


Focused Feasibility Study
Boylston Property
(Former BMW Seattle Property)
714 East Pike/715 East Pine Street
Seattle, Washington

Prepared for
Seattle Core Development Site I, LLC

September 20, 2013
17859-03

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ACRONYMS AND ABBREVIATIONS

AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
COC	constituent of concern
cm/s	centimeters per second
CSM	conceptual site model
CUL	cleanup levels
cy	cubic yards
DCA	disproportionate cost analysis
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FFS	Focused Feasibility Study
HASP	health and safety plan
LNAPL	light non-aqueous phase liquid
mg/kg	milligrams per kilogram
MTCA	Model Toxics Control Act
POC	point of compliance
RAO	remedial action objective
RCW	Revised Code of Washington
RI	Remedial Investigation
TCLP	toxicity characteristic leaching procedure
TPH	total petroleum hydrocarbons
UST	underground storage tank
VCP	Voluntary Cleanup Program
WAC	Washington Administrative Code

FOCUSED FEASIBILITY STUDY (FFS)
BOYLSTON PROPERTY
(FORMER BMW SEATTLE PROPERTY)
714 EAST PIKE/715 EAST PINE STREET
SEATTLE, WASHINGTON

1.0 INTRODUCTION

This report presents the results of a Focused Feasibility Study (FFS) for the Boylston Property in Seattle, Washington. This property was known as the former BMW Seattle property. This FFS was prepared for Seattle Core Development Site I, LLC, per the requirements of the Model Toxics Control Act (MTCA; Chapter 70.105D RCW) and its implementing regulations (Chapter 173-340 WAC) under Washington State Department of Ecology (Ecology). The Boylston property is registered in Ecology's Voluntary Cleanup Program (VCP) under VCP Project Number NW2618 (Facility Site ID 33641566).

This feasibility study addresses the known total petroleum hydrocarbon (TPH)-lead-, and cadmium-impacted soil at the Boylston Property (Site). A Remedial Investigation (RI) that was completed prior to this FFS compiles and summarizes results of past site investigations and underground storage tank (UST) removal, and a more recent site investigation on the Site (Hart Crowser 2013). The RI includes a copy of the previously-issued No Further Action Determination Letter, including the accompanying Restrictive Covenant document that was granted for the Site on January 25, 1999.

1.1 Purpose

The purpose of this FFS report is to present the remedial alternatives that were developed and evaluated for the Site, and to provide the basis for the selection of the most appropriate alternative for remedial activities based on present and future land use and the evaluation criteria listed below. According to the MTCA regulations, a cleanup alternative must satisfy all of the following threshold criteria as specified in WAC 173-340-360(2):

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

While these criteria represent the minimum standards for an acceptable cleanup action, WAC 173-340-360(2)(b) also requires that the selected cleanup action:

- Use permanent solutions to the maximum extent practicable;
- Provide for a reasonable restoration time frame; and
- Consider public concerns about the proposed cleanup action alternative.

A more detailed description of the MTCA evaluation criteria is presented in Section 6.1.

1.2 Focused Feasibility Study Approach and Report Organization

The preparation of this FFS involved identifying, evaluating, and recommending an appropriate remedial action for the areas of concern (AOCs) to be performed in conjunction with the planned redevelopment that would meet MTCA requirements specified in WAC 173-340-350(8). Specific tasks for this FFS included:

- Reviewing existing site information to reassess current soil and groundwater conditions and potential exposure pathways;
- Identifying AOCs for remediation;
- Developing remedial action objectives (RAOs) and remediation goals based on the cleanup standards established for the Site;
- Screening applicable remediation technologies and developing remediation alternatives for the AOCs from these technologies;
- Evaluating alternatives following the criteria specified in WAC 173-340-360; and
- Recommending a remedial alternative.

Following this introduction, the FFS report is organized into the following sections:

- **Section 2.0 – Site Setting and Historical Activities.** This section describes the Site, its location, and historical and current activities and investigations.

