in Feet (NAVD88)
100	PCB Concentration Contour in ng/L (ppt) (Based on Shallow Wells Only)
	West Discharge Ravine

0 250 500
Scale in Feet
Vertical Datum in NAVD88

N

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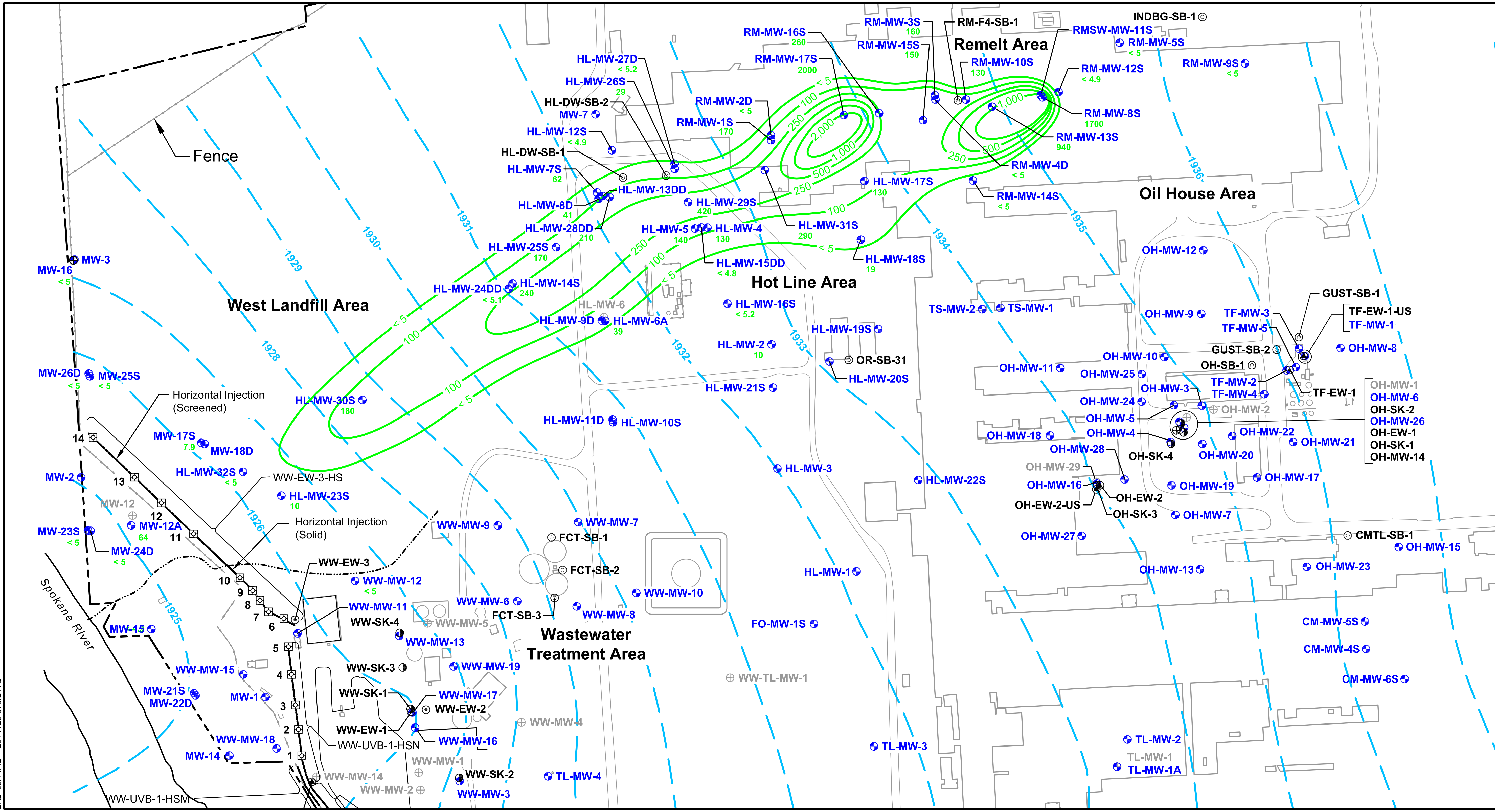
Figure 5-3

April 2010 Groundwater Elevation and PCB Concentration Contour Map



Source: Base map from 2007 ALTA Survey by Adams & Clark, provided by Kaiser.

HL-MW-26S	Monitoring Well Location and Number
200	PCB Concentration in ng/L (ppt)
< 5	Less than Reporting Limit Noted
OH-EW-1	Extraction Well Location and Number
WW-MW-5	Abandoned Monitoring Well Location and Number
WW-SK-4	Skimming Well Location and Number
TF-EW-1-US	Upper Screen Well Location and Number
OR-SB-31	Soil Boring Location and Number
11	Horizontal Injection Well Stickup Location and Number
1932	Groundwater Elevation Contour in Feet (NAVD88)
100	PCB Concentration Contour in ng/L (ppt) (Based on Shallow Wells Only)
	West Discharge Ravine

0 250 500
Scale in Feet
Vertical Datum in NAVD88

N

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Figure 5-4

EAL 05/14/12 2644125-073.DWG

Pump House River Gage Elevation Data

January 2002 - June 2010

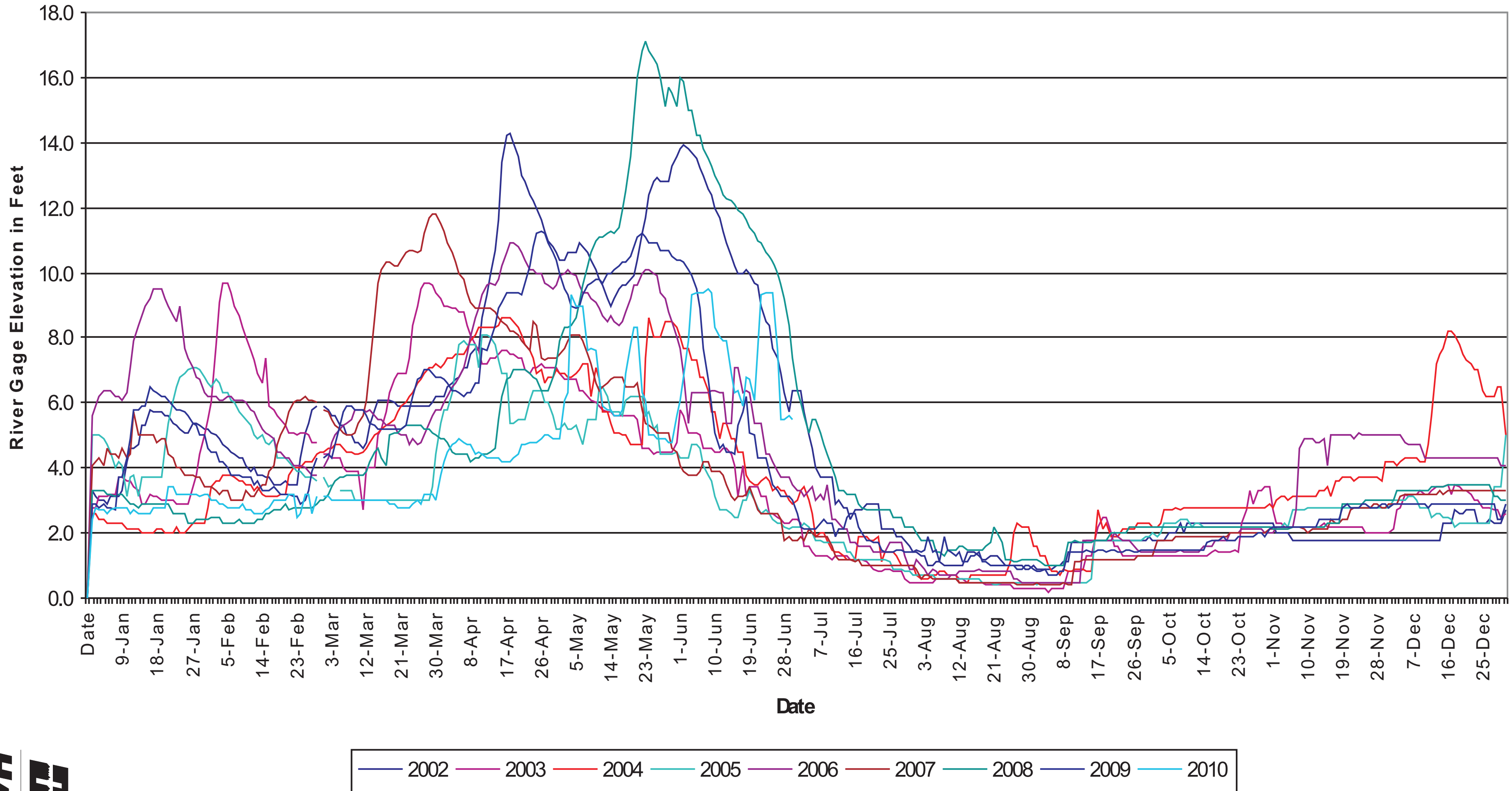

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Figure 5-5
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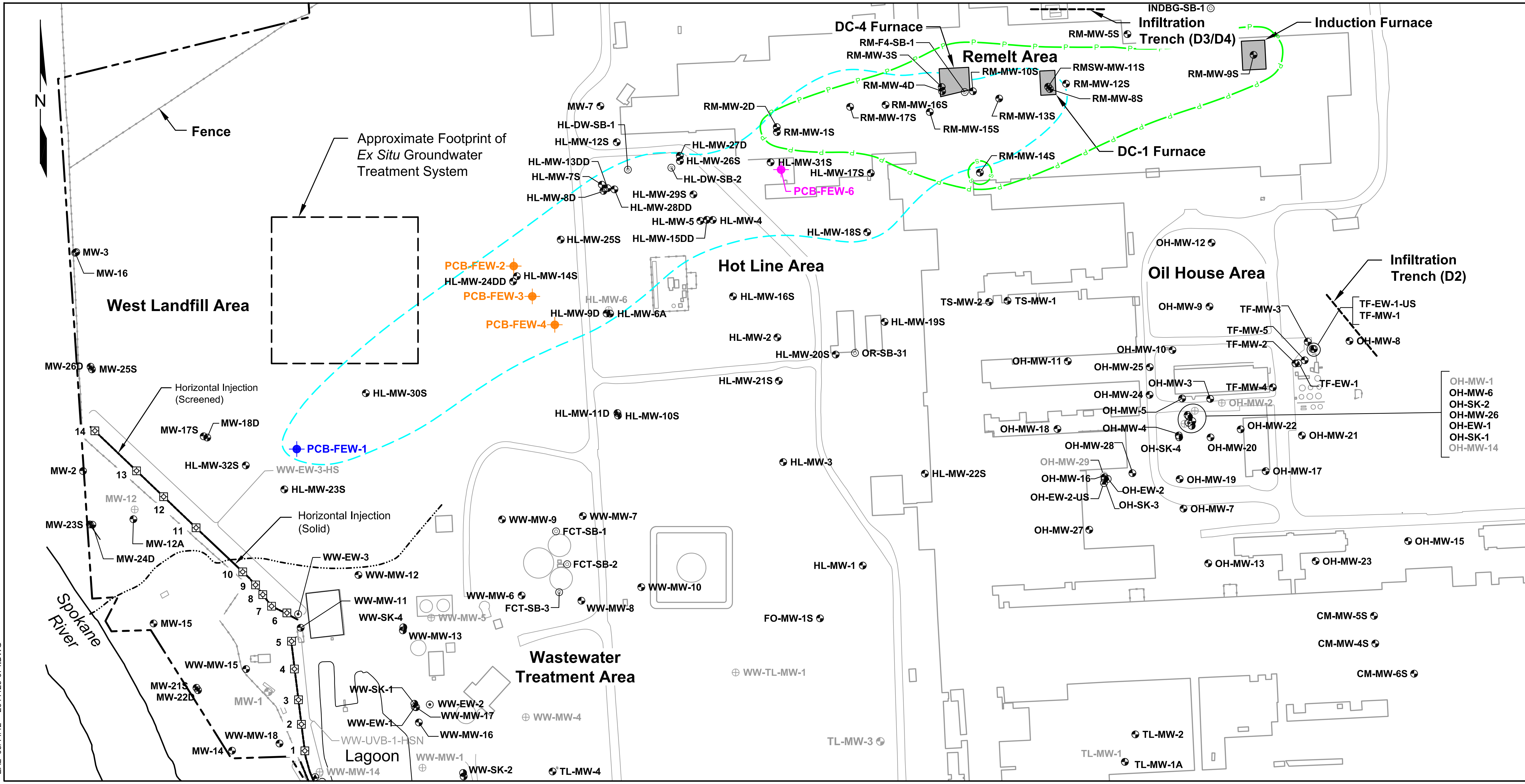
EAL 05/14/11 2644125-AB.cdr

Alternatives D2, D3, and D4 - Proposed Groundwater Extraction Well and Ex Situ Treatment System Locations

Remelt/Hot Line Groundwater Plume



EAL 05/14/12 2644125-074.DWG

Source: Base map from 2007 ALTA Survey by Adams & Clark, provided by Kaiser.

OH-EW-1	Extraction Well Location and Number
HL-MW-26S	Monitoring Well Location and Number
WW-MW-5	Abandoned Monitoring Well Location and Number
WW-SK-4	Skimming Well Location and Number
TF-EW-1-US	Upper Screen Well Location and Number
OR-SB-31	Soil Boring Location and Number
11	Horizontal Injection Well Stickup Location and Number
	Inferred Extent of PCB Concentrations in Groundwater ≥ 5 ng/L (ppt)
	Smear Zone Soil
P	PCB Area of Screening Level Exceedance in Smear Zone Soil
S	SVOC (Heavy Oil) Area of Screening Level Exceedance in Smear Zone Soil
PCB-FEW-1	Proposed Groundwater Extraction Well Location and Number (Scenario D2a)
PCB-FEW-2	Proposed Groundwater Extraction Well Location and Number (Scenarios D2b and D3)
PCB-FEW-6	Proposed Groundwater Extraction Well Location and Number (Scenario 4)

Note: PCB groundwater plume location based on April 2010 analytical data (see Figure 5-4).

0 250 500
Scale in Feet

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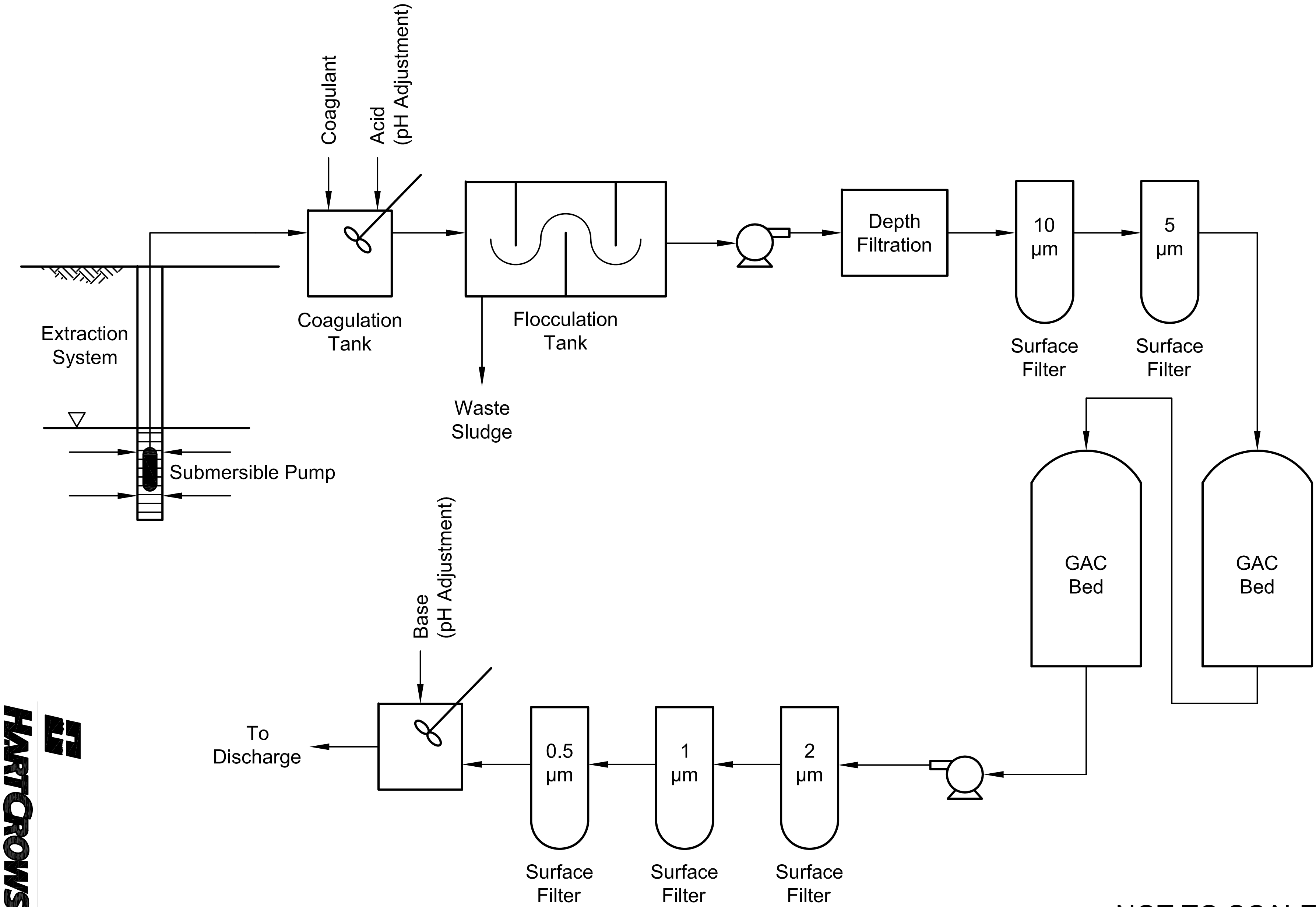
Figure 5-6

Alternatives D3 and D4 - Proposed Ex Situ Treatment Process Flow Diagram
Remelt/Hotline Groundwater Plume



NOT TO SCALE

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Figure 5-7

EAL 05/14/12 2644125-075.DWG

CONTENTS Page

CONTENTS (Continued)

Page

TABLES

FIGURES

6.0 PROPOSED REMEDIATION ALTERNATIVES FOR THE KAISER FACILITY

This FS divides the Kaiser Facility into four distinct segments to facilitate selection of the most appropriate technology-based remedial alternatives for the environmental media present at the Facility. The segments are:

- Near-surface soil (Section 2);
- Deep vadose zone soil (Section 3);
- Petroleum hydrocarbon plumes and associated smear zone soil (Section 4); and
- Remelt/Hot Line PCB plume and associated smear zone soil (Section 5).

The segments were chosen since differing groups of technologies were applied to remediate the COCs in the environmental media in each segment.

The most appropriate technology-based remedial alternative was identified for each COC (i.e., VOCs, SVOCs, PCBs, FPP, and metals) that was in each segment in Sections 2 through 5. Section 6 assembles the most appropriate technology-based remedial alternatives for each segment of the Facility into the combination of alternatives that are judged to be appropriate for each operating area of the Facility (e.g., Oil House, ORB, Wastewater Treatment areas).

Section 6 is organized as follows:

- Section 6.1 – Summary of the Most Appropriate Technology-Based Remediation Alternatives Selected in Sections 2 though 5;
- Section 6.2 – Process Used to Assemble Technology-Based Remediation Alternatives into Alternatives Appropriate for Each Area of the Kaiser Facility;
- Section 6.3 – Area-Based Remediation Alternatives for the Kaiser Facility;
- Section 6.4 – Rough Order of Magnitude (ROM) Cost of the Preferred Remediation Alternatives for the Kaiser Facility; and
- Section 6.5 – Evaluation of the Area-Based Remediation Alternatives Selected for the Kaiser Facility.

6.1 SUMMARY OF THE MOST APPROPRIATE TECHNOLOGY-BASED REMEDIATION ALTERNATIVES SELECTED IN SECTIONS 2 THROUGH 5

Technology-based remedial alternatives identified as potential alternatives for each segment of the Facility were initially assessed to determine whether they met the threshold requirements established by MTCA (WAC 173-340-360[2][a]). A disproportionate cost analysis (WAC 173-340-360[3][e]) was conducted to determine whether the technology-based remedial alternatives that met threshold requirements used permanent solutions to the maximum extent practicable. Each technology-based remedial alternative was evaluated to determine whether it provided for a reasonable restoration time frame (WAC 173-240-360[4]). A comparative analysis of alternatives was conducted to assess the relative capability of alternatives that met threshold requirements to use permanent solutions to the maximum extent practicable, and to provide for a reasonable restoration time frame. The comparative analysis was used to identify the most appropriate technology-based alternative.

The most appropriate technology-based remedial alternatives identified in Sections 2 through 5 of this FS are listed in Table 6-1 and summarized below.

6.1.1 Near-Surface Soil

Alternative A2, which consists of institutional controls, monitoring, monitored natural attenuation (MNA), and containment, was selected as the most appropriate treatment alternative for each of the COCs (VOCs, SVOC, PCBs, metals [lead, arsenic]) that are in the near-surface soil at concentrations above screening levels (SLs) at the Facility. Alternative A2 meets MTCA threshold requirements, uses permanent solutions to the maximum extent practicable, and provides for a reasonable restoration time frame. The containment surfaces provided in Alternative A2 isolate Facility workers and visitors from the COCs in near-surface soil and prevent rainwater infiltration through near-surface soil, which prevents COC migration from near-surface soil to groundwater and potentially to receptors in the Spokane River.

Alternative A2 is described in detail in Section 2.1.2 of this FS. Ecology agreed that Alternative A2 was a viable alternative for near-surface soils with COCs at concentrations above SLs. However, Ecology determined that their preferred remedy for some near-surface soil at the Facility was similar to Alternative A4, and would entail the excavation and off-site disposal of near-surface soil under the following all-inclusive conditions (Ecology 2011):

- Near-surface soil is not located above deep vadose zone soil that contains COCs above cleanup levels;

- The areas in question are neither within a building footprint nor within 20 feet of a building foundation, so as to not undermine the building foundation during excavation;

- The areas in question are not located such that the excavation would jeopardize existing utilities; and

- The areas in question are not under existing asphalt caps that would need to be maintained even if shallow soil contamination were not present (e.g., roadways and asphalt laydown areas).

An index of the relevant text and tables in this FS for Alternatives A2 and A4 is summarized in Table 6-2 and presents the locations of the following:

- Comparative analysis of alternatives used to select Alternative A2 as the most appropriate treatment alternative for near-surface soil;

- Figures that show the near-surface soil AOCs and existing floor slabs and pavement that cover the AOCs; and

- Proposed new cap surfaces and excavation areas.

The institutional controls, groundwater monitoring, and MNA associated with Alternatives A2 and A4 are described in Sections 2.1.1.1, 2.1.1.2, 2.1.1.3, and 2.1.4.3.

The containment surfaces used in Alternative A2 include existing floor slabs, roadways, and new cap surfaces. These containment surfaces total approximately 128,000 square feet (sq ft), of which approximately 35 percent (45,300 sq ft) is located below existing floor slabs or pavement in the operating areas of the Facility. Of the approximately 82,700 sq ft that could comprise new cap surface under Alternative A2, approximately 60,400 sq ft of surface area fit the criteria listed above and can be excavated. The excavated volume is expected to total approximately 29,000 CY.

The new containment technologies judged appropriate for near-surface soil include asphalt, concrete, and multi-layer caps (refer to the FSTM Section 2, Hart Crowser 2012c). The footprint over which the cap associated with Alternative A2 could be applied is described in Section 2.1.2.1 of this FS and the construction of the cap is outlined in Section 2.1.2.2. The O&M requirements that will assure the long-term integrity of the existing floor slabs, pavement, and new cap surfaces are described in Section 2.1.2.3 of this FS.

The near-surface soil areas of excavation are described in Section 2.1.4.1, and a description of the excavation and off-site disposal process is provided in Section 2.1.4.2. The footprint of near-surface soil areas of excavation and new capping surfaces in each operating area of the Facility are shown on Figures 6-1, 6-3, 6-5, 6-7, 6-9, and 6-11 through 6-13.

6.1.2 Deep Vadose Zone Soil

Alternative B2, which consists of institutional controls, monitoring, MNA, and containment was selected as the most appropriate treatment alternative for VOCs, SVOCs, PCBs comingled with SVOCs, and metals (chromium, arsenic) that are in deep vadose zone soil with constituent concentrations above SLs at the Facility. Alternative B2 meets MTCA threshold requirements, uses permanent solutions to the maximum extent practicable, and provides for a reasonable restoration time frame. Alternative B2 is described in detail in Section 3.1.2 of this FS. The containment surfaces provided in Alternative B2 prevent the infiltration of rainwater through deep vadose zone soil and thus prevent the migration of COCs from deep vadose zone soil to groundwater and potentially to receptors in the Spokane River.

The consolidated area of deep vadose zone soil AOCs totals approximately 44,000 sq ft, of which approximately 62 percent (27,400 sq ft) is located below existing floor slabs, pavement, or caps (i.e., Hoffman Tank area multi-layer cap) within the operating areas. The total area of potential new cap installed in Alternative B2 is approximately 16,600 sq ft. The multi-layer cap extension in the Hoffman Tank area will add approximately 3,200 sq ft of cap in this area, which results in a total potential new cap area of approximately 19,800 sq ft. The O&M requirements that will assure the long-term integrity of the existing floor slabs, pavement, and new cap surfaces are described in Section 2.1.2.3 of this FS.

Some of this potential new cap area overlaps with the cap area identified in Alternative A2 to isolate near-surface soil AOCs. The consolidated cap areas needed to isolate Facility workers and visitors from COCs in near-surface soil, prevent rainwater infiltration through near-surface and deep vadose zone soil, and prevent the migration of COCs from soil to groundwater and potentially to receptors in the Spokane River, are defined for each operating area of the Facility on Figures 6-1, 6.3, 6-5, 6.7, and 6-9 through 6-13.

Alternative B5, consisting of institutional controls, monitoring, MNA, and containment, was selected as the most appropriate treatment alternative for PCBs that are not comingled with SVOCs that are in deep vadose zone soil at the Facility. Alternative B5 is described in detail in Section 3.1.5 of this FS. The deep vadose zone soil AOCs where PCBs are not comingled with SVOCs are located below the concrete floor slab of the existing building in the Remelt area and below the existing pavement in the Oil House French Drain area. The area of these PCB AOCs totals approximately 6,900 sq ft.

The floor slab above these AOCs is assumed to be suitable as a containment cap in its current condition. Thus, Alternative B5 will not require the installation of new containment caps; however, monitoring to ensure floor slab integrity and effective containment of the deep vadose zone PCB AOCs will be required. The floor slab O&M and monitoring plans will be prepared as part of the institutional controls element of this alternative, as described in Sections 2.1.1.1 and 3.1.1 in this FS.

An index of the relevant text and tables in this FS for Alternatives B2 and B5 is summarized in Table 6-3, which presents the locations of the following:

- Comparative analysis used to select Alternatives B2 and B5 as the most appropriate treatment alternatives for deep vadose zone soil;

- Figures that show the deep vadose zone soil AOCs, existing floor slabs, and pavement that cover the AOCs; and

- Proposed new cap surfaces.

The footprints of new cap surfaces for deep vadose zone soil in each operating area of the Facility, are shown on Figures 6-1, 6-3, 6-5, 6-7, 6-9, and 6-11 through 6-13.

6.1.3 Petroleum Hydrocarbon Plumes and Associated Smear Zone Soil

The smear zone soil and petroleum hydrocarbon plume AOCs are located at depths that prevent Facility workers and visitors from direct contact with COCs in these areas. Institutional controls in place at the Facility include physical and administrative controls and BMPs that are currently being used to reduce the potential for worker exposure to COCs. Institutional controls also include measures to prevent the potential release of COCs to the environment during industrial activities at the Facility.

Smear zone soil and accumulations of FPP are in contact with groundwater, which allows for the transport of COCs from soil and FPP in these AOCs into groundwater, which can potentially migrate to the Spokane River. Current operation of the groundwater IRM system provides hydraulic containment of the majority of the petroleum hydrocarbon plumes present at the Facility and recovers FPP from the surface of the water table.

The petroleum hydrocarbon plumes, FPP, and smear zone soil AOCs are shown on Figures 4-1 through 4-3. The petroleum and FPP AOCs shown on these figures are generally smaller in area than shown on the corresponding Figures 5-1 through 5-3 contained in the FSTM. The figures in the FSTM were based on data collected through 2008. Figures 4-1 through 4-3 in this FS include more recent data collected during 2009 and 2010.

The extent of the FPP plumes has decreased by 82 and 94 percent in the Wastewater Treatment and Oil House areas, respectively, from historical highs (Hart Crowser 2012b, Table 5-6). More than 4,000 gallons of FPP have been removed using pumps and belt skimmers from the source areas at the Facility (Hart Crowser 2012b, Table 5-4).

The petroleum hydrocarbon plumes are shrinking based on the comparison of the maximum historical lateral extent of hydrocarbons to the extent in 2008 (Hart Crowser 2012b, Figures 5-1 through 5-4). The groundwater concentrations within these plumes have also decreased over the past decade (Hart Crowser 2012b, Table 5-4). This shrinking footprint of the petroleum hydrocarbon plumes is attributed to the FPP removal and natural attenuation that has occurred and is continuing to occur in the plumes (refer to Appendix F). An assessment of biodegradation processes included in Appendix F also indicates that PCBs that are comingled with SVOCs in the petroleum plumes and associated smear zone soil are also subject to biodegradation as the PCBs are released by the SVOCs or otherwise enter the aqueous phase where biodegradation of PCBs under anaerobic or aerobic conditions can occur.

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established.

The existing groundwater IRM system in the Oil House and Wastewater Treatment areas of the Facility is used to control the migration of COCs and FPP with groundwater flow, to recover FPP from the surface of the water table, and to enhance biodegradation of dissolved and residual petroleum hydrocarbons in groundwater in localized areas of the Facility.

Alternative C2 was selected as the most appropriate remediation alternative for the petroleum hydrocarbon plumes and associated smear zone soil at the Facility. Alternative C2 meets MTCA threshold requirements, uses permanent solutions to the maximum extent practicable, and provides for a reasonable restoration time frame. Alternative C2 provides additional containment and FPP removal capability in addition to the institutional control, MNA, and IRM features that are currently present or planned at the Facility. Alternative C2 considers the applicability of two types of containment technologies for petroleum-impacted groundwater and associated smear zone soil: surface containment and hydraulic containment.

Because of the depth of the smear zone and water table, the direct-contact exposure pathway does not exist for the petroleum hydrocarbon plumes and associated smear zone soil. Thus, capping these AOCs would not provide additional human health or environmental benefits. Because smear zone soil and groundwater are in ongoing periodic contact, rainwater that has infiltrated from the surface and traveled through the smear zone would not significantly affect this exposure pathway. Thus, installing surface containment would not provide added human health or environmental benefit by mitigating rainwater infiltration. For these reasons, applying surface containment technology (e.g., a cap) to smear zone soil AOCs was not included as an element of Alternative C2.

Alternative C2 contains an extraction well near the ORB petroleum hydrocarbon plume to provide the hydraulic containment of this plume. However, because of ongoing natural attenuation processes, the limited extent of the petroleum hydrocarbon plume in this area, and data that show that the petroleum plume is shrinking, it has been determined that the ORB containment system is not necessary to meet MTCA requirements and protect human health and the environment. Current groundwater monitoring data indicate that the petroleum hydrocarbon plume in this area is limited to about 300 feet in length and does not extend to the Spokane river (Figure 6-6). MNA activities will continue in the area until natural attenuation processes reduce petroleum concentrations in groundwater near the ORB to protective levels. Institutional controls regarding use of the shallow groundwater for drinking water purposes within the ORB petroleum plume area will be necessary and will protect human health until groundwater conditions improve to acceptable levels. The use of a groundwater containment system in this area would not reduce overall site risk compared to MNA and institutional controls. As a result, a new extraction well located in the ORB area to contain the ORB groundwater plume will not be installed.

Alternative C2 also includes FPP recovery points in the Oil House and Wastewater Treatment areas of the Facility to complete the removal of FPP from groundwater and smear zone soil. The FFP recovery features of Alternative C2 would be operated until the FPP present was removed using normally accepted engineering practices (for example, using belt skimmers).

Alternative C2 is described in detail in Section 4.1.2 of this FS. Alternative C2 uses institutional controls, containment, MNA, and monitoring to break the pathways by which COCs in the petroleum hydrocarbon plumes and associated smear zone soil can reach potential receptors at the Facility or in the Spokane River. An index of the text and tables in this FS for Alternative C2 is summarized in Table 6-4 and presents the locations of the following:

- Comparative analysis used to select Alternative C2 as the most appropriate treatment alternative for the petroleum groundwater plumes and associated smear zone soil;
- Figures that show the petroleum hydrocarbon plumes and associated smear zone soil AOCs; and
- Locations of existing, reactivated, and new FPP skimming wells.

6.1.4 Remelt/Hot Line PCB Plume and Associated Smear Zone Soil

Alternative D2 was selected as the most appropriate remediation alternative for the Remelt/Hot Line PCB plume and associated smear zone soil at the Facility. Alternative D2 meets MTCA threshold requirements, uses permanent solutions to the maximum extent practicable, and provides for a reasonable restoration time frame. Alternative D2 provides hydraulic containment in addition to the institutional controls, MNA, and monitoring features that are currently present or planned at the Facility.

The leading edge of the plume is considered to be stable and located more than 650 feet from the Spokane River. The future use of proposed EPA Method 1668 to measure ultra-low PCB concentrations may indicate that PCBs from the Remelt/Hot Line PCB plume reach the Spokane River at a concentration below 0.0045 micrograms per liter (µg/L), and perhaps below a concentration of 0.000064 µg/L. If PCB are reaching the river at concentrations above 0.000064 µg/L, the combined benefit of natural attenuation and containment provided by the implementation of Alternative D2 would prevent these low concentrations of PCBs from reaching the receptors in the Spokane River.

In September 2010, EPA proposed promulgation of Method 1668C as an agency-approved analytical method to identify PCB congeners at extremely low concentrations (i.e., low picogram per liter (pg/L) levels). The method has not been finalized in part because of significant public concern over a variety of issues, including the reliability of the method to accurately detect PCB congeners at such low concentrations. WAC 173-340-830(3)(c) and (d) specify acceptable analytical methods for use in determining compliance with the groundwater and surface water requirements, respectively. Proposed EPA Method 1668C is not currently included in the MTCA list of methods acceptable for use in determining compliance with groundwater and surface water compliance. If proposed Method 1668C is finalized and Ecology incorporates it into the MTCA, it may be necessary to use the practical quantitation limit (PQL) for the new method as the compliance level for groundwater and surface water as specified in WAC 173-340-707 if the PQL for Method 1668C is also above the PCUL of 0.000064 µg/L.

Alternative D2 relies on existing floor slabs and pavement to eliminate the rainfall to soil to groundwater exposure pathway that could convey COCs from smear zone soil (in addition to near-surface and deep vadose zone soil) to groundwater (refer to Figure 6-7). However, this exposure pathway is not considered to be a significant pathway relative to the extent of COC mobilization into groundwater caused by the seasonal fluctuation of the water table through smear zone soil.

Hydraulic containment of the Remelt/Hot Line PCB plume was considered necessary to assure that MTCA minimum requirements would be achieved, particularly if proposed EPA Method 1668 is approved for use by both the EPA and Ecology to measure ultra-low PCB concentrations and this method indicates that PCBs from the Remelt/Hot Line PCB plume reach the Spokane River at a concentration below 0.0045 µg/L and above a concentration of 0.000064 µg/L. A series of three extraction wells located to the southwest of the Remelt building, near wells HL-MW-24DD and HL-MW-28DD (refer to Figure 6-8), will be installed to contain the Remelt/Hot Line PCB plume even though this plume does not currently appear to be reaching the Spokane River (based on modified Method 8082 with a MDL of 0.0045 µg/L). The containment system will be operated until additional downgradient monitoring well information is collected to confirm that the Remelt/Hot Line PCB plume is not advancing and is in fact retreating toward its source area in the Remelt building.

The extracted groundwater (approximately 3 MGD) will be transported to a location upgradient of the Oil House petroleum hydrocarbon plume (refer to Figure 6-2) and reintroduced to the subsurface. Because PCBs are hydrophobic (Hart Crowser 2012a), and because of their affinity for petroleum hydrocarbons, the PCBs are expected to initially become adsorbed or sequestered by the SVOCs in the smear zone soil and FPP. The PCBs are expected to be attenuated by the natural processes that will anaerobically and aerobically degrade the PCBs as they are released by the SVOCs and enter the aqueous phase (refer to Appendix F).

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established.

The PCBs (approximately 9 pounds) that are presently comingled with SVOCs (approximately 587,000 pounds) (refer to Appendix I) and the very small quantities of additional PCBs that will be introduced to the Oil House area by implementation of Alternative D2 (approximately 5.1 pounds over 30 years) are expected to be biodegraded by anaerobic and aerobic microbes (refer to Appendix F) as the PCBs enter the aqueous phase over time.

Neither SVOC nor PCB concentrations above SLs have been detected in groundwater downgradient from the localized Oil House petroleum hydrocarbon plume (refer to Section 4.1.1.1). The containment of the petroleum hydrocarbon plume in the Oil House area by the currently operating IRM provides an additional level of protection to human health and the environment beyond the protection provided by the ongoing natural attenuation of the plume. In the unlikely event that any PCBs (even colloidal PCBs, such as those in the Remelt/Hot Line plume) are not biodegraded within the Oil House area, and evade hydraulic containment provided by the IRM system for this area, it is expected that natural attenuation processes would reduce the concentration of these PCBs to below the PCUL of 0.000064 μg/L as a result of the processes that are now attenuating the Remelt/Hot Line PCB plume (refer to Appendix E).

Alternative D2 is described in detail in Section 5.1.2 of this FS. An index of the relevant text and tables in this FS for Alternative D2 is summarized in Table 6-5 and presents the following:

- Comparative analysis used to select Alternative D2 as the most appropriate permanent treatment alternative for the Remelt/Hot Line plume and associated smear zone soil;
- Figures that show the Remelt/Hot Line plume and associated smear zone soil AOCs; and
- The location of the new containment wells in the Remelt/Hot Line area and the associated horizontal infiltration system in the Oil House area.

6.2 PROCESS USED TO ASSEMBLE TECHNOLOGY-BASED REMEDIATION ALTERNATIVES INTO ALTERNATIVES APPROPRIATE FOR EACH AREA OF THE KAISER FACILITY

The technology-based remedial alternatives selected for each segment of the Facility are summarized in Section 6.1. The first step in assembling these alternatives into remedial alternatives appropriate for each area of the Facility is to identify the affected areas of the Facility. For the purposes of this section of the FS, the affected operating areas of the Facility were identified as the:

- Oil House area;
- Wastewater Treatment area;
- ORB area;
- Remelt/Hot Line area; and
- Other areas (Cold Mill/Finishing area, Truck Shop area, Former Rail Car Unloading area, and Former Discharge Ravine areas).

The environmental media, COCs that are present at concentrations above SLs, and the technology-based remedial alternatives that must be assembled for each area of the Facility are summarized in Table 6-6.

The next step in assembling the remedial alternatives appropriate for each operating area of the Facility is to gather the information indexed in Tables 6-1 through 6-5. Finally, the information indexed in Tables 6-1 through 6-5 can be assembled as indicated in Table 6-6 to identify the combination of technology-based remedial alternatives that are appropriate for each operating area of the Facility. The combination of technology-based remedial alternatives judged to be appropriate for each operating area of the Facility are discussed in Section 6.3 below.

6.3 AREA-BASED REMEDIATION ALTERNATIVES FOR THE KAISER FACILITY

The area-based remedial alternatives judged to be appropriate for the Facility are discussed in this section. Section 6.3 is organizes as follows:

- Section 6.3.1 – Most Appropriate Remedial Alternatives for the Oil House Area;

- Section 6.3.2 – Most Appropriate Remedial Alternatives for the Wastewater Treatment Area;
- Section 6.3.3 – Most Appropriate Remedial Alternatives for the ORB Area;
- Section 6.3.4 – Most Appropriate Remedial Alternatives for the Remelt/Hot Line Area; and
- Section 6.3.5 – Most Appropriate Remedial Alternatives for Other AOCs of the Facility.

6.3.1 Most Appropriate Remedial Alternatives for the Oil House Area

The Oil House area contains approximately 55 percent of the mass of COCs that are present at concentrations above SLs in the near-surface, deep vadose zone, and smear zone soil at the Facility (percentage derived using modified masses from FSTM Tables 2-18, 3-16, and 4-21). Approximately 98 percent or more of these COCs are SVOCs, primarily diesel, Kensol, and heavy oil. The COCs in Oil House area soil are distributed approximately as follows: near-surface soil (about 1 percent), deep vadose zone soil (about 14 percent), and smear zone soil (about 85 percent).

Remedial Alternatives A2, B2, and B5 were selected as the most appropriate remedial alternatives for near-surface and deep vadose zone soil(refer to Table 6-6). Alternatives A2, B2, and B5 include institutional controls, monitoring, MNA, and surface containment (i.e., cap).

The locations that require surface containment in the Oil House area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-1. These areas include existing floor slabs and pavement, as well as new capped surfaces.

The two petroleum groundwater plumes that are in the Oil House area, associated smear zone soil, and recent detections of FPP are shown on Figure 6-2. The petroleum plumes have been shrinking because of FPP removal and natural attenuation (refer to Appendix F), as have the footprints where FPP has been detected (refer to Section 4.1.1.2). These petroleum hydrocarbon groundwater plumes do not currently present unacceptable risk to human health and the environment.

The groundwater extracted from the Remelt/Hot Line PCB plume to contain its flow and prevent it from flowing toward the Spokane River (refer to Section 6.1.4) will be reintroduced to the soil column at a location upgradient of the Oil

House area (refer to Section 5.1.5.2). The approximate location of the infiltration trench used for this purpose is identified on Figure 6-2.

Alternative C2 will remove the remaining FPP that is in the Oil House area using belt skimmers to the extent practicable. Biodegradation of SVOCs present in the petroleum hydrocarbon plumes and associated smear zone soil has occurred and is expected to continue to occur. The PCBs that are comingled with the SVOCs are expected to be attenuated by the natural processes that will anaerobically and aerobically degrade the PCBs as they are released by the SVOCs and enter the aqueous phase (refer to Appendix F).