- **Section 3.0 – Conceptual Site Model.** This section provides a conceptual understanding of the Site that is based on the results of historical research, subsurface investigations, and previous remedial activities at the Site. This section includes a discussion of the confirmed and suspected source areas, the chemicals and media of concern, the fate and transport characteristics of the release of hazardous substances, and the potential exposure pathways.

- **Section 4.0 – Cleanup Requirements.** This section identifies RAOs and preliminary cleanup standards for the Site. These requirements address conditions relative to potential human and ecological receptor impacts. Together, the RAOs and cleanup standards provide the framework for evaluating remedial alternatives described later in this FFS, and for selecting a preferred alternative.

- **Section 5.0 – Development of Remediation Alternatives.** This section details each remediation alternative. Candidate remedial technologies were identified and screened to develop potential cleanup alternatives for further evaluation in this FFS.

- **Section 6.0 – MTCA Evaluation Criteria.** This section introduces and describes the MTCA criteria in WAC 173-340-360 that are evaluated in the selection of a remedial action. Each Alternative is evaluated to see how it meets the MTCA criteria. A disproportionate cost analysis (DCA) is used to determine whether the cleanup action uses permanent solutions to the maximum practicable extent.

- **Section 7.0 – Preferred Alternative Recommendations.** This section summarizes the findings of the FFS and identifies the preferred cleanup alternative based on technical feasibility, effectiveness, protectiveness, and cost.

- **Section 8.0 – Limitations.**

- **Section 9.0 – References.**

Supporting information is provided in tables and figures. Table 1 summarizes the MTCA cleanup and screening levels selected as part of the cleanup standards for the Site. Table 2 summarizes the remediation technology screening. Table 3 presents the evaluation of each alternative. Table 4 presents the results from the disproportionate cost analysis. Tables 5 through 8 present the cost estimates and net present values for each alternative.

Figure 1 is a vicinity map showing the location of the Site. Figure 2 shows the location of various Site features, and Figure 3 shows the location of explorations at the Site. Figures 4 and 5 provide cross sections of the Site. Areas of TPH-impacted soil are shown on Figure 6, and areas of metal-impacted soil are shown on Figure 7. Figures 8 through 10 show the conceptual layouts and features of the remediation alternatives evaluated in this FFS.

2.0 SITE SETTING AND HISTORICAL ACTIVITIES

The Site is a former BMW Seattle dealership location, which was historically used by various business operations, including an automobile spring manufacturer and an auto repair facility. Site soils are impacted by historical releases of TPH from on-site operations and former USTs, and by releases of metals from the automobile spring manufacturing activities.

2.1 Site Description and Setting

The Site covers approximately 54,000 square feet (1.26 acres) in Seattle, Washington (Figure 1), in the Capitol Hill neighborhood. It occupies most of the block that is bounded by East Pike and East Pine Streets and Boylston and Harvard Avenues. The Site includes two buildings: one at 714 East Pike and one at 715 East Pine Street and three parking lots: west, east, and southwest.

2.1.1 Geology

The geologic units at the Site consist of Fill, Till, and Advance Outwash sand units. The Fill unit is approximately 5 to 10 feet thick, and consists of silty, gravelly Sand with concrete or brick fragments. Underlying the Fill unit, a Till unit consists of dense, silty, gravelly Sand to sandy Silt. The Advance Outwash unit consists of sand and gravel with little silt and was observed in the five explorations from the 2012 investigation (HCE-7, HCE-9, HCE-21, MW-1, and MW-2) from depths of 27.5 to 43 feet, and was not noted in the other 20 borings to depths of 49 feet. Three borings (HCE-2, HCE-5, and HCE-9) encountered a loose silty Sand to Sand zone between 30 and 35 feet deep. Most of the planned excavation will be within the Fill and Till units. In some areas, the excavation could break into the Outwash unit and the loose Sand zones. Cross sections showing generalized subsurface conditions at the Site are provided on Figures 4 and 5.