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established.

In addition, Alternative C2 will use the existing IRM system that is operating at the Facility to contain the shrinking petroleum hydrocarbon groundwater plumes in the Oil House area. Thus, three remedial measures (MNA of SVOCs and PCBs that are comingled with SVOCs, FPP removal, and hydraulic containment) will prevent the SVOCs and PCBs comingled with the SVOCs in the petroleum hydrocarbon plumes, from reaching potential receptors in the Spokane River. These remedial measures will supplement the institutional controls and monitoring that are integral parts of Alternatives A2, B2, B5, and C2.

In the unlikely event that any PCBs (even colloidal PCBs, such as those in the Remelt/Hot Line plume) are not biodegraded within the Oil House area, and evade hydraulic containment provided by the IRM system for this area, it is expected that natural attenuation processes would reduce the concentration of these PCBs to below the PCUL of 0.000064 μg/L as a result of the processes that are now attenuating the Remelt/Hot Line PCB plume (refer to Appendix E).

6.3.2 Most Appropriate Remedial Alternatives for the Wastewater Treatment Area

The Wastewater Treatment area contains approximately 13 percent of the mass of COCs at concentrations above SLs in the near-surface, deep vadose zone, and smear zone soil at the Facility (percentage derived using modified masses from FSTM Tables 2-18, 3-16, and 4-21). Approximately 98 percent or more of these COCs are SVOCs, primarily diesel, Kensol, and heavy oil. The COCs in the Wastewater Treatment area soil are distributed approximately as follows: near-surface soil (about 10 percent), deep vadose zone soil (about 2 percent), and smear zone soil (about 88 percent).

Remedial Alternatives A2, A4, and B2 were selected as the most appropriate remedial alternatives for near-surface and deep vadose zone soil (refer to Table 6-6). Alternatives A2 and B2 include institutional controls, monitoring, MNA, and surface containment (i.e., cap). Alternative A4 includes excavation and off-site disposal of near-surface soil that meets the criteria listed in Section 6.1.1.

The locations that require surface containment in the Wastewater Treatment area are identified in Table 6-2 and 6-3 and depicted on Figure 6-3. These areas include existing floor slabs, pavement, and caps, in addition to new capped surfaces. The new capped surfaces include an area adjacent to and to the west of the existing Hoffman Tank multi-layer cap. The locations that will be excavated include two areas associated with the Field-Constructed Tanks.

The two petroleum groundwater plumes that are in the Wastewater Treatment area, associated smear zone soil, and recent detections of FPP are shown on Figure 6-4. The petroleum plumes have been shrinking because of natural attenuation (refer to Appendix F), as have the footprints where FPP has been detected (refer to Section 4.1.1.2). These petroleum hydrocarbon groundwater plumes currently are not presenting unacceptable risk to human health and the environment.

Implementation of Alternative C2 will remove the remaining FPP in the Wastewater Treatment area using belt skimmers to the maximum extent practicable. Biodegradation of SVOCs present in the petroleum hydrocarbon plumes and associated smear zone soil has occurred and is expected to continue to occur (refer to Appendix F). The PCBs that are comingled with the SVOCs are expected to be attenuated by the natural processes that will anaerobically and aerobically degrade the PCBs as they are released by the SVOCs and enter the aqueous phase (refer to Appendix F).

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established.

In addition, Alternative C2 will use the existing IRM system that is operating at the Facility to contain the shrinking petroleum hydrocarbon groundwater plumes in the Wastewater Treatment area. Thus, three active remedial measures (MNA of SVOCs and PCBs comingled with SVOCs, FPP removal, and hydraulic containment) will prevent the SVOCs and PCBs comingled with SVOCs in the petroleum hydrocarbon plumes from reaching potential receptors in the Spokane River. These active remedial measures will supplement the institutional controls and monitoring that are integral parts of Alternatives A2, A4, B2, and C2.

6.3.3 Most Appropriate Remedial Alternatives for the ORB Area

The ORB area contains approximately 16 percent of the mass of COCs that are present at concentrations above SLs in the near-surface, deep vadose zone, and smear zone soil at the Facility (percentage derived using modified masses from FSTM Tables 2-18, 3-16, and 4-21). Approximately 98 percent or more of these COCs are SVOCs, primarily diesel, Kensol, and heavy oil. The COCs in ORB area soil are distributed approximately as follows: near-surface soil (about 36 percent), deep vadose zone soil (about 4 percent), and smear zone soil (about 60 percent).

Remedial Alternatives A2, A4, and B2 were selected as the most appropriate remedial alternatives for near-surface and deep vadose zone soil (refer to Table 6-6). Alternatives A2 and B2 include institutional controls, monitoring, MNA, and surface containment. Alternative A4 includes excavation and off-site disposal of near-surface soil that meet the criteria listed in Section 6.1.1.

The locations that require surface containment in the ORB area are identified in Table 6-2 and 6-3 and depicted on Figure 6-5. These areas include existing floor slabs and pavement in addition to new capped surfaces. The new capped surfaces are in areas within 20 feet of the Oil Reclamation building and in the West Depression area, and over areas that contain VOCs. The areas that will be excavated extend to the west of the Oil Reclamation Building and include a small area farther to the west that was associated with the G3 transfer line.

The petroleum groundwater plume that is in the ORB area and associated smear zone soil are shown on Figure 6-6. The petroleum plume has been shrinking as a result of natural attenuation (refer to Appendix F). Significant amounts of FPP have not been recently detected in the ORB area (refer to Section 4.1.). The concentration of SVOCs in the ORB area petroleum hydrocarbon groundwater plume is currently below the SL and PCUL for SVOCs (500 µg/L). This plume is not currently presenting unacceptable risk to human health and the environment.

As discussed above in Section 6.1.3, it has been determined that groundwater containment of the ORB petroleum hydrocarbon plume is not required to meet MTCA requirements and protect human health and the environment. Thus, the extraction well included in Alternative C2 for the ORB area will not be necessary. The natural attenuation of SVOCs is preventing, and will continue to prevent, the SVOCs in the ORB area petroleum hydrocarbon plume from reaching potential receptors in the Spokane River. The IRM supplemented with additional FPP recovery add to the institutional controls and monitoring that are integral parts of Alternatives A2, A4, B2, and C2.

6.3.4 Most Appropriate Remedial Alternatives for the Remelt/Hot Line Area

The Remelt/Hot Line area contains approximately 2.5 percent of the mass of COCs that are present at concentrations above SLs in the near-surface, deep vadose zone, and smear zone soil at the Facility (percentages derived using modified masses from FSTM Tables 2-18, 3-16, and 4-21). Approximately 89 percent or more of these COCs are SVOCs, primarily diesel, Kensol, and heavy oil. The SVOCs in the Remelt/Hot Line area soil are distributed approximately as follows: near-surface soil (about 56 percent), deep vadose zone soil (about 31 percent), and smear zone soil (about 13 percent). The PCBs in the Remelt/Hot Line area soil are distributed approximately as follows: near-surface soil (about 2 percent), deep vadose zone soil (about 98 percent), and smear zone soil (approximately less than 1 percent).

Remedial Alternatives A2, B2, and B5 were selected as the most appropriate remedial alternatives for near-surface and deep vadose zone soil (refer to Table 6-6). Alternatives A2, B2, and B5 include institutional controls, monitoring, MNA, and surface containment.

The locations that require surface containment in the Remelt/Hot Line area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-7. These areas include existing floor slabs and pavement in addition to two small, new cap surfaces located in the vicinity of the historical West Landfill.

The PCB groundwater plume that is in the Remelt/Hot Line area and associated smear zone soil are shown on Figure 6-8. The Remelt/Hot Line groundwater plume has remained relatively stable as a result of natural attenuation (refer to Sections 5.1.1 to 5.1.3 and Appendices E and F). FPP has not been detected in the Remelt/Hot Line area (refer to Section 4.1.1.2). The PCB groundwater plume does not currently present unacceptable risk to human health and the environment based on modified Method 8082 with a MDL of 0.0045 µg/L. (refer to Sections 5.1.2, 5.1.3, and 5.2.2.2).

Alternative D2 will add additional extraction wells at a location near the source of PCBs below the Remelt building to contain the PCB plume in the Remelt/Hot Line area (refer to Figure 6-8). Thus, two remedial measures (MNA and hydraulic containment) will prevent the PCBs in the Remelt/Hot Line groundwater plume from reaching potential receptors in the Spokane River.

The groundwater extracted from the Remelt/Hot Line groundwater plume to contain its flow and prevent it from flowing toward the Spokane River (refer to Section 6.1.4) will be reintroduced to the soil column at a location upgradient of the Oil House area (Refer to Section 5.1.5.2). The approximate location of the infiltration trench used for this purpose is identified on Figure 6-2. Because PCBs are hydrophobic (Hart Crowser 2012a), and because of their affinity for petroleum hydrocarbons, the PCBs are expected to initially become adsorbed or sequestered by the SVOCs in the smear zone soil. The PCBs are expected to be attenuated by the natural processes that will anaerobically and aerobically degrade the PCBs as they are released by the SVOCs and enter the aqueous phase (refer to Appendix F). These remedial measures will supplement the institutional controls and monitoring that are integral parts of Alternatives A2, B2, B5, and D2.

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established.

6.3.5 Most Appropriate Remedial Alternatives for Other AOCs of the Kaiser Facility

The other AOCs of the Facility, which include the Cold Mill/Finishing area, Truck Shop area, Former Rail Car Unloading area, and the Former Discharge Ravine areas, contain approximately 13.5 percent of the mass of COCs that are present at concentrations above SLs in the near-surface, deep vadose zone, and smear zone soil at the Facility (percentages derived using modified masses from FSTM Tables 2-18, 3-16, and 4-21). Approximately 98 percent or more of these COCs are SVOCs, primarily diesel, Kensol, and heavy oil. The COCs in the soil in the other operating areas are distributed in soil approximately as follows: near-surface soil (about 5 percent), deep vadose zone soil (approximately less than 1 percent), and smear zone soil (about 95 percent). Approximately 95 percent of the mass of COCs in the other AOCs is present in the Cold Mill/Finishing area.

Remedial Alternatives A2, A4, and B2 were selected as the most appropriate remedial alternatives for near-surface and deep vadose zone soil (refer to Table 6-1). Alternatives A2 and B2 include institutional controls, monitoring, MNA, and surface containment. Alternative A4 adds excavation and off-site disposal of near-surface soil that meet the criteria identified in Section 6.1.1.

6.3.5.1 Cold Mill/Finishing Area

The locations that require surface containment in the Cold Mill/Finishing area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-9. These areas include existing floor slabs and pavement in addition to two small, new cap surfaces in the Chromium Transfer Line area.

The petroleum groundwater plume in the Cold Mill/Finishing area and associated smear zone soil are shown on Figure 6-10. The petroleum plume has been shrinking as a result of natural attenuation (refer to Appendix F). The petroleum hydrocarbon groundwater plumes are not currently presenting unacceptable risk to human health and the environment (refer to Section 4.2.2).

Alternative C2 will use the existing IRM system that is operating at the Facility to contain the shrinking petroleum hydrocarbon groundwater plume in the Cold Mill/Finishing area. Thus, two remedial measures (MNA of SVOCs and PCBs comingled with SVOCs, and hydraulic containment) will prevent the SVOCs in the petroleum-contaminated groundwater plume, and PCBs comingled with the SVOCs in the smear zone soil, from reaching potential receptors in the Spokane River. These remedial measures will supplement the institutional controls and monitoring that are integral parts of Alternatives A2, B2, and C2.

6.3.5.2 Truck Shop Area

The Truck Shop area is located east of the Hot Line area and south of the Remelt area. The Truck Shop area is used for vehicle maintenance and consists of an enclosed steam-cleaning room, an equipment repair area (inside the main building), and an office structure. A 2,000-gallon UST is located east of the steam-cleaning room. The tank has been taken out of service but remains in place. Near-surface and deep vadose zone soil contains SVOCs at concentrations above SLs at this location. Near-surface soil also contains a small quantity of VOCs at concentrations above SLs.

The locations that require surface containment in the Truck Shop area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-11. These areas include existing floor slabs and pavement plus new cap surfaces. Smear zone soil is not impacted at this location.

6.3.5.3 Former Rail Car Unloading Area

This area of the Facility was historically used to unload fuel that arrived at the plant by rail car or truck. Currently a pump house building, formerly used east and west fuel lines, and the rail spur remain in place. The majority of the area is bare ground. There is minimal activity on this area, which has minimal access, although Evergreen Way to the immediate west experiences heavy vehicle traffic.

The Former Rail Car Unloading (RCU) area contains SVOCs at concentrations above SLs in near-surface and deep vadose zone soil. The locations that require surface containment or excavation in the RCU area are identified in Tables 6-2 and 6-3 and depicted on Figure 6-3. Several surface soil locations in the RCU area will be excavated and the soil disposed of off site. One area in the RCU area will be capped.

The northeast end of the north petroleum groundwater plume in the Wastewater Treatment area may extend to the vicinity of the RCU area.

6.3.5.4 Former Discharge Ravines

The approximate location of the former discharge ravines are shown on Figures 6-12 (South) and 6-13 (West). The former West Discharge Ravine (WDR) is located north and northwest of the wastewater lagoon and started near the sanitary wastewater treatment plant. The WDR trends south and west toward the Spokane River. This ravine was used to convey process water to the Spokane River from the northern end of the mill prior to construction of the first industrial wastewater treatment (IWT) plant in 1973.

The former South Discharge Ravine (SDR) is located directly south of the plant. The open channel section of the ravine starts at the south fence line and runs generally north to south through adjacent property toward the Spokane River. This ravine was used to convey process water from the southern end of the mill to the Spokane River prior to construction of the IWT plant in 1973.

There is no infrastructure in the ravines, although they are adjacent to unpaved perimeter roadways and fence lines. Additionally, Kaiser's current IWT outfall pipe and off-gas structure is located along the top of the slope of the southern WDR side wall. No Facility-related activities have taken place in the former discharge ravines since 1973.

The WDR contains an estimated 6 pounds of PCBs in near-surface soil. The SDR is estimated to contain approximately 640 pounds of SVOCs and 5 pounds of PCBs in near-surface soil (masses modified from FSTM Table 2-18). The locations that require surface containment or excavation in the SDR and WDR areas are identified in Tables 6-2 and 6-3 and depicted on Figure 6-12 and 6-13, respectively. The uneven surfaces in these areas will require that a multi-layer cap be installed in locations designated for capping. The segment of the WDR west of the perimeter road has steep side walls that prohibit further excavation in this area. This area will receive a multi-layer cap. The side walls of the SDR are less steep. This FS assumes that the soil in the SDR will be excavated and disposed of off site.

6.4 ROM COST OF THE PREFERRED REMEDIATION ALTERNATIVES FOR THE KAISER FACILITY

The rough order of magnitude (ROM) estimated cost of the technology-based remediation alternatives described in Sections 2 through 5 are contained in Appendices A through D. These estimated costs were used to evaluate the financial cost of relative reductions in the human health and environmental risks posed by each of the alternatives evaluated to remediate near-surface, deep vadose zone, and smear zone soil and of the remediation alternatives evaluated to address the petroleum hydrocarbon plumes and Remelt/Hot Line PCB plume.

Many of the cost elements (institutional controls, monitoring, MNA) included in the cost estimate for Alternative B2 were also included in the cost estimate for Alternative A2/A4. Thus, the overall cost of implementing both Alternatives A2/A4 and B2 in an operating area of the Facility would include the cost of Alternative A2/A4 plus the incremental cost of the additional containment surfaces (and associated O&M) necessary to cut the soil to groundwater pathway for deep vadose zone soil (incremental cost of Alternative B2).

For those operating areas (Oil House, ORB, Wastewater Treatment, and Cold Mill/Finishing areas) where Alternative C2 is implemented in addition to Alternatives A2/A4 and B2, the overall cost for the operating area would include:

- The cost of Alternative A2/A4, which includes the added incremental cost of Alternative A4 for excavation and off-site disposal of near-surface soil that meets the criteria listed in Section 6.1.1;

- The added incremental cost of the additional containment surfaces (and associated O&M) necessary to remove the soil to groundwater pathway for deep vadose zone soil (Alternative B2); and

- The added incremental cost of Alternative C2 (e.g., removing FPP and operating or expanding the existing IRM system).

Similarly, for the Remelt/Hot Line area, where Alternative D2 is implemented in addition to Alternatives A2/A4 and B2, the overall cost for the operating area would include:

- The cost of Alternative A2/A4;

- The added cost of the additional containment surfaces (and associated O&M) necessary to cut the soil to groundwater pathway for deep vadose zone soil (Alternative B2); and

- The added incremental cost of Alternative D2 (e.g., installing and operating the new groundwater extraction and redistribution system).

The cost estimates (refer to Appendices A through D) prepared for Alternatives A2, A4, B2, B5, C2, and D2 were developed on a Facility-wide basis for each environmental segment (i.e., near-surface soil, deep vadose zone soil, groundwater plumes, and associated smear zone soil) present at the Facility. Each cost estimate is a standalone estimate that assumed only its specific environmental segment would be remediated. As a result, each cost estimate contained some costs that are redundant, such as costs associated with institutional controls, monitoring, and MNA. These costs actually will be shared among the alternatives that would be implemented at the Facility. The actual cost of implementing the combined recommended alternatives for the Facility will be significantly less than the sum of the individual cost estimates prepared for each of the alternatives. The total estimated cost of implementing the recommended alternatives at the Facility is approximately $31.6 million (-35 to +50 percent). This estimate was prepared by identifying a baseline cost (Alternative A2/A4) and adding the incremental costs associated with Alternatives B2, B5, C2, and D2 to this baseline cost. This process is summarized in Table 6-7.

6.5 EVALUATION OF THE PREFERRED AREA-BASED REMEDIATION ALTERNATIVES SELECTED FOR THE KAISER FACILITY

The environmental media, COCs that are present at concentrations above SLs, and the technology-based remedial technologies that must be assembled for each area of the Facility are summarized in Table 6-6. The combination of technology-based remedial alternatives judged to be appropriate for each operating area of the Kaiser Facility were discussed in Section 6.3 above. These technologies are evaluated in this section. The evaluation assesses the capability of the selected remediation alternatives to meet the remedial action objectives (RAOs) established for the Facility.

The RAOs that are appropriate for the soil and groundwater AOCs at the Facility are:

- Protect Facility workers and visitors from direct contact (and/or ingestion) with contaminated near-surface soil containing lead, PCBs, and SVOCs;
- Protect groundwater and surface water quality from the COCs that may leach from soil to groundwater that flows toward the Spokane River, to protect human and ecological receptors that may use these resources.
- Meet the overall MTCA threshold requirements under WAC 173-340-360(2)(a), as defined by WAC 173-340-740(6)(f) for surface containment remedies;
- Use permanent solutions to the maximum extent practicable (WAC 173-340-360[3]);
- Provide for a reasonable restoration time frame (WAC 173-340-360[2][b][ii]);
- Meet MTCA requirements for groundwater cleanup actions (WAC 173-340-360[2][c]); and
- Consider public concerns (WAC 173-340-360[2][b][iii]).

The ways in which the selected area-based remedial alternatives meet these RAOs is discussed below.

6.5.1 Threshold Criteria

6.5.1.1 Protect Human Health and the Environment

Near-Surface and Deep Vadose Zone Soils

Institutional controls (physical and administrative measures) and BMPs (including substantial improvements in the Remelt building [refer to Table 2-2]) will be used to reduce the potential for worker and visitor exposure to the COCs that are present in near-surface and deep vadose zone soils (refer to Section 2.1.1.1). Performance and protection monitoring will be implemented. MNA of near-surface and deep vadose zone soil will continue.

Accessible near-surface soils with concentrations of COCs above SLs will be excavated and disposed of off site. Excavation and off-site disposal will be implemented in those near-surface soil AOCs where no COCs at concentrations above SLs will remain in deep vadose zone soil after the near-surface soil has been remediated. These measures will reduce the potential for COCs in near-surface and deep vadose zone soil to migrate to groundwater.

A containment surface (existing pavement and floor slabs, and new asphalt, concrete, or multi-layer cap) will be placed above each deep vadose zone soil AOC and above each near-surface soil AOC that is not excavated. A stormwater collection system will be installed along with the new containment surfaces to direct stormwater to soil areas that are not contaminated and allow it to infiltrate, or to direct it to the Kaiser WWT facility. The containment surfaces will prevent Facility workers and visitors from direct contact with COCs in these areas, and will prevent rainwater from conveying COCs from near-surface soil to groundwater.

The excavation and off-site disposal of the excavated soil removed from the near-surface soil AOCs impacted by SVOCs, PCBs, and metals, will prevent Facility workers and visitors from directly contacting COCs in these AOCs, and will prevent rainwater from conveying COCs from near-surface soil to groundwater. A total of approximately 107,000 pounds of COCs are expected to be excavated and disposed of off site (refer to Section 6.1.1).

The natural attenuation processes of near-surface soil discussed in Section 2.1.1.3 will continue and will be monitored for progress.