2.1.2 Hydrogeology

During the 2012 investigation, Hart Crowser advanced 23 explorations and installed 2 monitoring wells. Groundwater was not encountered in any of the explorations, which ranged from 10 to 49 feet deep. A limited amount of perched water was encountered in one shallow (15 feet deep) push probe HCE-10, on the east side of the building, at 12.5 feet deep. A sample could not be collected because of the limited volume of available water in the push probe.

Groundwater was encountered in monitoring wells MW-1 and MW-2 at 45 and 51 feet below ground surface, respectively, in the Advance Outwash unit. Groundwater samples were collected from these monitoring wells following development. Groundwater conditions, including depth and volume, may fluctuate because of variations in rainfall, temperature, season, and other factors.

The surrounding area topography slopes down to the west and south toward Elliott Bay, located approximately 1 mile southwest of the Site. The Site elevation is higher to the northeast along East Pine Street and Harvard Avenue at approximately elevation 290 feet (NAVD 88). The ground floor of the former BMW dealership building is at street level on East Pike Street at approximately elevation 280 feet. Based on the area’s topography, groundwater is likely to flow to the west/southwest, toward Elliott Bay. The estimated gradient using MW-1 and MW-2 is approximately 0.05 feet/foot.

2.2 Future Development

Seattle Core Development Site I, LLC, intends to redevelop the Site beginning in mid-December 2013. The redevelopment will include three levels of underground parking, street-level retail space, and six floors of residential units above the retail level.

Figure 2 depicts the proposed footprint and excavation limits of the development and underground parking area. The footprint of the parking area and limits of excavation in the southwest area as shown on Figure 2 have been expanded from previous proposals. This additional excavation and design modification is established in the discussion of Alternative 1 (see Section 5.3.1). The expanded underground parking excavation discussed in Alternative 1 has been designed to remove and dispose of all known existing impacted soil from the Site.

The excavation for the parking structure is expected to extend to 35 feet deep. Only one historical area of sampling (TPH5922) detected contamination below 35 feet, and it is anticipated that some over-excavation may occur in this isolated location. Some areas of the property will only be minimally disturbed to approximately 4 feet below grade for footing excavation and grading during site development. These minimally excavated areas do not include any known impacted soil and will be covered by concrete pavement as part of the redevelopment.

2.3 Historical Use Summary

The 715 East Pine Street building is currently vacant except for a portion of the mezzanine, which is being used as office and meeting space for the developer. Historical property features in the 715 East Pine Street building (former Maintenance Shop) include an auto parts storage area; a 5,000-gallon diesel UST that was closed in place in 1998; a former hydraulic, bulk, and used oil tank area; a former recessed waste oil tank area; and former aboveground hydraulic lifts.

The 714 East Pike Street building is partly occupied by a sports drink company and the remainder of the building is vacant. Historical site features of the 714 East Pike Street property (former BMW Sales Showroom) include a heating oil UST that was closed in place in 1986.

The western parking lot along Boylston Avenue was occupied by a multifamily residence (St. Clair Apartments), which was torn down during the 1990s. The eastern parking lot along Harvard Avenue and the southwestern parking lot on the corner of Pike Street and Boylston Avenue were historically occupied by apartment buildings, which were torn down sometime after 1969. A 2,000-gallon diesel UST was removed from the southwestern paved parking lot in 1994.

Historical features are shown on Figure 2.

2.4 Previous Investigations and Remediation Activities

Hart Crowser and others have conducted several environmental field investigations, remedial actions, and groundwater sampling and analysis events on the Site since 1989, including a recent investigation in November and December 2012. These activities are detailed in Section 3.0 of the RI conducted by Hart Crowser and submitted to Ecology on January 31, 2013. Key elements from the RI are summarized below.

- A 2,000-gallon diesel fuel oil UST located in the southwest parking lot was decommissioned and removed in 1994. Impacted soil was removed and confirmation soil samples were collected from the side walls and bottom of the excavation. All confirmation samples were below detection limits for TPH.

- A 400-gallon heating oil UST located in the central area of the Site was closed in place in 1986. Soil samples were collected near the 400-gallon tank and analyzed for TPH in 1990 from two borings that were drilled near the UST to 10.5 and 11 feet deep. The results indicated that TPH concentrations (diesel) were below the MTCA Method A soil cleanup level of 2,000 mg/kg.

- A 5,000-gallon diesel fuel oil UST was closed in place in 1998 in the southwest portion of the former Maintenance Shop area. Soil samples were collected under the UST by drilling through the bottom of the tank when it was decommissioned. The results indicated that soil beneath the tank was impacted with TPH constituents (primarily diesel) above the MTCA Method A soil cleanup level of 2,000 mg/kg.

- Diesel- and heavy oil-range TPH (TPH-D and TPH-O, respectively) were analyzed during historical investigations. Based on the field screening and soil analytical results, TPH-impacted soil is primarily located in the center of the Site within the upper 10 to 20 feet (Figure 6). However, one historical boring (TPH5922) had TPH-impacted soil at a depth of 40 feet. After additional investigation in the fall of 2012, it is our opinion that the TPH historically detected at 40 feet is localized and does not extend below 45 feet.

- Soil samples were analyzed for gasoline-range TPH (TPH-G) in 2012. TPH-G concentrations were detected above the MTCA Method A soil cleanup level (100 mg/kg without benzene present) in soil samples from two borings (HCE-7 and MW-2) in the center of the Site to depths of 26 feet. According to the recent data, the TPH-G is limited to the area around borings HCE-7 and MW-2. These boring locations are close to the property boundary and are not easily accessible due to underground and aboveground utilities and the adjacent apartment building. Other gasoline-related VOCs were detected in soil at concentrations below applicable Method A soil cleanup levels. No benzene constituents were detected, indicating that the gasoline-related soil impacts are weathered and aged gasoline. The TPH-G concentrations exceeding the MTCA Method A soil cleanup level (100 mg/kg) from MW-2 and HCE-7 were to depths of 21.3 feet and 16.5 feet, respectively, below the planned 4-foot excavation depth in this specific area.

- TPH-O was detected in boring HCE-6 (located in the former Maintenance Shop area) to a depth of 10 to 12 feet in 2012 above the MTCA soil cleanup level of 2,000 mg/kg. There were no other TPH-O exceedances during the 2012 investigation. The source of TPH may be historical releases from the motorcycle shop and auto repair facility located east of the Site.

- Metal impacts in the soil (specifically lead and cadmium) were previously documented in the center of the Site to a depth of 8 feet. Toxicity characteristic leaching procedure (TCLP) results for lead exceeded the Dangerous Waste criteria in two samples described in historical memoranda (ThermoRetec 2001a and 2001b). The specific samples or sample locations were not identified, though they were noted as being from the soil samples collected in the center of the Site. In 2012, Hart Crowser collected and analyzed additional soil samples and confirmed that previously detected metal impacts are contained in the upper 8 to 10 feet in a limited area (Figure 7). However, none of the 2012 samples analyzed for TCLP exceeded the Dangerous Waste levels for lead (5 mg/L) or cadmium (51 mg/L).

- Two groundwater monitoring wells (Figure 3) were installed on the Site to characterize groundwater quality. Groundwater was encountered in the two deep monitoring wells between 45 and 51 feet below ground surface. Groundwater samples were collected during the 2012 investigation and analyzed for TPH, VOCs, and total metals. These analytes were not detected in either groundwater sample.