Surface containment (Alternatives A2 and B2) will not actively reduce the concentration of the COCs in near-surface or deep vadose zone soil at the Facility to meet the SLs that have been established for these COCs. Some natural attenuation of SVOCs in near-surface and deep vadose zone soil has occurred and is expected to continue. The excavation and off-site disposal of near-surface soil and the installation of new containment surfaces above remaining near-surface and deep vadose zone soil AOCs can be implemented in 2 to 3 years. These remedial measures will produce a significant reduction in the risk to potential human and ecological receptors.

Groundwater quality that currently exceeds SLs below the containment surfaces will be improved by Alternatives A2/A4 and B2. Since the COCs in smear zone soil will continue to contact groundwater, Alternative A2/A4 alone is not expected to cause the concentration of COCs in groundwater to fall below SLs for a long time. However, approximately 107,000 pounds of COCs will be removed from the Facility, and the containment surfaces will reduce the potential for COCs to migrate from the unsaturated soil above the smear zone to the water table.

Petroleum Groundwater Plumes and Associated Smear Zone Soil

Alternative C2 provides hydraulic containment of the petroleum hydrocarbon groundwater plumes and adds additional FPP removal at the Facility. An assessment of natural attenuation processes in groundwater at the Facility (Appendix F) demonstrates that the petroleum hydrocarbon groundwater plumes are shrinking. Biodegradation of SVOCs in the petroleum groundwater plumes is being promoted by the high levels of dissolved oxygen and other electron acceptors that are present in most plume areas. The PCBs comingled with SVOCs can be biodegraded by anaerobic and aerobic microbes once the PCBs partition from the SVOCs and enter the aqueous phase (refer to Appendix F). Anaerobic conditions are generally present in areas where FPP is present (refer to Figure F-2), with aerobic conditions typically present in the other areas where petroleum plumes are located.

The combined benefit of hydraulic containment, FPP removal (see below), and active natural attenuation greatly decreases the possibility that COCs (SVOCs and PCBs comingled with SVOCs) present at concentrations above SLs at the Facility could reach the Spokane River. Ongoing groundwater monitoring confirms that petroleum constituents and associated COCs are not migrating beyond the downgradient Facility property line (Hart Crowser 2012a).

Alternative C2 expands source control measures at the Facility by expanding FPP recovery through installation and operation of one additional skimming well and restarting operations at two existing idle skimming locations (see Section 4.1.2.3). FPP recovery will be implemented where historical FPP thickness measurement data indicate the ongoing presence of FPP. Because the source area in smear zone soil is likely to be present for some time, transfer of COCs from the smear zone and FPP into groundwater will be ongoing as groundwater flows through these impacted areas. The concentrations of these COCs in groundwater are expected to reach the SLs and PCULs listed in Tables 4-1 in approximately 4 years (Oil House area South plume) to 34 years (Wastewater Treatment area North plume) (Refer to Appendix I).

Alternative C2 does not completely cut the rainfall to soil to groundwater exposure pathway that could convey COCs from smear zone soil to groundwater. However, this exposure pathway is not considered to be a significant pathway relative to the extent of COC mobilization into groundwater caused by the seasonal fluctuation of the water table through smear zone soil.

Alternative C2 acts to reduce the concentration of COCs in the petroleum hydrocarbon groundwater plumes, and in associated smear zone soil, by adding oxygen to groundwater through the operation of the existing IRM and by the addition of FPP skimming locations. Alternative C2 further controls the potential risk to receptors in the Spokane River through the hydraulic containment of the petroleum hydrocarbon groundwater plume COCs, and through natural attenuation causing the petroleum hydrocarbon plumes to shrink. The risk to human receptors that may extract and drink petroleum-contaminated groundwater is controlled by the current practice that prohibits this activity at the Facility, and by a restrictive covenant that will prohibit this activity in the future.

Remelt/Hot Line PCB Plume and Associated Smear Zone Soil

The smear zone in the Remelt/Hot Line area contains PCBs at an average concentration of approximately 0.07 mg/kg, or a total quantity of approximately 11.4 pounds of PCBs (refer to Table 1 of the Remelt/Hot Line PCB Restoration Time Frame memo included in Appendix I). Groundwater that flows through this smear zone has mobilized some of these PCBs and created the Remelt/Hot Line PCB plume. Most of the Remelt/Hot Line PCB plume and smear zone soil reside beneath the floor slab of the existing building. Alternative D2 provides floor slabs and existing pavement over the majority of the smear zone soil AOC that directly cut the rainfall to soil to groundwater exposure pathway that could convey PCBs from smear zone soil.

An assessment of plume boundaries in groundwater at the Facility (Section 5.1.4.1) indicates that the leading edge of the Remelt/Hot Line PCB plume has remained more than 650 feet from the Spokane River. This FS defines the leading edge of the plume (refer to Section 5.1) as located in the vicinity of well HL-MW-30S based on modified Method 8082, which has a MDL of 0.0045 µg/L. The MDL for EPA Method 1668 (if promulgated) is expected to be below 0.0045 µg/L. EPA Method 1668 has not been finalized as a rule under the Clean Water Act and has not been incorporated into MTCA, and is under review as this FS is being prepared.

It is not known as this FS is being prepared whether the weight of evidence of future analyses using proposed EPA Method 1668 will show that the PCB SL and PCUL of 0.000064 µg/L is being exceeded over time at the location where groundwater from the Remelt/Hot Line plume enters the Spokane River. Alternative D2 will protect receptors in the Spokane River if the future use of proposed EPA Method 1668 determines that PCBs are currently reaching the river at concentrations above 0.000064 µg/L.

An assessment of natural attenuation processes in groundwater at the Facility (Appendix F) indicates that these processes are present in the Remelt/Hot Line plume, particularly in the first 500 feet downgradient from the Remelt building.

The combined benefit of hydraulic containment and natural attenuation greatly decreases the probability that PCBs from the Remelt/Hot Line plume at concentrations above the SL and PCUL of 0.000064 µg/L at the Facility are reaching the Spokane River. Ongoing groundwater monitoring confirms that PCBs are not migrating beyond the downgradient Facility property boundary (Hart Crowser 2012a) based on modified Method 8082 with a MDL of 0.0045 µg/L.

The groundwater extracted in Alternative D2 will reduce the concentration of PCBs in smear zone soil below the Remelt building over time as PCBs partition into the groundwater flowing through the plume. PCB concentrations are likely to exceed the PCB SL and PCUL for a standard point of compliance (POC) (0.000064 µg/L) for a long time in the Remelt/Hot Line AOC. If a conditional POC is established by Ecology, the restoration time frame needed to reach the PCUL (0.22 µg/L) in the source area would decrease to approximately 4 years (refer to Appendix I).

Alternative D2 controls the risk to receptors in the Spokane River through natural attenuation that has kept the leading edge of the Remelt/Hot Line plume greater than 650 feet from the Spokane River and through the hydraulic containment of PCBs in the Remelt/Hot Line groundwater plume (based on modified Method 8082 with a MDL of 0.0045 µg/L). The new hydraulic containment system installed in Alternative D2 will extract groundwater that contains PCBs from the Remelt/Hot Line area plume. The extracted groundwater will be infiltrated in the vicinity of the Oil House area. This small PCB mass being infiltrated (about 5.1 pounds over 30 years) will initially be immobilized and contained by the SVOCs present in the smear zone soil in this area (approximately 587,000 pounds). The PCBs are expected to be biodegraded by anaerobic and aerobic bacteria as the PCBs partition from the SVOCs to the aqueous phase over time (refer to Appendix F). The Oil House area groundwater plume will itself be contained by the operation of the IRM system, which currently contains the petroleum groundwater plume in this area.

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established.

In the unlikely event that any PCBs (even colloidal PCBs, such as those in the Remelt/Hot Line PCB plume) are not biodegraded within the Oil House area, <u>and</u> evade hydraulic containment provided by the IRM system for this area, it is expected that natural attenuation processes would reduce the concentration of these PCBs to below the SL and PCUL of 0.000064 µg/L as a result of the processes that are now attenuating the Remelt/Hot Line groundwater plume (Appendix E).

Alternative D2 is protective of human health and the environment because:

- It mitigates human health direct contact and ingestion pathways by the use of institutional controls, surface containment (building roof, floor slabs, and other pavement), and MNA;
- It allows natural processes to keep the leading edge of the Remelt/Hot Line groundwater plume 650 feet or more from the Spokane River (based on the use of modified Method 8082 to measure groundwater PCB concentrations);
- It adds another level of risk control by hydraulically containing the Remelt/Hot Line groundwater plume and preventing the plume from reaching receptors in the Spokane River;
- It allows biodegradation of the PCBs to occur in the Oil House area; and
- It continues the use of the existing IRM system to contain the Oil House plume.

Thus, the combination of Alternatives A2/A4, B2, B5, C2, and D2 is judged to be protective of human health and the environment.

6.5.1.2 Comply with MTCA Cleanup Standards

The SLs and PCULs developed for the Facility were based on the requirements of MTCA and contaminant-specific state and federal applicable or relevant and appropriate requirements (ARARs). They were designed to be conservative. Final cleanup levels will be established by Ecology in the cleanup action plan. The SLs are currently exceeded in the near-surface and deep vadose zone AOCs identified in Sections 2 and 3. The excavation and off-site disposal of approximately 29,000 cubic yards (CY) of near-surface soil that contains approximately 107,000 pounds of COCs will directly reduce the risk to human health and the environment posed by these COCs. Although surface containment (Alternatives A2 and B2) is not expected to directly reduce the concentration of COCs that are in near-surface and deep vadose zone soil, Alternatives A2 and B2 can be deemed to meet SLs if certain requirements set out in WAC 173-340-740(6)(f) are met. The surface containment proposed for the Facility meets these criteria (refer to Sections 2.2.4 and 3.2.3).

SLs are currently exceeded in the smear zone soil and petroleum-impacted groundwater AOCs identified on Figures 4-1 through 4-5 and in smear zone soil below the Remelt building and in the Remelt/Hot Line groundwater plume (Figures 5-6 and 6-8). Alternatives C2 and D2 will directly reduce the concentration of COCs in these AOCs over time (refer to Appendix I).

The SLs for groundwater established in the FSTM and the PCULs established for groundwater by Ecology (Ecology 2010a and Ecology 2010b) for a standard POC and for a conditional POC are summarized in Table 4-1. The SL and PCUL established for diesel and heavy oil are both 500 µg/L. The PCUL for total petroleum hydrocarbons is also 500 µg/L. Alternative C2 is expected to reduce petroleum hydrocarbon concentrations to below 500 µg/L within approximately 4 to 34 years (refer to Section 4.2.3.2 and Appendix I). Thus, Alternative C2 is expected to meet MTCA standards for petroleum hydrocarbons regardless of whether a conditional POC is established by Ecology for the petroleum plumes. The concentration of PCBs in the petroleum plume FPP areas may exceed the SL for a standard POC until the FPP is no longer present. A more thorough discussion of the anticipated restoration time frame (RTF) for PCBs that are comingled with SVOCs is provided in Section 4.2.3.2 and Appendix I.

The implementation of Alternative D2 will not result in compliance with MTCA cleanup requirements for a long time, or with ARARs promulgated by state and federal laws, if a standard POC is established throughout Facility soil and groundwater. The PCB SL and PCUL (refer to Table 4-1) for a standard POC has been established by Ecology as 0.000064 µg/L (adjusted up to 0.0045 µg/L, which is the MDL for modified Method 8082) for groundwater, and 0.0000199 mg/kg (adjusted up to 0.01 mg/kg, the MDL for standard Method 8082) for saturated soil. Alternative D2 relies on source control measures, natural attenuation, and containment (of surface soil and groundwater) to reduce the concentration of PCBs to SLs that are present in these AOCs over long time periods (refer to Appendix I).

However, if a conditional POC is established by Ecology, MTCA standards could be attained under Alternative D2 for the Remelt/Hot Line PCB plume. Under a conditional POC, the PCB PCUL is 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL of modified Method 8082) for groundwater that flows into the river and 0.22 µg/L (adjusted down from 0.44 µg/L, the drinking water criterion to bring total cancer risk down to 0.5 x 10^{-5}) at other locations throughout the Facility. The corresponding soil PCB concentration is 0.068 mg/kg for smear zone soil.

It is expected to take approximately 4 years for Alternative D2 to attain compliance with the PCULs associated with a conditional POC and reduce the

PCB concentration in the Remelt/Hot Line plume to less than 0.22 µg/L (drinking water PCUL), and the concentration of PCBs in soil in the Remelt area to decline to 0.068 mg/kg (refer to Appendix I, PCB Restoration Time Frame Memo, Table 2), if a PCUL of 0.0045 µg/L is established by Ecology (refer to Appendix I).

Compliance with CULs will be measured at the monitoring wells defined in a new Sampling and Analysis Plan that will be developed to assess the performance of Alternatives C2 and D2.

MTCA provides additional requirements for permanent groundwater cleanup actions under WAC 173-340-360(2)(c)(i) and for nonpermanent groundwater cleanup actions under WAC 173-340-360(2)(c)(ii). These are summarized for Alternatives C2 and D2 below:

WAC 173-340-360(2)(c)(i). Alternative C2 is expected to meet PCULs for SVOCs and PCBs comingled with SVOCs at the standard POC in approximately 4 years in the Oil House area South plume to approximately 34 years in the Wastewater Treatment area North plume (refer to Appendix I). If a conditional POC is established by Ecology for the groundwater petroleum plumes, the time required for the concentration of PCBs and PAHs in groundwater and associated smear zone soil in the operating areas of the Facility to reach the PCULs associated with this conditional POC will be shorter than the time frames needed to meet the PCULs established by Ecology for a standard POC (refer to Table 4-1). The cleanup of petroleum-contaminated groundwater at the Facility is judged to be a permanent groundwater cleanup action.

It will take a long time for Alternative D2 to reach the PCB SL and PCUL of 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL for modified Method 8082) established for a standard POC. If a conditional POC is established by Ecology, it is expected to take approximately 3 years for Alternative D2 to reduce the PCB concentration in the Remelt Hot line plume to less than 0.22 µg/L (drinking water PCUL), and the concentration of PCB in soil in the Remelt area to decline to 0.068 mg/kg (Appendix I). This FS assumes that Ecology would consider the cleanup of groundwater at the Facility by Alternative D2 to be an acceptable nonstandard groundwater cleanup action.

WAC 173-340-360(2)(c)(ii). Alternatives C2 and D2 use a substantial number of existing and new source control measures to prevent the release of COCs to near-surface soil. Alternative C2 allows for the continued natural attenuation of the SVOCs that are present in groundwater and of PCBs that partition from SVOCs and enter the aqueous phase. There are seven locations at the Facility where FPP collects. In addition to four locations where FPP recovery is currently active, operation at two existing skimming locations will resume under

Alternative C2, and one new FPP recovery system will be installed and operated (refer to Section 4.1.2.3). Alternative C2 uses the existing IRM to hydraulically contain the petroleum groundwater plumes. Thus, Alternative C2 reduces COC mass in smear zone soil and keeps COCs from reaching human or ecological receptors.

Alternative D2 implements an extensive series of measures to prevent leaks and spills within the Remelt building (refer to Table 2-2) that could add PCBs to smear zone soil. This alternative also prevents PCBs in smear zone soil from reaching human or ecological receptors. Alternative D2 implements hydraulic containment that, together with the ongoing natural attenuation at the Facility, is judged to be an effective treatment and containment system for the PCBs in the Remelt/Hot Line groundwater plume and the smear zone soil associated with the plume. The PCB mass contained in the extracted groundwater generated by the hydraulic containment system is expected to initially partition to the SVOCs in smear zone soil in the Oil House area. These PCBs are expected to attenuate by the natural processes that will anaerobically and aerobically degrade the PCBs as they are released by the SVOCs and enter the aqueous phase. In addition, the Oil House area groundwater plume will be contained by the operation of the IRM system, which helps to contain the petroleum groundwater plume in the Oil House area.

Since active groundwater restoration and containment technologies that incorporate the active pumping of groundwater are integral parts of Alternatives C2 and D2, compliance with the final groundwater CULs presented in the Cleanup Action Plan (CAP) will be determined when groundwater characteristics at the Facility are no longer influenced by the actions taken under Alternatives C2 and D2 (WAC 173-340-720[9][c][vi]).

MTCA identifies several expectations for cleanup action alternatives (WAC 173-340-370). These expectations represent the types of cleanup actions Ecology considers likely remedies from the selection process described in WAC 173-340-350 through WAC 173-340-360; however, Ecology recognizes that there may be some sites where cleanup actions conforming to these expectations are not appropriate.

Ecology expects that natural attenuation of hazardous substances may be appropriate at sites where:

(a) Source control has been conducted to the maximum extent practicable;

As discussed in Sections 4.1.2 and 5.1.4, source control is an important component of Alternatives C2 and D2 (and of Alternatives A2/A4, B2, and B5).

For instance, substantial upgrades to the Remelt building are underway, with additional upgrades planned for the future (refer to Table 2-2). These source control measures will significantly reduce the potential for PCBs to enter smear zone soil and underlying groundwater.

(b) Leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health and the environment;

As discussed above, Alternatives C2 and D2 are judged to be protective of human health and the environment.

(c) There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and

Considerable evidence is available to support the assertion that biodegradation of the heavy oil and diesel fuels present in the petroleum plumes and associated smear zone soil has occurred in the past and is expected to continue in the future (refer to Appendix F). While there is considerable indication that the degradation of PCBs that are associated with the petroleum hydrocarbons in the Oil House and Wastewater Treatment areas is occurring and will continue to occur, evidence to support this assertion will need to be collected and assessed.

Similarly, there are indications that biodegradation of PCBs that partition to the aqueous phase in the Remelt/Hot Line groundwater plume has occurred (refer to Appendix F). This biodegradation, together with other natural attenuation processes, has kept the leading edge of the plume more than 650 feet from the Spokane River (based on the modified Method 8082 MDL of 0.0045 µg/L).

(d) Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

Monitoring is a component of Alternatives C2 and D2, and is described in Sections 4.1.2 and 5.1.4, respectively.

Based on our evaluation of available site data and conditions, Alternatives A2/A4, B2, B5, C2, and D2 are protective of human health and the environment. The hydraulic containment, MNA, FPP recovery systems, and institutional controls provided in Alternatives C2 and D2 prevent COCs in the petroleum hydrocarbon and Remelt/Hot Line PCB plumes and associated smear zone soil from reaching human or ecological receptors. As a result, Alternatives C2 and D2 meet the threshold requirement established by WAC 173-340-360(2)(c)(ii).

Thus, the combination of Alternatives A2/A4, B2, B5, C2, and D2 complies with MTCA cleanup standards.

6.5.1.3 Comply with Applicable State and Federal Laws

Contaminant-specific ARARs were included in the development of SLs and PCULs, and compliance with these ARARs is discussed above. Several action-specific ARARs were identified as being potentially applicable or relevant and appropriate to the implementation of Alternatives C2 and D2 (refer to Appendix G, Tables G-3 and G-4).

Alternatives C2 and D2 include the groundwater IRM system that was first installed in 1993. This system includes: (1) groundwater extraction wells that provide hydraulic containment and oxygenated groundwater for distribution to the shallow portion of the aquifer; (2) horizontal and vertical distribution wells for delivery of oxygenated groundwater to the shallow depths of the aquifer; (3) skimming wells and belt skimmers for recovery of FPP; and (4) deep observation wells to monitor for potential downward migration of various COCs, (including PCBs and SVOCs) near groundwater extraction wells.

Groundwater extraction wells are now operating in the Oil House and Wastewater Treatment areas of the Facility. The extraction wells draw groundwater from the deep within the aquifer below zones of impacted groundwater.

Currently, extraction well OH-EW-1 is operating at a pumping rate of approximately 1.2 million gallons per day (MGD). Extracted groundwater from well OH-EW-1 is conveyed to plant processes for use as both contact process water and non-contact cooling water.

Extraction wells WW-EW-1, WW-EW-2, and WW-UVB-1 are currently operating in the Wastewater Treatment area at flow rates of approximately 4.5, 7.1, and 4.4 MGD, respectively. Groundwater extracted from WW-EW-1 is used in plant processes for contact and non-contact cooling. Groundwater from WW-EW-2, which is drawn from deep in the aquifer, is currently discharged to the Spokane River. Groundwater extracted from WW-EW-2 is not impacted by COCs, as verified by quarterly sample analytical results presented in the Final Groundwater Remedial Investigation Report (Hart Crowser 2012a, Appendix F) and is not treated prior to discharge to the river.

Groundwater from WW-UVB-1 is conveyed underground to a horizontal infiltration system (WW-UVB-1-HS) with a distribution system consisting of three screened intervals to deliver oxygenated groundwater to the upper portion of the aquifer. The three horizontal screens receive extracted groundwater at flow rates of 1.78 MGD (WW-UVB-1-HSS), 0.97 MGD (WW-UVB-1-HSM), and 1.62 MGD (WW-UVB-1-HSN).

The implementation of Alternative D2 extracts approximately 3 MGD from three extraction wells located at the midpoint of the plume, west of the Remelt building, to hydraulically contain the Remelt/Hot Line plume (Figures 5-6 and 6-8). The water is extracted from both shallow and deep locations within the aquifer. The extracted groundwater will be conveyed via an underground pipe around the north side of the Remelt building and will be directed into a horizontal infiltration area located in the Oil House area (Figure 5-6). The infiltration area is not expected to contain perforated pipes to distribute the water that is discharged.

Three regulations authorized by state statutes are judged to be potentially applicable or relevant and appropriate to the operation of horizontal infiltration well WW-UVB-1-HS (Alternative C2) and the infiltration gallery in Alternative D2. The WAC citations for these state requirements are: (1) the Water Quality Standards for Groundwaters of the State of Washington (Chapter 173-200 WAC); (2) the State Waste Discharge Permit Program (Chapter 173-216 WAC);and (3) the Underground Injection Control (UIC) Program (Chapter 173-218 WAC). The UIC and Waste Discharge Permit programs require the use of all known, available, and reasonable methods of prevention, control, and treatment (AKART) for discharges governed by their programs. The applicability, relevance, and appropriateness of these requirements and of AKART to Alternatives C2 and D2 is discussed below.

Alternatives C2 and D2 continue the operation of the existing IRM system to provide additional containment of the plume in the Oil House area. The application of the three potentially applicable action-specific ARARs associated with the operation of the IRM system were discussed in Section 4.2.2.1 and are not repeated here. The action-specific ARARs were not considered to be applicable or relevant and appropriate or applicable to the operation of the IRM system.

Groundwater Quality Standards (Chapter 173-200 WAC). This regulation is designed to protect and preserve the groundwater of the state. This requirement does not apply to cleanup actions approved by Ecology under MTCA (WAC 173-200-010[3][c]); rather, groundwater cleanup standards are developed under rules promulgated under the MTCA as specified in WAC 173-340-720. The compliance of Alternatives C2 and D2 with WAC 173-340-720 is discussed above.

State Waste Discharge Permit Program (Chapter 173-216 WAC). The purpose of this requirement is to implement a state permit program applicable to the discharge of waste materials from industrial, commercial, and municipal operations *into* ground and surface waters of the state and *into* municipal sewerage systems (emphasis added). Alternative D2 does not discharge *into* the subsurface. The conveyance piping is entirely below ground. The infiltration area will not contain perforated pipes to distribute the water that is infiltrated. The surface of the earth is not pierced by the groundwater that is extracted in Alternative D2. The State Waste Discharge Program regulations are neither applicable nor relevant and appropriate to Alternative D2, since the infiltration that occurs is not a regulated discharge. Moreover, the dissolved oxygen in the water that is infiltrated is expected to improve the aerobic biodegradation of SVOCs and PCBs.

State Underground Injection Control Program (Chapter 173-218 WAC). The purpose of this statute is (1) to preserve and protect groundwater by preventing the discharge of fluids *into* UIC wells that will endanger groundwater (emphasis added); (2) to require the use of AKART to the discharge of fluids and waste fluids *into* the waters of the state; and (3) to prohibit the injection of fluids through wells except as authorized by this regulation.

Groundwater removed from the Remelt/Hot Line plume will be conveyed underground to a horizontal infiltration area located in the Oil House area. The infiltration area will not contain perforated pipes to distribute the water that is discharged. Per WAC 173-218-050(4), infiltration trenches that do not contain perforated pipes are not considered UIC wells and are not regulated under Chapter 173-218 WAC. In addition, a UIC well is a well that is used to discharge fluids *into* the subsurface (emphasis added). This means that the discharge of fluids must break the surface of the ground to constitute a discharge *into* the subsurface and for infiltration to waters of the state. The water extracted in Alternative D2 does not pierce the surface of the earth on its journey from the Remelt/Hot Line plume to the horizontal infiltration area near the Oil House area. For both of these reasons, the horizontal infiltration area created in Alternative D2 is not a UIC well, and the UIC program is not applicable, or relevant and appropriate.

Use of AKART. The UIC, Waste Discharge Program, and Water Quality Standards for Groundwater specify the need for AKART before a regulated discharge is introduced *into* the subsurface. The Remelt/Hot Line PCB plume is unique in that it contains very low concentrations of PCBs (e.g., parts per trillion and lower) and that it contains some PCBs that are attached to colloids. The concentration of PCBs in the groundwater transferred from the plume to the Oil House area is expected to be approximately 0.040 μg/L. If a conditional POC is established by Ecology, the PCUL for PCBs in groundwater throughout the Facility will be 0.22 µg/L (adjusted down from 0.44 µg/L, the drinking water criterion to bring total cancer risk down to 0.5 x 10^{-5}). Thus, the groundwater that will be introduced in the Oil House area will contain PCBs at a concentration that is protective of drinking water.

The PCBs in the Remelt/Hot Line plume likely consist of a small fraction of soluble PCBs and a larger fraction of colloidal PCBs (refer to FSTM Section 6.2.1). While treatment with granular activated carbon (GAC) is considered a presumptive remedy for the treatment of soluble PCBs, there is no presumptive remedy for the treatment of colloidal PCBs. Ecology has acknowledged this and has recognized that bench- and pilot-scale tests will be required to demonstrate the effectiveness of the technologies that compose Alternatives D3 and D4 (Ecology 2011).

For a technology to be considered AKART, it must be known, available, and reasonable. There is no known treatment method for this dilute colloidal PCB plume. While the individual technical components of the treatment process proposed for Alternatives D3 and D4 are available, they have never been used individually or together to capture colloidal PCBs at concentrations in the 0.040 µg/L range. The treatment system has never been assembled for this use, and, therefore, is not currently available. The cost of installing and operating the treatment system is expected to be very high (approximately $7.2 million to $28.1 million over 30 years – refer to Sections 5.1.6.6 and 5.1.7.5) and not considered to be practicable (refer to Section 5.3), given the very small quantity of PCBs (approximately 5.1 pounds for Alternative D3 and 1.3 pounds for Alternative D4) that will be removed from the environment by the alternatives over a 30-year time period.

The Pollution Control Hearings Board (PCHB) has stated that a public agency could not require an applicant to develop a new technology to advance the art of emission control. The technology must be “known” in the sense that it has been tested and found to control emissions effectively and efficiently. “Under this test the public agency may not insist that an emission source be utilized as a proving ground for an as yet untried technology” (PCHB 85-218). Ecology itself has relied on this PCHB decision in its Water Quality Program Permit Writer's Manual to define AKART (see Ecology 2010c, page IV-36). This ruling by the PCHB and Ecology's acknowledgment of its applicability in the AKART context provide further support for the determination that requiring treatment of the very dilute concentration of colloidal PCBs that are present in the Remelt/Hot Line plume does not constitute AKART.

Summary of ARARs Analysis. The UIC and Waster Discharge Programs are not applicable to Alternative D2 because there is no discharge *into* the subsurface or *into* waters of the state (emphasis added). Moreover, the infiltration system does not contain perforated pipe, so it is expressly exempt from regulation as a UIC well. Neither of these programs are relevant and appropriate to Alternative D2 because they do not address situations that are "sufficiently similar to those encountered at the site that their use is well suited to the site." The State Water Quality Standards (Chapter 173-200 WAC) do not apply to cleanup actions approved by Ecology under MTCA (WAC 173-200 [010][3][c]); rather, groundwater cleanup standards are developed under the MTCA (WAC-173-340-720). Finally, in accordance with PCHB authority that has been relied on by Ecology in the AKART context, there are no known, available, and reasonable treatment technologies for the treatment of the very dilute colloidal PCBs that are present in the Remelt/Hot Line plume at the Facility.

6.5.1.4 Consider Public Concerns

Public concerns will be considered during the public comment period for this FS. Public acceptance was not used as a criterion to distinguish among the remediation alternatives evaluated in this FS. Selection of the appropriate remediation alternative(s) may be revised based on the results of the public review process.

6.5.1.5 Summary of the Ability of Selected Remedial Alternatives to Meet Threshold Requirements

The technology-based remediation alternatives judged to be appropriate for each operating area of the Facility are listed in Table 6-6. The ability of these alternatives to meet threshold requirements is discussed above in Sections 6.5.1.1 through 6.5.1.4. The alternatives are judged to be protective of human health and the environment, compliant with MTCA cleanup standards, and compliant with state and federal laws. Public concerns will be considered during the public comment period for this FS.

6.5.2 Other Requirements

Other requirements that remedial alternatives must fulfill once they meet threshold requirements are defined by WAC 173-340-360(2)(b). These requirements include the use of permanent solutions to the maximum extent practicable (WAC 173-340-360[3]) and the provision of a reasonable restoration time frame (WAC 173-340-360[4]).

6.5.2.1 Use Permanent Solutions to the Maximum Extent Practicable

The use of permanent solutions to the maximum extent practicable is a primary evaluation criterion for the remedial alternatives being considered for the Remelt/Hot Line plume and associated smear zone soil. The specific criteria that must be addressed are specified in WAC 173-340-360(3)(f) and are discussed below.

Protectiveness

The excavation and off-site disposal of 29,000 CY of contaminated near-surface soil (Alternative A4) and the installation of containment surfaces (Alternative A2) and institutional controls (e.g., source control measures, restrictions and special procedures on digging in areas where residual contamination was left in place) will eliminate the pathways by which Facility workers and visitors can directly contact and/or ingest soil within the near-surface soil AOCs. Thus, the risk to Facility workers and visitors from direct contact or ingestion of near-surface soil will be eliminated by the off-site disposal of contaminated soil and the installation of these containment surfaces and controls.

The installation of containment surfaces (Alternatives A2 and B2) will also cut the rainfall to soil to groundwater pathway and reduce the future transport of COCs from near-surface and deep vadose zone soil to groundwater.

Alternative C2 reduces COCs in the petroleum hydrocarbon groundwater plumes and associated smear zone soil at the Facility through FPP recovery, institutional controls, hydraulic containment, and natural attenuation processes stimulated through dissolved oxygen enhancement. Alternative C2 will reduce the toxicity and volume of COCs that can be biodegraded or reduced through other natural attenuation processes. These processes are expected to take from 4 to 34 years to attain the SLs and PCULs established for SVOCs in groundwater and associated smear zone soil (refer to Appendix I). The available evidence indicates that the estimated restoration time frame for PCBs comingled with SVOCs for Alternative C2 will be approximately the same as the estimated restoration time frame for SVOCs alone (see Section 4.2.3.2 and Appendix I). During this time, approximately 690,000 pounds of SVOCs and 4 pounds of PCBs are expected to be removed from the petroleum hydrocarbon plumes and associated smear zone soil (refer to Table 4-7 and Appendix I).

FPP mass on the water table is currently being reduced through FPP recovery using skimming wells. Available FPP recovery data recorded between 1994 and the end of 2008 document over 4,200 gallons of FPP removed by the skimming systems operated at the Facility (Hart Crowser 2012a, Table 5-4). Approximately 4,700 gallons of FPP are expected to be removed in the Wastewater Treatment and Oil House areas through implementation of Alternative C2 (see Section 4.1.1.2). Removal periods of 10 years for the Oil House area and 25 years for the Wastewater Treatment area are estimated for Alternative C2 (see Section 4.1.2.3).

The soil to groundwater exposure pathway remains between smear zone soil and groundwater in limited areas of the Facility, but this impact to groundwater is controlled through the hydraulic containment provided in Alternatives C2 and D2, and through the groundwater natural attenuation processes occurring at the Facility.

The human direct contact or ingestion pathway to Facility workers and visitors is mitigated because of the depth of the deep vadose zone and smear zone soil and groundwater plume AOCs, through implementation of institutional controls, and because the groundwater plumes do not appear to be reaching surface water.

Alternative D2 will not reduce the concentration of PCBs to below SLs and PCULs for a standard POC in smear zone soil (0.0000199 mg/kg, adjusted up to 0.01 mg/kg, the MDL for standard Method 8082) and the Remelt/Hot Line plume (0.000064 µg/L, adjusted up to 0.0045 µg/L, the MDL for modified Method 8082) AOCs for a long time if a standard POC is established throughout the Facility for soil and groundwater (refer to Appendix I).

However, if a conditional POC is established by Ecology, MTCA standards could be attained under Alternative D2 for the Remelt/Hot Line plume in a shorter time period. Under a conditional POC, the PCUL is 0.000064 µg/L (adjusted up to 0.0045 µg/L, the MDL based on modified Method 8082) for groundwater that flows into the Spokane River and 0.22 µg/L (adjusted down from 0.44 µg/L, the drinking water criterion to bring total cancer risk down to 0.5×10^{-5}) everywhere else. The corresponding soil concentration is 0.068 mg/kg for smear zone soil. If a conditional POC is established by Ecology, it is expected to take about 4 years for the PCB concentration in the plume to reach the PCUL of 0.22 µg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I).

Natural attenuation of the Remelt/Hot Line plume has been shown to be occurring at the Facility and is expected to continue (refer to Appendix F). The soil to groundwater exposure pathway remains between smear zone soil and groundwater, but this impact to groundwater is controlled through the hydraulic containment provided in Alternative D2, and through the groundwater natural attenuation processes occurring at the Facility. Attenuation of PCBs in the Remelt/Hot Line plume has been demonstrated and is expected to occur for the PCBs currently present, and for the PCBs that will be added to the Oil House area plume in Alternative D2.

The new hydraulic containment system installed in Alternative D2 will extract groundwater that contains PCBs from the Remelt/Hot Line area plume. The extracted groundwater will be infiltrated upgradient of the Oil House area. This small PCB mass (about 5.1 pounds over 30 years) will be immobilized and contained by the SVOCs in the smear zone soil in this area (approximately 587,000 pounds), and is expected to be biodegraded by anaerobic and aerobic bacteria as the PCBs partition from the SVOCs to the aqueous phase over time (refer to Appendix F). In addition, the Oil House area groundwater plume will itself be contained by the operation of the IRM system, which currently contains the petroleum groundwater plume in this area.

In the unlikely event that dissolved and colloidal PCBs are not biodegraded within the Oil House area and evade hydraulic containment provided by the IRM system for this area, it is expected that natural attenuation processes would reduce the concentration of these PCBs to below the SL and PCUL of 0.000064 µg/L as a result of the processes that are now attenuating the Remelt/Hot Line PCB plume (Appendix E).

Alternative D2 will also protect receptors in the Spokane River if proposed EPA Method 1668 is promulgated and it is determined with analytical certainty that PCBs are currently reaching the river at concentrations below 0.0045 µg/L and above 0.000064 µg/L.

Permanence

The BMPs in place at the Facility are reducing the potential for release of hazardous substances into the environment. Additional BMPs that will be provided in the Remelt building (refer Section 2.1.1.1 and Table 2-2) and in other areas of the Facility will further reduce the potential for releases. Facility access controls are reducing the possibility of Facility workers and visitors to have contact with the COCs in near-surface soil.

The existing pavement and floor slab and the additional containment provided in Alternatives A2, B2, and B5 will prevent Facility workers and visitors from directly contacting COCs in these areas. Thus, the surface containment provided in Alternatives A2, B2, and B5 will eliminate the risk to Facility workers and the public due to the potential for direct contact or ingestion of contaminated near-surface soil.

Implementation of Alternatives A2, B2, and B5 will not generate treatment residues or waste materials. Surface water runoff from the containment surfaces will be either collected, directed to areas of the Facility without soil contamination and allowed to infiltrate, or will be transported to the Kaiser WWT facility for treatment.

The excavation and off-site disposal of approximately 29,000 CY of contaminated near-surface soil will permanently remove approximately 107,000 pounds of COCs from the Facility.

The natural attenuation processes that appear to be active in smear zone soil and groundwater will reduce COC concentrations over time. The FPP removal and dissolved oxygen augmentation provided by skimming wells and the existing horizontal infiltration systems actively remove or enhance the biodegradation of COCs in groundwater. These processes are expected to take from 4 to 34 years to attain the SLs and PCULs established for groundwater and associated smear zone soil SVOCs (refer to Appendix I). The available evidence indicates that the estimated restoration time frame for PCBs comingled with SVOCs for Alternative C2 will be approximately the same as the estimated restoration time frame for SVOCs alone (see Section 4.2.3.2 and Appendix I). During this time, approximately 690,000 pounds of SVOCs and 4 pounds of PCBs are expected to be irreversibly converted to degradation products (refer to Appendix I), or removed from the site as FPP is recovered in Alternative C2. The FPP recovery wells and biodegradation processes generate manageable quantities of process residuals.

The mobility of the groundwater COCs is reduced by the hydraulic containment provided in Alternatives C2 and D2, which prevents COC migration to the Spokane River. The PCB mass extracted in Alternative D2 (approximately 5.1 pounds over 30 years) will initially be immobilized by SVOCs and contained within the smear zone soil in the Oil House area. Over time, as the PCBs partition from the SVOCs to the aqueous phase, anaerobic and aerobic bacteria are expected to degrade the PCBs (refer to Appendix F). The fact that neither SVOCs nor PCBs have been detected in groundwater directly downgradient from the Oil House petroleum hydrocarbon plume is an indication that degradation of SVOCs and PCBs could be occurring.

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established.

Institutional controls in place at the Facility help to prevent the release of COCs into the environment through the Facility's industrial activities. Aggressive measures to prevent leaks and spills of water or other materials are underway in the Remelt complex (refer to Table 2-2). Contact process wastewater and sanitary wastewater generated by the plant are treated at the on-site WWT facility prior to discharge to the Spokane River.

Cost

The NPV of implementing the recommended remediation alternatives at the Facility (Alternatives A2/A4, B2, B5, C2, and D2) over a 30-year time period is estimated to total approximately $31.6 million (-35 to +50 percent). The assumptions used to prepare this estimate are described in Section 6.4 and in the cost tables contained in Appendices A through D and summarized in Table 6-7.

Effectiveness over the Long Term

The excavation and off-site disposal of near-surface soil, together with surface containment provided by existing pavement and floor slabs and new cap surfaces provided in Alternatives A2, B2, and B5, will protect Facility workers and visitors from direct contact with COCs in these areas and will prevent rainwater from conveying COCs to groundwater. The depth of the deep vadose zone soil AOCs prevents Facility workers and visitors from directly contacting or ingesting impacted deep vadose zone soil.

Institutional controls will be put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system. An inspection and maintenance plan that will ensure the integrity of the existing pavement, floor slabs, and new containment surfaces will be prepared and implemented. The containment surfaces are expected to remain effective for a long time.

Alternatives A2, B2, and B5 will not generate treatment residues or waste materials. Surface water runoff from the containment surfaces will be either collected, directed to areas of the Facility without soil contamination and allowed to infiltrate, or will be transported to the Kaiser WWT facility for treatment.

The depth of the petroleum hydrocarbon and Remelt/Hot Line PCB plumes and associated smear zone soil AOCs prevents Facility workers and visitors from directly contacting or ingesting COCs in these locations. The hydraulic containment provided in Alternatives C2 and D2 will prevent the groundwater COCs from reaching the Spokane River.

The dissolved oxygen augmentation provided by the existing horizontal infiltration system actively enhances the biodegradation of SVOCs in groundwater. These processes are expected to take from 4 to 34 years to attain the SLs and PCULs established for SVOCs in groundwater and associated smear zone soil (refer to Appendix I). The available evidence indicates that the estimated restoration time frame for PCBs that are comingled with SVOCs for Alternative C2 will be approximately the same as the estimated restoration time frame for SVOCs alone (see Section 4.2.3.2 and Appendix I). During this time approximately 690,000 pounds of SVOCs and 4 pounds of PCBs are expected to be irreversibly converted to degradation products (refer to Appendix I).

FPP mass on the water table is currently being reduced through FPP recovery using skimming wells. Approximately 4,700 gallons of FPP are expected to be removed in the Wastewater Treatment and Oil House areas through implementation of Alternative C2 (see Section 4.1.1.2). Removal periods of 10 years for the Oil House area and 25 years for the Wastewater Treatment area are estimated for Alternative C2 (see Section 4.1.2.3).

It will take a long time for Alternative D2 to reach the PCB SL and PCUL of 0.000064 μg/L (adjusted up to 0.0045 μg/L, the MDL for modified Method 8082) established for a standard POC. If a conditional POC is established by Ecology, it is expected to take 4 years for the PCB concentration in the plume to reach the PCUL of 0.22 μg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I). PCBs are not currently reaching the river from the Remelt/Hot Line plume at concentrations above the MDL (0.0045 μg/L).

If the PCUL for a conditional POC is established as 0.000064 μg/L, attenuation data in the Remelt/Hot Line plume (see Appendix E) predict that the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 μg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 μg/L by the time the PCBs from the Remelt/Hot Line plume reach the river. It is expected to take about 60 years for the PCB concentrations in smear zone soil to decline to these values. The hydraulic containment provided in Alternative D2 will prevent PCBs at concentrations above 0.000064 μg/L from reaching the Spokane River.

Natural attenuation is expected to reduce PCB source area mass in smear zone soil over time. Approximately 57 percent of the mass (5.1 pounds) of PCBs is expected to be removed from smear zone soil below the Remelt building during the initial 30-year operating period of Alternative D2 (Table 5-4) and transferred to the Oil House area to initially be sequestered by SVOCs and biodegraded as the PCBs enter the aqueous phase. Institutional controls in place at the Facility help to prevent the release of PCBs into the environment by the Facility's industrial activities.

Ecology has indicated that sufficient evidence has not been presented to establish that biodegradation of PCBs is occurring at the site. As a result, bench tests and/or pilot-scale tests will be performed to determine whether site-specific evidence of PCB biodegradation can be established.

Alternative D2 is expected to be protective over the long term. The existing containment (building roof, floor slabs, and other pavement), MNA, institutional controls, plus the new hydraulic containment of the plume and subsequent biodegradation of the PCBs as they partition from the SVOCs to the aqueous phase in the Oil House area, prevent PCBs in smear zone soil and the Remelt/Hot Line plume from reaching human or ecological receptors in the Spokane River.