3.0 CONCEPTUAL SITE MODEL

This section provides a conceptual understanding of the Site that is based on the results of historical research, subsurface investigations, and previous remedial actions performed at the Site. A discussion of the chemicals and media of concern, the fate and transport characteristics of the release of hazardous substances, and the potential exposure pathways are included in this section. The conceptual site model (CSM) serves as the basis for developing technically feasible cleanup alternatives and selecting a final cleanup action for the planned redevelopment of the property. The CSM may be refined throughout the cleanup action process as additional information becomes available.

3.1 Confirmed Source Areas and Affected Media

Subsurface soil TPH and metal impacts at the Site appear to have been caused by: (1) releases from former USTs and auto-service operations; and (2) former operations of the automobile spring manufacturer before 1989. The TPH and metal impacts appear to have been primarily located in the central area of the Site (Figures 6 and 7).

3.1.1 Media of Concern

Soil has been identified as the sole affected media at the Site based on the elevated concentrations of TPH, lead, and cadmium beneath the site. Groundwater sampling results from a 2012 investigation indicate groundwater has not been affected by TPH, VOCs, or metals.

Based on the soil sampling results from the previous and recent 2012 investigations, soil vapor has not been selected as a media of concern because TPH in the gasoline range was only detected slightly above MTCA Method A cleanup levels in two explorations (out of 25 explorations) in an isolated area on the property. In addition, no benzene or toluene has been detected in any soil samples on the property. Only low concentration of ethylbenzene, xylenes, and other gasoline-related VOCs were detected in a few soil samples. This indicates that the gasoline is likely weathered and less volatile.

3.1.2 Constituents of Concern

The environmental constituents of concern (COCs) identified for soil are TPH-D, TPH-O, TPH-G, lead, and cadmium.

3.1.3 Area of Concerns

The locations where impacted media reside define the Site AOCs. Figure 6 shows the approximate distribution and depth of the TPH-impacted soil. Most of the impacted soil is within the upper 10 to 20 feet. One soil sample, TPH5922, collected in 1996 from a depth of 40 feet exceeded MTCA Method A soil cleanup levels. No TPH-impacted soil was detected at sample locations around this depth during the 2012 Site investigation. Figure 7 shows the approximate distribution of the lead- and cadmium-impacted soil. Lead- and cadmium-impacted soil is limited to the upper 10 feet.

3.2 Release Mechanisms and Transport Processes

The primary release mechanisms and transport processes by which constituents can migrate from sources to receptors are identified in this section. This includes a discussion of the transport mechanisms and environmental fate of TPH and metals in the subsurface.

3.2.1 Environmental Fate of COCs in the Subsurface

The primary physical and chemical processes that can influence contaminant concentrations and migration include:

- Adsorption to soil;
- Leaching or dissolution into groundwater;
- Volatilization; and
- Degradation.

In general, when TPH is released into the subsurface, the light non-aqueous phase liquid (LNAPL) may travel through the unsaturated zone as free phase product. TPH constituents can sorb onto soil particles and leach or dissolve into groundwater (when present) and migrate with groundwater flow. It should be noted that LNAPL has not been observed or found at the Site. TPH constituents also degrade over time through chemical or biological processes. The volatile constituents in TPH-G evaporate and can migrate through the unsaturated zone as soil vapor. Some TPH-G vapor may escape to the atmosphere or accumulate in enclosed spaces such as buildings.

The most significant fate process for TPH is biodegradation (i.e., natural attenuation). Biological degradation of contaminants in LNAPL, dissolved, residual, and vapor phases occurs under various environmental conditions, although it occurs predominantly in the aqueous, residual, and vapor phases. Degradation products of gasoline constituents are generally less toxic than their parent species. TPH compounds that are the most mobile are the most easily biodegraded.

Metals are typically susceptible only to adsorption to soil and leaching or dissolution into groundwater. Metal adsorption and solubility can vary widely and are controlled by oxidation state, speciation, associated counter ions, water pH and oxidation-reduction potential, soil particle size, and the type of mineral phase present in the aquifer.