The extracted PCB mass (approximately 5.1 pounds over 30 years) will initially be immobilized by SVOCs (approximately 587,000 pounds) and will be contained within the smear zone soil in the Oil House area. Over time, as the PCBs partition from the SVOCs to the aqueous phase, anaerobic and aerobic bacteria are expected to degrade the PCBs. The Oil House area groundwater plume is, in turn, contained by the IRM system. Thus, Alternative D2 in effect provides double containment of the PCBs that originate in the Remelt/Hot Line groundwater plume. In the unlikely event that dissolved or colloidal PCBs are not biodegraded within the Oil House area, and evade hydraulic containment provided by the IRM system for this area, it is expected that natural attenuation processes would reduce the concentration to below the SL and PCUL of 0.000064 μg/L at the Spokane River, as a result of the processes that are now attenuating the Remelt/Hot Line groundwater plume (Appendix E).

The institutional control, monitoring, MNA, and containment actions that constitute remediation Alternatives A2/A4, B2, B5, C2, and D2 have been used successfully at the Facility in the past and are designed to be effective over the long term.

Management of Short-Term Risks

Short-term risks associated with the excavation, screening, transport, and off-site disposal include worker exposure to contaminants during excavation and mechanical screening. The HASP will be implemented during construction activities to protect on-site workers. Additional human health and environmental risks are associated with the transport of the material from the Facility to the landfill for disposal. Transport containers will be covered and take the appropriate measures to reduce risk to the communities through which they travel. Only properly licensed material haulers will be used. Material greater than 2 inches in diameter will remain on site and is assumed to pose little risk to human health and the environment, since the contamination in soil at the Facility is associated with the finer-grained material.

Short-term risks to construction workers during the installation of the containment surfaces (Alternatives A2 and B2) will be mitigated by their adherence to the HASP prepared to guide health and safety practices during the construction work.

The short-term risks associated with the installation of containment surfaces include the following:

- Exposure of Facility workers to media containing COCs;
- Exposure of Facility workers to hazardous materials (e.g., exposure to hot-mix asphalt resulting in burn injuries);
- Construction area hazards (e.g., working near heavy equipment); and
- Hazards associated with the industrial activities taking place at various locations within the Facility.

The procedures contained in the HASP and the inspection and maintenance plan that will be created to guide the installation and maintenance of the containment surfaces have been shown to effectively manage the limited risk associated with these activities.

Short-term risks associated with construction activities in Alternatives C2 and D2 (for example, groundwater well installation) will be mitigated by adherence to the HASP prepared to guide health and safety practices during the construction work. The short-term risks associated with Alternatives C2 and D2 also include the following:

- Potential exposure of Facility workers and visitors to hazardous materials (e.g., handling items containing hazardous waste as part of executing BMPs); and

- Hazards to workers associated with the industrial activities taking place at locations within the Facility.

Technical and Administrative Implementability

Excavation and disposal are conventional activities and can be easily implemented. These activities have been successfully performed at the Facility on numerous occasions previously. Reduction of COC volume is expected to take place in a short time frame, since the reduction will occur during implementation of the remedial action. The contained area will likely need to be monitored in perpetuity, and a restrictive covenant will be implemented.

BMPs, groundwater monitoring, and institutional controls are already in place at the Facility. The installation of new containment surfaces is a routine activity and has been employed at the Facility for many years. The installation of groundwater extraction wells and FPP skimming wells has also been employed at the Facility in the past and is a practice with which Kaiser is familiar. Hydraulic containment is currently being used at the Facility as part of the existing IRM System (see Section 4.1.1) and has been empirically demonstrated to be effective. The hydraulic containment included in Alternative D2 will be similar to the design and installation of the existing IRM system.

The State Groundwater Quality, UIC, and Waste Discharge Programs are judged to be neither applicable nor relevant and appropriate to the implementation of Alternatives C2 and D2.

Alternative D2 transfers approximately 5.1 pounds of PCBs from the Remelt/Hot Line plume to the Oil House area, where they will initially comingle with the SVOCs that are present there. As the PCBs partition from the SVOCs to the aqueous phase, the PCBs are expected to biodegrade. While there are many indications that the degradation of PCBs associated with SVOCs in the Oil House and Wastewater Treatment areas has occurred and is occurring (refer to Appendix F), evidence to support these indications still must be collected and assessed.

The technical and administrative implementability of Alternatives A2/A4, B2, B5, C2, and D2 is judged to be high.

Summary of Disproportionate Cost Analysis

The combination of Alternatives A2/A4, B2, B5, C2, and D2 was judged to provide permanent solutions to the maximum extent practicable for the COCs and contaminated media present at the Facility.

6.5.2.2 Restoration Time Frame

COCs in Near-Surface and Deep Vadose Zone Soils

Excavation and off-site disposal is expected to significantly reduce the COC mass and volume in near-surface soil in a short time frame (about 1 year). COCs at concentrations above SLs will still be present in near-surface soil below existing roads and floor slabs and adjacent to building foundations. Contaminated near-surface soil that is not excavated (see Section 6.1.1) and contaminated deep vadose zone soil will be capped. SVOC concentrations and metal COC mobility in these soils are expected to decrease over time because of natural attenuation. Contaminated soil under a cap may be determined to meet cleanup standards if the requirements under WAC 173-340-740(6)(f) are met. Alternatives A2 and B2 meet these criteria as discussed above in Sections 2.2.4.1 and 3.2.3.1. The restoration time frame for AOCs that are capped is approximated by the estimated time to construct the containment surfaces (about 1 to 2 years).

The time frame needed for the concentration of COCs in near-surface, deep vadose zone, and smear zone soil to fall below screening levels for a standard POC once containment surfaces are installed in Alternatives A2 and B2 is expected to be long. If a conditional POC is granted by Ecology, the time frame needed for the concentrations of COCs to meet the SLs associated with a conditional POC will be reduced. However, once the containment caps are in place with the necessary institutional controls, the soil under the cap can be considered to be in compliance with SLs.

SVOCs in the Petroleum Groundwater Plumes and Associated Smear Zone Soil

The approach used to estimate the restoration time frame for Alternative C2 is discussed in Appendix I and summarized in Section 4.2.3.2. The estimated RTFs for SVOCs in Alternative C2 for each operating area of the Facility are summarized in Table 4-7, and range from approximately 4 years in the Oil House area South plume to approximately 34 years in the Wastewater Treatment area North plume. These time frames are considered to be reasonable as defined by WAC 173-340-360(4).

PCBs Comingled with SVOCs

It is anticipated that, over time, PCBs will remain associated with FPP and that the removal rate of FPP from the smear zone would be a factor in the restoration time frame for comingled PCBs. The estimated recovery time for FPP in Alternative C2 is estimated to be approximately 10 years in the Oil House area and 25 years in the Wastewater Treatment area of the Facility (refer to Section 4.2.3.2). The restoration time frame for comingled PCBs may be associated with these time frames for the removal of FPP, but may also be associated with the restoration time frame for SVOCs in the petroleum groundwater plumes and associated smear zone soil to attain SLs and PCULs by natural attenuation in Alternative C2.

The SL and PCUL for SVOCs in smear zone soil is 2,000 mg/kg, which is the default residual saturation value for diesel and heavy oil in soil. Petroleum hydrocarbon concentrations in soil above the residual saturation value may indicate the presence of FPP. The concentration of SVOCs in smear zone soil is expected to be below 2,000 mg/kg, for petroleum hydrocarbons at the end of the restoration time frame for the petroleum groundwater plumes.

It can be assumed that comingled PCBs may still be present if the petroleum hydrocarbon concentration in the soil exceeds the residual saturation default value of 2,000 mg/kg, and that the estimated restoration time frame for comingled PCBs may be associated with the time needed for the concentration of petroleum hydrocarbons to decline to this value. However, considering the potential for non-recoverable product to remain in the subsurface (even if the concentration of SVOCs declines to below 2,000 mg/kg), the restoration time frame for comingled PCBs may be longer.

The RTF for SVOCs is judged to be reasonable. The RTF for PCBs that are comingled with SVOCs is also judged to be reasonable.

Remelt/Hot Line PCB Plume and Associated Smear Zone Soil

The approach used to estimate the RTF for Alternative D2 is discussed in Appendix I and summarized in Section 5.1.5. If a standard POC is established by Ecology, the estimated RTF for Alternative D2 is approximately 170 years to reduce PCB concentrations in the Remelt/Hot Line plume to the modified Method 8082 MDL of 0.0045 μg/L, and 350 years to reduce PCB concentrations in the plume to 0.000064 μg/L.

If a conditional POC is established by Ecology, it is expected to take 4 years for the PCB concentration in the plume to reach the PCUL of 0.22 μg/L and the concentration in the smear zone soil in the Remelt area to decline to 0.068 mg/kg (Appendix I). PCBs are not currently reaching the Spokane River from the Remelt/Hot Line plume at concentrations above the MDL (0.0045 μg/L).

If the PCUL for a conditional POC is established as 0.000064 μg/L, calculations in Appendix E (based on the documented natural attenuation of the Remelt/Hot

Line plume) predict that the PCB concentration in groundwater in the Remelt source area would need to be approximately 0.060 μg/L (with a smear zone soil concentration of approximately 0.019 mg/kg) for the concentration to decline to 0.000064 μg/L by the time PCBs from the Remelt/Hot Line plume reach the Spokane River. It is expected to take about 60 years for the PCB concentrations in smear zone soil to decline to these values. The hydraulic containment provided in Alternative D2 will prevent PCBs from the Remelt/Hot Line plume from reaching the river at concentrations above 0.000064 μg/L.

The time frames cited above are considered to be reasonable, as defined by WAC 173-340-360(4). Alternatives A2/A4, B2, B5, C2, and D2 meet the minimum requirements for cleanup actions under WAC 173-340-360(2). An assessment of the factors used to determine whether Alternatives A2/A4, B2, B5, C2, and D2 provide for a reasonable restoration time frame (WAC 173-340-360[4][b]) follows:

(i) Potential risks posed by the site to human health and the environment;

Alternatives A2/A4, B2, B5, C2, and D2 address the risks to human health and the environment posed by the COCs that are present at the Facility and are judged to be protective of human health and the environment (see discussion above).

(ii) Practicality of achieving shorter restoration time frame;

A disproportionate cost analysis was conducted as each technology-based remedial alternative was evaluated. Alternatives A2/A4, B2, B5, C2, and D2 are judged to be the alternatives that use permanent solutions to the maximum extent practicable for their respective segment of the Facility (e.g., near-surface soil). The expected restoration time frame for each alternative was compared to the expected restoration time frame of other potential treatment alternatives that could potentially achieve a shorter restoration time frame. The other alternatives were judged to provide no additional protection of human health and the environment beyond the protection provided in Alternatives A2/A4, B2, B5, C2, and D2, Thus, these selected alternatives and were judged to use permanent solutions to the maximum extent practicable.

(iii) Current use of the site, surrounding area, and associated resources that are, or may be, affected by releases from the site;

Releases from the Facility may pose risks to human and ecological receptors, and may potentially affect groundwater and the Spokane River.

Alternatives A2/A4, B2, B5, C2, and D2 include physical and administrative controls, BMPs, natural attenuation, and containment of surface soil and groundwater to reduce the potential for worker exposure to COCs and to reduce the potential for COCs in smear zone soil and groundwater to migrate to the Spokane River. These controls are expected to effectively cut the pathways by which COCs could reach potential human and ecological receptors.

(iv) Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

A restrictive covenant will limit future uses of the Facility. Potential releases from the Facility, if they are identified, could affect receptors in the Spokane River. PCBs have not been detected in wells near the river at concentrations above PCULs (based on the use of modified Method 8082 to measure groundwater PCB concentrations). If future groundwater monitoring using proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above the SL of 0.000064 µg/L, Alternative D2 would still be able to meet the threshold requirements established by WAC 173-340-360(2)(c)(ii).

(v) Availability of alternative water supplies;

Considerable groundwater exists at the Facility that is outside of the footprint of the petroleum hydrocarbon and Remelt/Hot Line PCB plumes. A restrictive covenant will be prepared for the Facility. One element of this covenant will be a restriction on the drilling of drinking water wells on impacted areas the property. Kaiser also has secured access to this groundwater for domestic and industrial use through a water right.

(vi) Likely effectiveness and reliability of institutional controls;

The institutional controls implemented in Alternatives A2/A4, B2, B5, C2, and D2 (refer to Sections 2.1.1.1 and 2.1.1.2 and Tables 2-2 and 2-3) have been shown to be effective and reliable at the Facility. Most of these measures have been successfully used at the Facility for many years.

(vii) Ability to control and monitor migration of hazardous substances from the site;

The groundwater monitoring program at the Facility is governed by a Sampling and Analysis Plan (Hart Crowser 2007a), as amended (Kaiser 2010a), that has been approved by Ecology. A new monitoring plan will be developed to monitor the performance of Alternatives A2/A4, B2, B5, C2, and D2 if they are selected by Ecology as the preferred alternatives for Facility.

(viii) Toxicity of hazardous substances at the site; and

FPP, SVOCs, PCBs, and metals have been identified as COCs for groundwater and soil at the Facility. The toxicity of these COCs will depend on their concentration and the duration of exposure. The implementation of physical and administrative controls, BMPs, and containment surfaces in Alternatives A2 and B2 will be used to reduce the potential for worker and visitor exposure to COCs, and to reduce the potential for COCs in near-surface and deep vadose zone soil to migrate to groundwater. The implementation of Alternative D2 in the Remelt/Hot Line area is expected to prevent PCBs from reaching potential human or ecological receptors in the future even if the future use of proposed EPA Method 1668 demonstrates that PCBs are reaching the Spokane River at concentrations above 0.000064 µg/L.

(ix) Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar conditions;

Natural attenuation of SVOCs and of PCBs comingled with SVOCs in the petroleum groundwater plumes has been underway for many years (refer to Appendix F). Several of the petroleum groundwater plumes have shrunk significantly during this time. These biodegradation processes are expected to continue in the future and reduce the concentration of SVOCs to SLs and PCULs in approximately 4 to 34 years. PCBs that enter the aqueous phase are also expected to undergo biodegradation during this time. PCB concentrations have not been measured in wells that are directly downgradient from the petroleum plumes.

This assessment indicates that PCBs in the Remelt/Hot Line area that enter the aqueous phase may be amenable to biodegradation under both anaerobic and aerobic conditions. This natural attenuation is expected to be concentrated in locations near the source areas of the PCBs. Anaerobic degradation is expected to be focused on trichlorinated byphenyls and more highly chlorinated PCBs located near the source area (where negative ORPs are present; see Appendix F, Figure F-2). Anaerobic degradation is expected to eventually convert trichlorinated biphenyls and more highly chlorinated PCBs to mono- and bichlorinated biphenyls that can be degraded by aerobic bacteria. PCBs introduced to the Oil House area will initially be sequestered by the SVOCs that are present there. As these PCBs are released to the aqueous phase over time, the PCBs are expected to be biodegraded by anaerobic and aerobic bacteria (refer to Appendix F).

As a result of this assessment, the combination of Alternatives A2/A4, B2, B5, C2, and D2 is judged to provide a reasonable restoration time frame.

6.5.2.3 Consider Public Concerns

Public concerns will be considered during the public comment period for this FS and during the public comment period for the CAP that will be developed by Ecology in the future.

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Table 6-1 - Summary of Selected Technology-Based Remedial Alternatives

Section of the FS	Environmental Segment	Description of Selected Remedial Alternative(s)	Contaminants of Concern			
			VOCs	SVOCs	PCBs	Metals
2	Near-Surface Soil	FS Sections 2.1.2 and 2.1.4	A2 - Institutional Controls, Monitoring, MNA, and Containment	A2 - Institutional Controls, Monitoring, MNA, and Containment A4 - Excavation and Off-Site Disposal	A2 - Institutional Controls, Monitoring, MNA, and Containment A4 - Excavation and Off-Site Disposal	A2 - Institutional Controls, Monitoring, MNA, and Containment A4 - Excavation and Off-Site Disposal
3	Deep Vadose Zone Soil	FS Section 3.1.2 for B2 and FS Section 3.1.5 for B5	B2 - Institutional Controls, Monitoring, MNA, and Containment	B2 - Institutional Controls, Monitoring, MNA, and Containment	B5 - Institutional Controls, Monitoring, MNA, and Containment of Non-Comingled PCBs	B2 - Institutional Controls, Monitoring, MNA, and Containment
4	Petroleum Hydrocarbon Plumes and Associated Smear Zone Soil	FS Section 4.1.2	NA	C2 - Institutional Controls, Monitoring, MNA, Operation of the Existing IRM System, and Enhanced FPP removal	NA	NA
5	Remelt/Hot Line PCB Plume and Associated Smear Zone Soil	FS Section 5.1.2	NA	NA	D2 - Institutional Controls, Monitoring, MNA, Groundwater Containment	NA

Notes:
NA - Not applicable.

Table 6-2 - Index of Text, Tables, and Figures for Near-Surface Soil AOCs

Contaminants of Concern	Comparative Analysis of Alternatives		AOC, Cap, Pavement Repair, Excavation Footprint Figures
	Text Section	Table	
VOCs	2.3.2	2-9	2-1, 2-3, 2-4, 2-10
SVOCs	2.3.3	2-10	2-1, 2-3 through 2-5, 2-7, 2-8, 2-10
PCBs	2.3.4	2-11	2-1, 2-3, 2-8, 2-9
Metals	2.3.5	2-12	2-1, 2-3 through 2-6

Table 6-3 - Index of Text, Tables, and Figures for Deep Vadose Zone Soil AOCs

Contaminants of Concern	Comparative Analysis of Alternatives		AOC, Cap, Pavement Repair Footprint Figures
	Text	Table	
VOCs	3.3.1	3-2	3-1, 3-3, 3-5
SVOCs and Comingled PCBs	3.3.2	3-3	3-1 through 3-5
PCBs Alone	3.3.3	NA	3-1
Metals	3.3.4	3-4	3-1, 3-2, 3-4

Notes:
NA - Not applicable.

Table 6-4 - Index of Text, Tables, and Figures for the Petroleum Hydrocarbon Plumes and Associated Smear Zone Soil

Contaminants of Concern	Comparative Analysis of Alternatives		Groundwater Plume/Free Phase Petroleum/ Smear Zone AOC Figures Natural Attenuation Figures Containment Figures
	Text Section	Table	
SVOCs and Comingled PCBs	4.3	4-35 - Groundwater 4-36 - Smear zone soil	4-1 through 4-9, Appendix F, Appendix E

Table 6-5 - Index of Text, Tables, and Figures for the Remelt/Hot Line PCB Plume and Associated Smear Zone Soil

Contaminants of Concern	Comparative Analysis of Alternatives		Groundwater Plume/Smear Zone AOC and Containment Figures
	Text Section	Table	
PCBs (dissolved and colloidal)	5.3	5-8 - Groundwater and smear zone soil	5-1 through 5-4, 5-6 Appendices E and F

Table 6-6 - Identification of the Technology-Based Remediation Alternatives Judged to be Appropriate for Operating Areas of the Facility

Operating Area of the Facility	Impacted Environmental Segment	COCs Present in the Environmental Segment	Technology-Based Remedial Alternatives Selected for the Operating Area
Oil House Area	Near-surface soil	VOCs, SVOCs, and PCB	A2
	Deep vadose zone soil	VOCs, SVOCs, PCBs, arsenic	B2, B5
	Smear zone soil	VOCs, SVOCs, PCBs, arsenic	C2
	Petroleum-contaminated groundwater	SVOCs, comingled PCBs	C2
Wastewater Treatment Area	Near-surface soil	VOCs, SVOCs, PCBs, and metals	A2, A4
	Deep vadose zone soil	SVOCs, PCBs, arsenic	B2
	Smear zone soil	SVOCs	C2
	Petroleum-contaminated groundwater	SVOCs, comingled PCBs	C2
ORB Area	Near-surface soil	VOCs, SVOCs, PCBs, and metals	A2, A4
	Deep vadose zone soil	SVOCs	B2
	Smear zone soil	SVOCs	C2
	Petroleum-contaminated groundwater	SVOCs	C2
Remelt/Hot Line Area	Near-surface soil	PCBs, SVOCs	A2
	Deep vadose zone soil	PCBs, SVOCs, arsenic	B2, B5
	Smear zone soil	PCBs, SVOCs	D2
	PCB-contaminated groundwater	PCBs	D2
Cold Mill/Finishing Area	Near-surface soil	SVOCs, chromium	A2
	Deep vadose zone soil	SVOCs, chromium	B2
	Smear zone soil	SVOCs, PCBs	C2
	Petroleum-contaminated groundwater	SVOCs	C2
Truck Shop Area	Near-surface soil	VOCs, SVOCs	A2
	Deep vadose zone soil	SVOCs	B2
Former Rail Car Unloading Area	Near-surface soil	SVOCs	A2, A4
	Deep vadose zone soil	SVOCs	B2
Former South Discharge Ravine	Near-surface soil	SVOCs, PCBs	A4
Former West Discharge Ravine	Near-surface soil	PCBs	A2, A4

Notes:
A2 - Institutional controls, monitoring, MNA, and containment (cap).
A4 - A2 plus excavation and off-site disposal.
B2 - Institutional controls, monitoring, MNA, and containment (cap).
B5 - Institutional controls, monitoring, MNA, and containment (cap) of non-comingled PCBs.
C2 - Institutional controls, monitoring, MNA, operation of the existing IRM system, enhanced FPP removal, additional groundwater containment.
D2 - Institutional controls, monitoring, MNA, and hydraulic containment of the Remelt/Hot Line plume.

Table 6-7 - ROM (-30/+50%) Cost Estimate for the Recommended Remediation Alternatives for the Kaiser Facility

Remediation Alternative	Environmental Medium	Estimated Cost [a]	Estimated Incremental Cost of the Remediation Alternative [b, c]	Incremental Cost Elements	Estimated Cost of Major Incremental Elements
A2 - Institutional Controls Monitoring, MNA, and Containment	Near-Surface Soil	$ 14,800,000	$ 14,700,000	Protection, performance, outfall, and treatment plant monitoring;	$ 7,000,000
				Pending upgrades in casting complex;	$ 1,300,000
				Institutional controls O&M - casting complex upgrades, maintain physical measures, BMPs;	$ 4,700,000
				New cap surfaces;	$ 270,000
				New cap O&M and monitoring	$ 840,000
A4 - Excavation and Off-Site Disposal	Near-Surface Soil	$ 18,800,000	$ 4,100,000	Excavation of impacted near-surface soil,	$ 1,600,000
				off-site disposal	$ 2,000,000
B2 - Institutional Controls Monitoring, MNA, and Containment	Deep Vadose Zone Soil	$ 14,700,000	$ 700,000	Additional cap surfaces, cap O&M, additional monitoring for soil MNA	
B5 - Institutional Controls, Monitoring, MNA, and Containment of Non-Comingled PCBs	Deep Vadose Zone Soil	Same as for B2	$ -	Containment of PCBs in Remelt/Hot Line and Oil House areas (assumed to be included as part of Alternative B2)	
C2 - Institutional Controls, Monitoring, MNA, Operation of the Existing IRM System, Enhanced FPP Removal	Petroleum Hydrocarbon Plumes and Associated Smear Zone Soil	$ 22,900,000	$ 8,800,000	Operation of the existing IRM and FPP recovery system;	$ 7,300,000
				Expand FPP recovery system;	$ 150,000
				Additional O&M for FPP removal	$ 330,000
D2 - Institutional Controls, Monitoring, MNA, Operation of the Existing IRM System, Additional Groundwater Containment	Remelt/Hot Line PCB Plume and Associated Smear Zone Soil	$ 23,100,000	$ 3,300,000	Addition of new groundwater containment system in the Remelt/Hot Line area; Installation of new groundwater conveyance piping; Addition of new groundwater injection trench in the Oil House area; Additional O&M	
TOTAL COST OF ALL RECOMMENDED ALTERNATIVES		Not applicable	**$ 31,600,000**		

Notes:
Costs of remedial alternatives are presented as net present value (NPV) costs, which assume a 30-year operating period and 7 percent discount rate. NPV costs have been adjusted where applicable to account for remedial alternative elements that have durations of less than 30 years.
(a) Represents estimated cost of technology-based remedial alternatives presented in Sections 2 through 5.
(b) Estimated incremental cost of area-based remedial alternatives (see Section 6).
(c) Baseline estimated cost (Alternative A2) was reduced to eliminate double accounting of Hoffman Tank area multilayer cap extension, which is included under Alternative B2.
The cap extension area required in Alternative A2 is located within the footprint of the required cap extension area in Alternative B2.

Oil House Area: Proposed Containment Surfaces

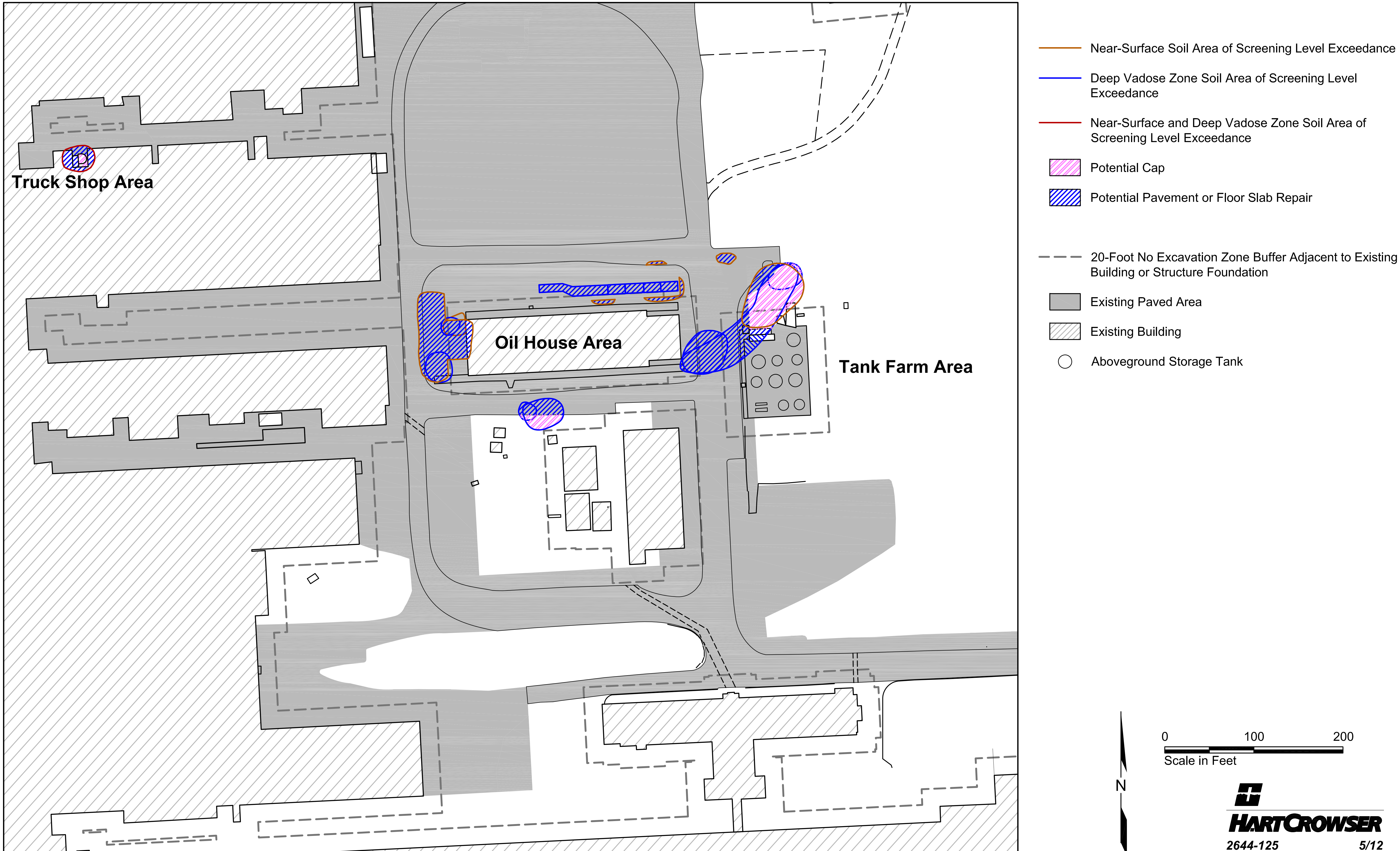

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Figure 6-1

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Oil House Area: Groundwater Plumes and Associated Smear Zone Soil Extent

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Figure 6-2

Wastewater Treatment/Rail Car Unloading (RCU) Areas: Proposed Excavation Areas and Containment Surfaces

- Near-Surface Soil Area of Screening Level Exceedance
- Deep Vadose Zone Soil Area of Screening Level Exceedance
- Near-Surface and Deep Vadose Zone Soil Area of Screening Level Exceedance
- 20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation
- Existing Paved Area
- Existing Building
- Existing Former Hoffman Tank Area Multi-Layer Cap
- Potential Excavation
- Potential Pavement or Floor Slab Repair
- Potential Cap

N

0 100 200
Scale in Feet

EAL 05/14/12 2644125-085.DWG

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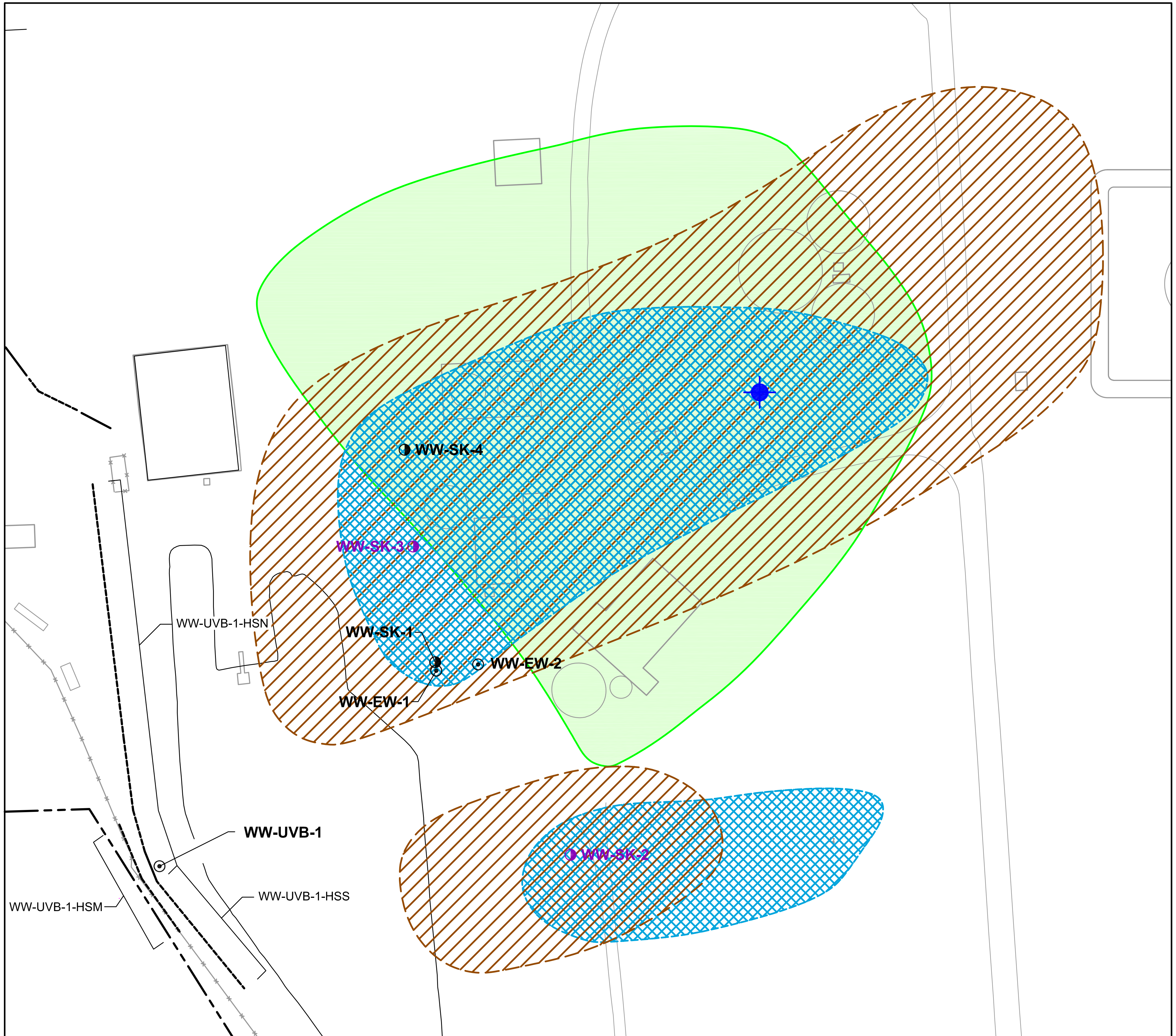
Figure 6-3

Wastewater Treatment Area: Groundwater Plumes and Associated Smear Zone Soil Extent



Exploration Location and Number

WW-SK-2 ◑ Reactivate Existing Skimming Well

WW-EW-2 ⊙ Existing Extraction Well

WW-SK-3 ◑ Existing Skimming Well

Proposed New Skimming Well

Inferred Extent of Diesel and Heavy Oil in Groundwater (2009/2010) Exceeding Screening Level

Inferred Extent of Free Phase Petroleum in Groundwater (2009/2010)

Smear Zone Soil Area of Screening Level Exceedance

N

0 100 200

Scale in Feet

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Figure 6-4

Oil Reclamation Building Area: Proposed Excavation Areas and Containment Surfaces

Near-Surface Soil Area of Screening Level Exceedance

Near-Surface and Deep Vadose Zone Soil Area of Screening Level Exceedance

Potential Excavation

Potential Pavement or Floor Slab Repair

Potential Cap

20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation

Existing Paved Area

Existing Building

0 50 100

Scale in Feet

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Figure 6-5

Oil Reclamation Building Area: Groundwater Plume and Associated Smear Zone Soil Extent

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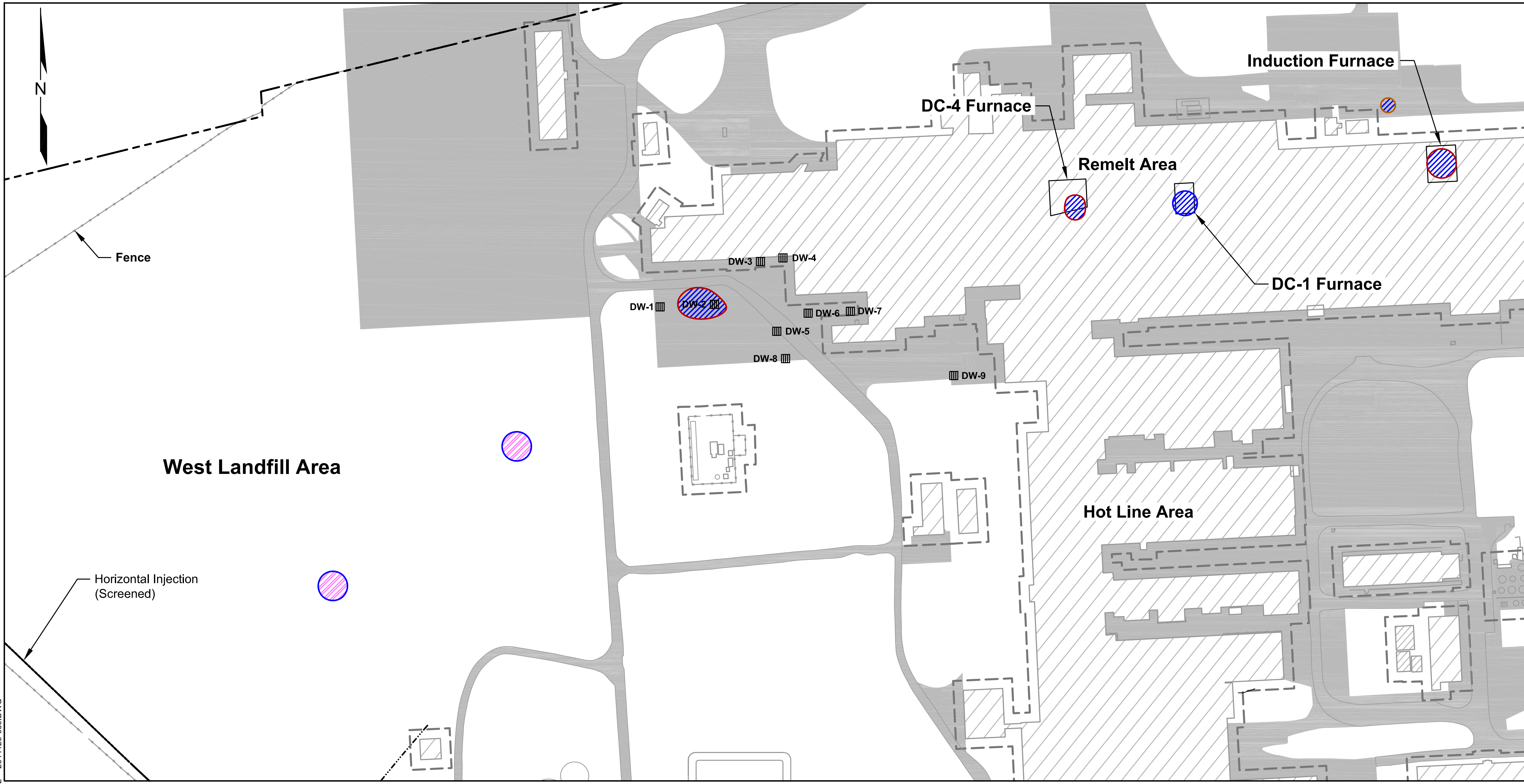
Figure 6-6

Remelt/Hot Line Area: Proposed Containment Surfaces



Feature Location and Number

DW-1 Dry Well

Potential Cap

Potential Pavement or Floor Slab Repair

Near-Surface Soil Area of Screening Level Exceedance

Deep Vadose Zone Soil Area of Screening Level Exceedance

Near-Surface and Deep Vadose Zone Soil Area of Screening Level Exceedance

20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation

Existing Paved Area

Existing Building

0 200 400

Scale in Feet

EAL 05/14/12 2644125-089.DWG

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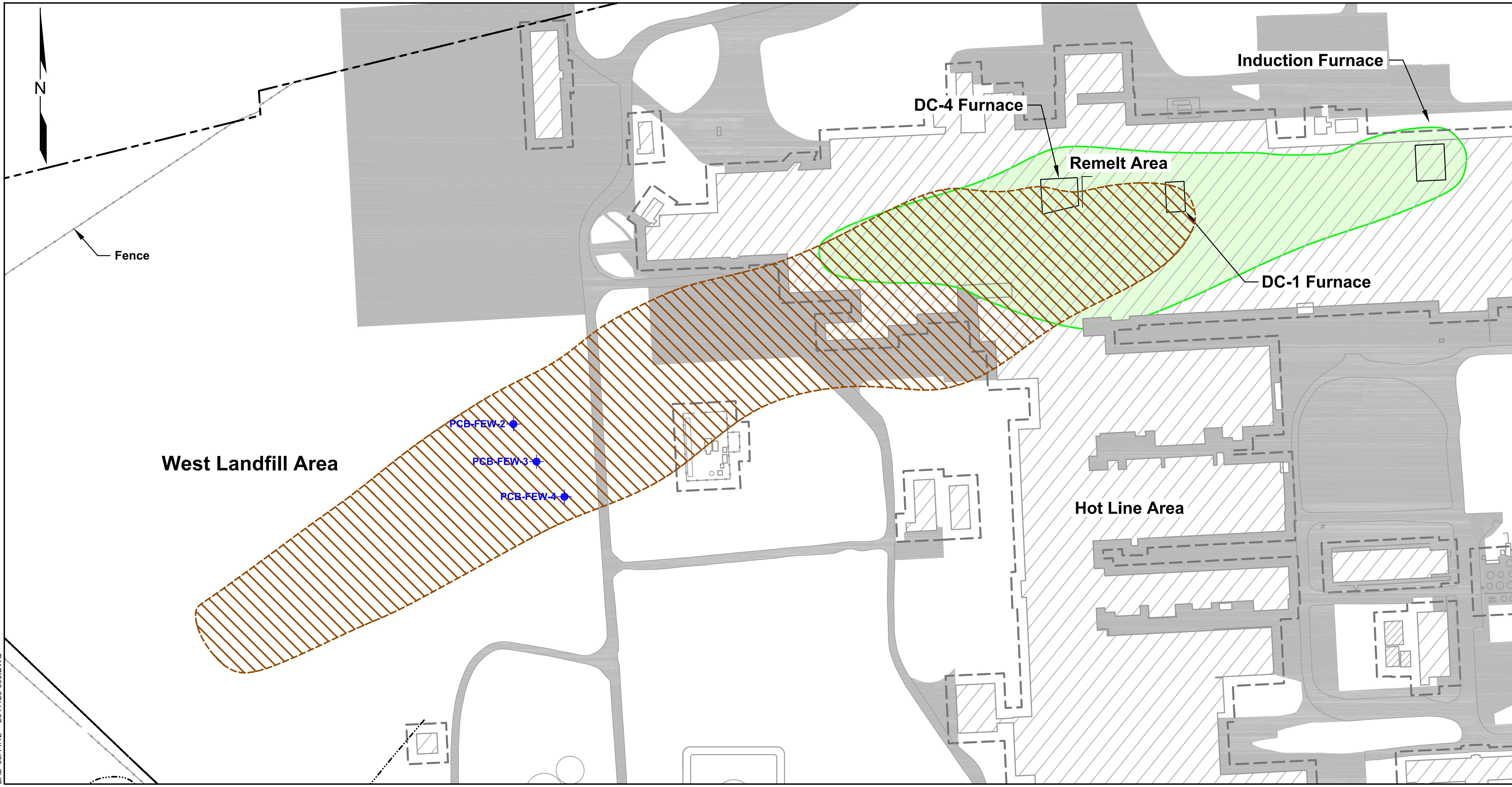
Figure 6-7

Remelt/Hot Line Area: Groundwater Plume and Associated Smear Zone Soil Extent



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PCB Area of Screening Level Exceedance in Smear Zone Soil

Inferred Extent of PCB Concentrations Dissolved in Groundwater Based on the Extent of Detected Concentrations

Former West Discharge Ravine

PCB-FEW-2 Proposed New Extraction Well Location and Number

20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation

Existing Paved Area

Existing Building

0 200 400

Scale in Feet

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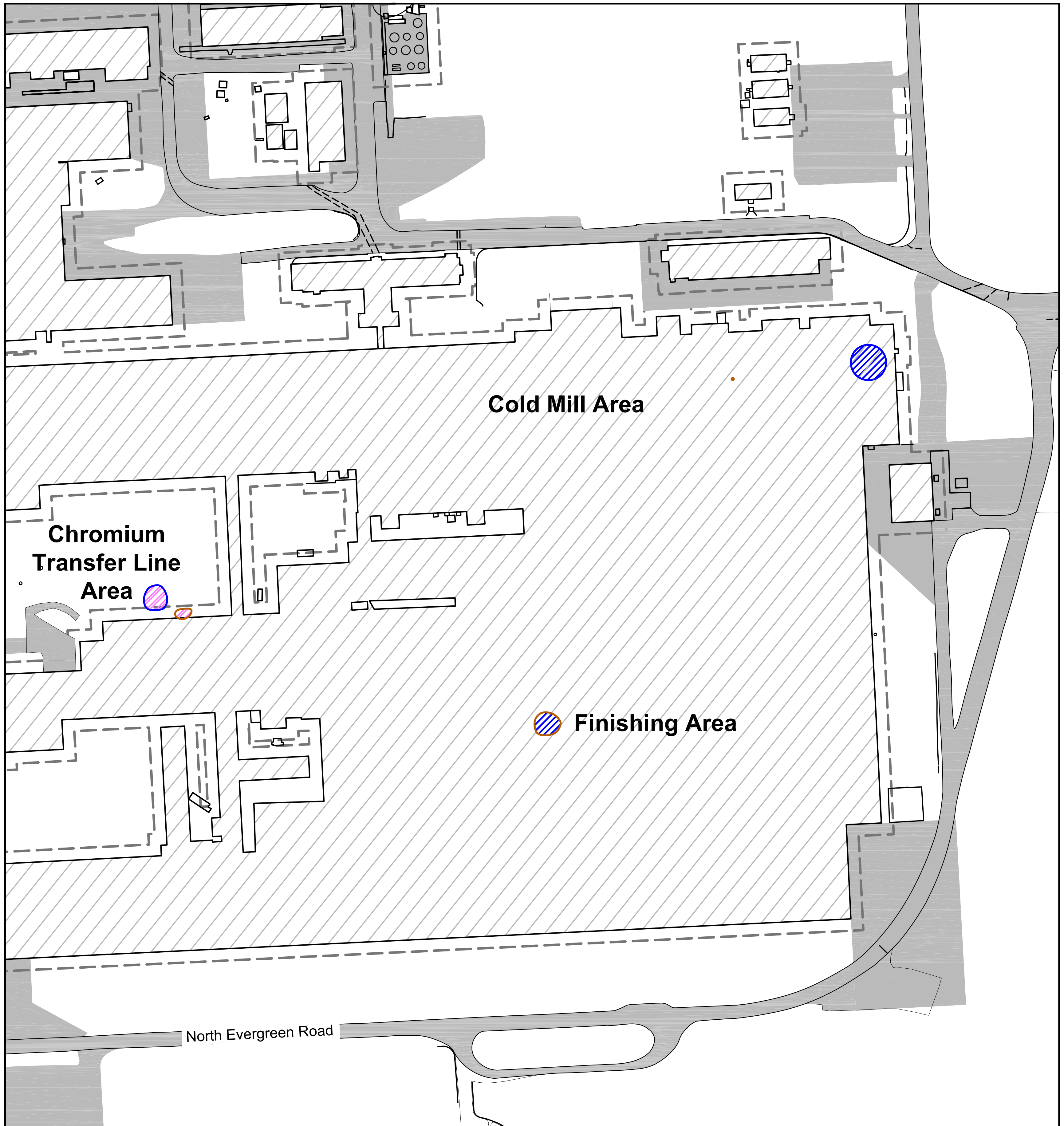
Figure 6-8

Cold Mill/Finishing Area: Proposed Containment Surfaces



Near-Surface Soil Area of Screening Level Exceedance

Deep Vadose Zone Soil Area of Screening Level Exceedance

Potential Cap

Potential Pavement or Floor Slab Repair

20-Foot No Excavation Zone Buffer Adjacent to Existing Building or Structure Foundation

Existing Paved Area

Existing Building

N

0 200 400

Scale in Feet

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Figure 6-9

EAL 05/14/12 2644125-091.DWG

Cold Mill/Finishing Area: Groundwater Plume and Associated Smear Zone Soil Extent

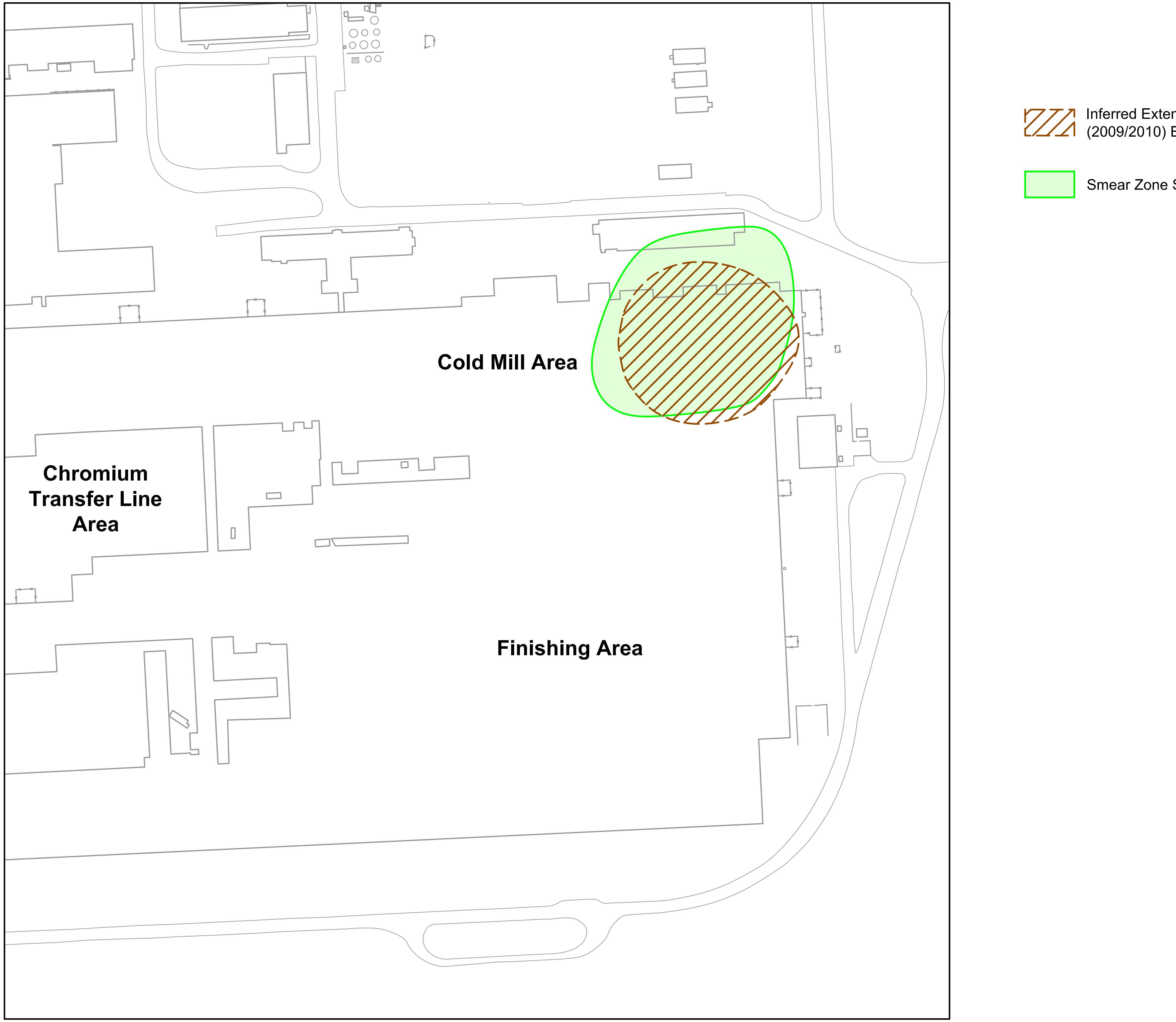

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Figure 6-10

EAL 05/14/12 2644125-092.DWG

Truck Shop Area: Proposed Containment Surfaces

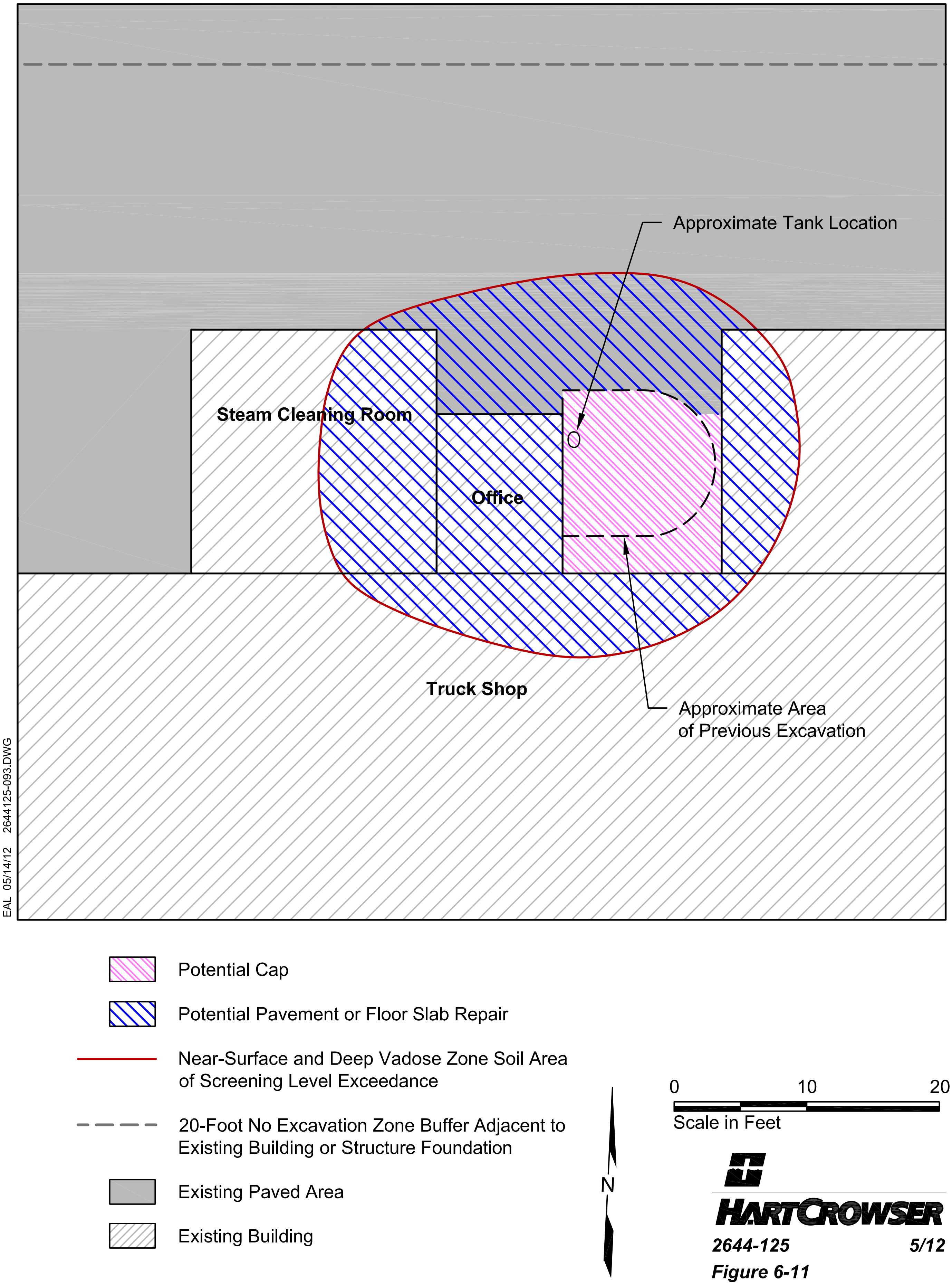

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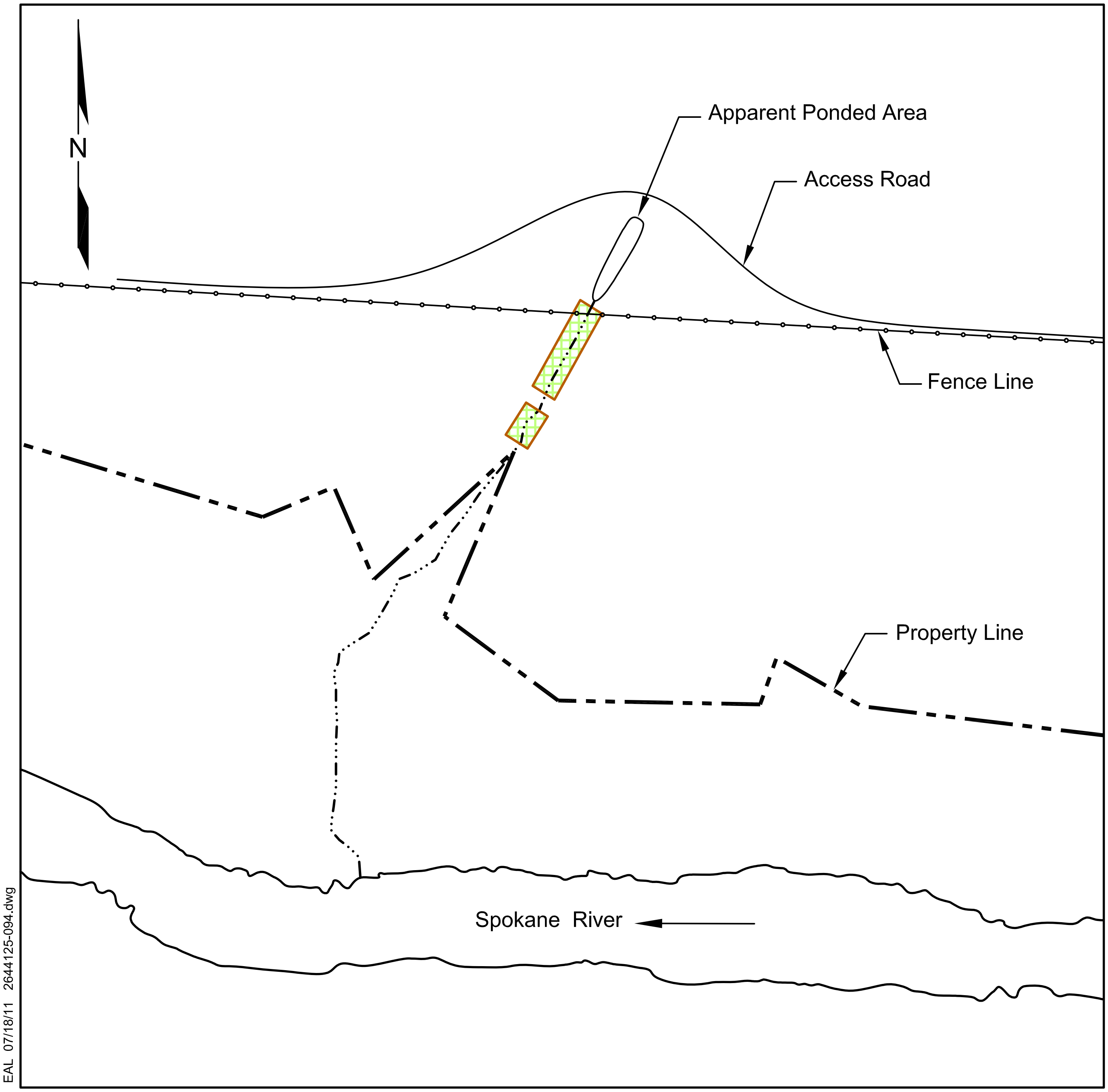
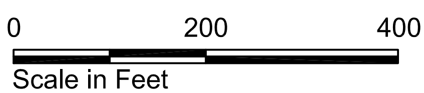
Figure 6-11

Former South Discharge Ravine Area: Proposed Excavation Area





Near-Surface Soil Area of Screening Level Exceedance

Potential Excavation

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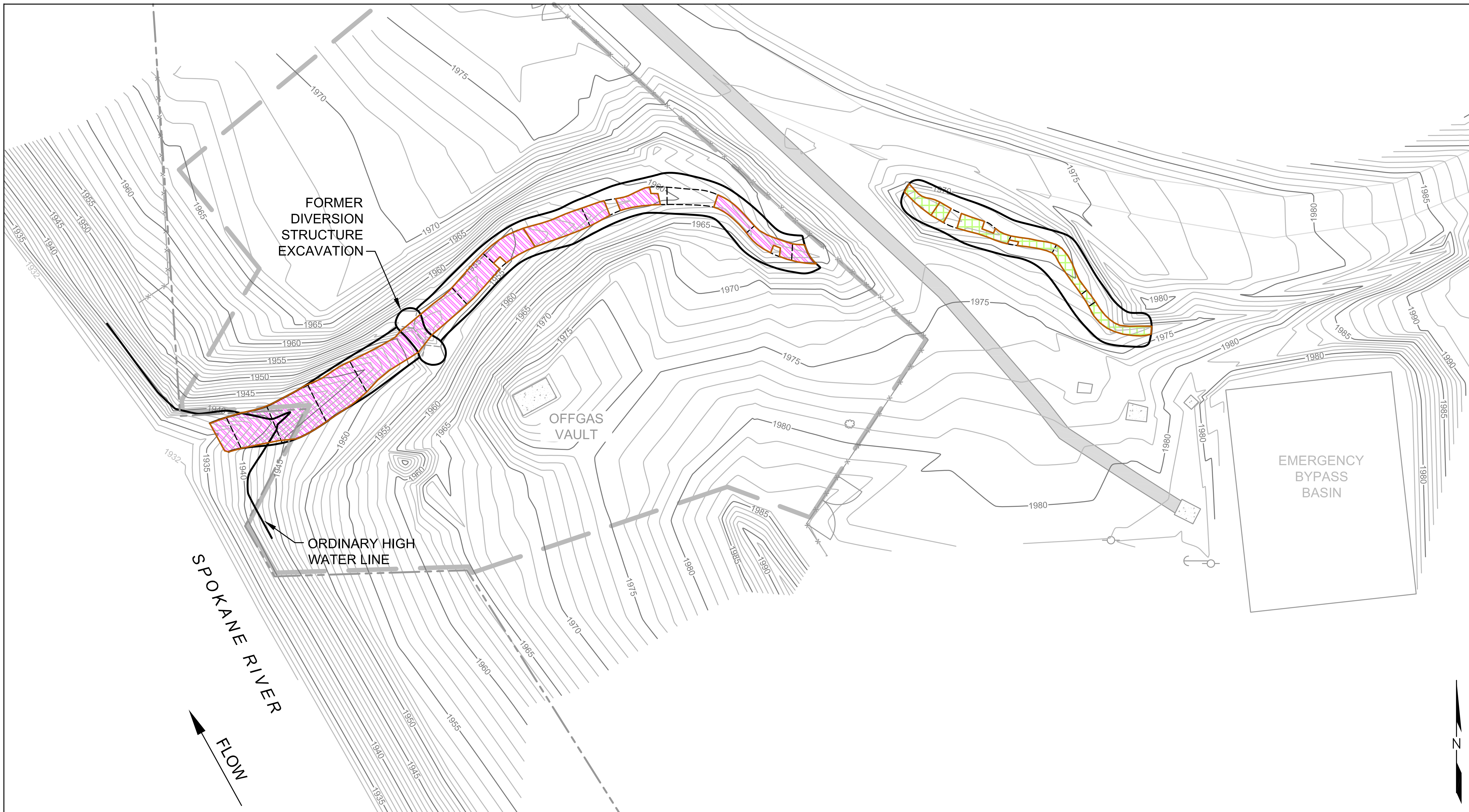
Figure 6-12

Former West Discharge Ravine Area: Proposed Excavation Areas and Containment Surfaces



Potential Excavation

Potential Cap

Near-Surface Soil Area of Screening Level Exceedance

Fence Line

0 50 100
Scale in Feet

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Figure 6-13

7.0 REFERENCES

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APPENDIX A
COST ESTIMATES FOR NEAR-SURFACE SOIL REMEDIAL ALTERNATIVES

APPENDIX B
COST ESTIMATES FOR DEEP VADOSE ZONE SOIL REMEDIAL ALTERNATIVES

APPENDIX C
COST ESTIMATES FOR PETROLEUM HYDROCARBON GROUNDWATER PLUME AND ASSOCIATED SMEAR ZONE SOIL REMEDIAL ALTERNATIVES

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APPENDIX I
RESTORATION TIME FRAME MEMORANDA

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PETROLEUM HYDROCARBON AREAS OF CONCERN MEMO

ATTACHMENT A
AOC RESTORATION TIME FRAME BASED ON ELECTRON DONOR DEMAND CALCULATIONS