3.2.2 Potential Exposure Pathway

Since most of the Site is (or will be) paved or lies beneath structures, potential exposure pathways are limited. These potential exposure pathways may be present:

- Direct ingestion or dermal contact of soil;
- Volatilization of contaminants from soil to air; and
- Infiltration, percolation, or dissolution/desorption into groundwater.

3.3 Receptors

Potential receptors at the Site include humans and terrestrial ecological receptors. Terrestrial ecological receptors include plants and animals exposed to impacted media, as well as secondary food chain consumers such as birds and mammals. As described in the RI (Hart Crowser 2013), the Site qualifies for an exclusion from a terrestrial ecological evaluation because there is no potential exposure pathway to terrestrial wildlife. Therefore, humans have been identified as the only receptors for the Site.

3.4 Summary of Completed Exposure Pathways

For a COC to present a risk to human health and/or the environment, the pathway from the COC to the receptor must be completed. The COC to receptor pathways judged to be present at the Site are discussed in this section, by medium.

3.4.1 Soil

The pathways that may allow COCs in soil to reach receptors include: (1) human direct contact with COCs in soil within 15 feet of the ground surface via the dermal contact or ingestion pathways, and (2) leaching of contaminants from soil to groundwater.

Protection from direct contact exposure to impacted soil and leaching from soil to groundwater would require capping or excavation. Impacted soil is (or will be) covered with asphalt, concrete, and/or building structures, which minimizes the risk of direct contact. However, future development activities at the Site could result in exposure to impacted soil during construction.

3.4.2 Groundwater

No pathway.

3.4.3 Air

The pathways judged to be potentially present that could allow COC vapors in air to reach receptors include the volatilization of TPH-G from soil to soil vapor. However, based on site conditions and the fact that the TPH-G seems to be weathered indicate that there is a low risk of vapor intrusion.

4.0 CLEANUP REQUIREMENTS

The following sections identify RAOs and preliminary cleanup standards for the Site, which were developed to address MTCA regulatory requirements for site cleanup. These requirements address conditions relative to potential human receptor impacts. Together, the RAOs and cleanup standards provide the framework for evaluating remedial alternatives described later in this FFS, and for selecting a preferred alternative.

4.1 Remedial Action Objectives

The primary objective for the FFS and cleanup action focuses on substantially eliminating, reducing, and/or controlling unacceptable risks to human health and the environment posed by site COCs to the extent practicable.

4.2 Cleanup Standards

Cleanup standards include cleanup levels and points of compliance (POCs) as described in WAC 173-340-700 through WAC 173-340-760. Cleanup standards must also incorporate other state and federal regulatory requirements applicable to the cleanup action and/or its location as appropriate. The following sections summarize current applicable cleanup standards for the Site.

4.2.1 Cleanup Levels

Table 1 summarizes the current cleanup levels (CULs) selected for the Site COCs. MTCA Method A soil CULs have been selected for the Site. Prior to cleanup, these cleanup levels may be modified if additional VPH/EPH analyses are performed on soil samples collected during construction.

Table 1 – MTCA Cleanup Levels

		Constituent of Concern				
Medium	Units	Hydrocarbons			Metals	
		Diesel-Range	Gasoline-Range	Heavy-Oil Range	Lead	Cadmium
Soil [a]	mg/kg	2000	100/30 [b]	2000	250	2

Notes:
(a) MTCA Method A cleanup level.
(b) 100 mg/kg for gasoline mixtures without benzene and the total of ethylbenzene, toluene, and xylenes are less than 1% of the gasoline mixture; 30 mg/kg for all other gasoline mixtures.

4.3 ARARs and Applicable Regulations

The following potential remedial technologies have been evaluated to meet the Applicable or Relevant and Appropriate Requirements (ARARs) associated with federal, state, and regional regulations, as described in Section 7.4 of the RI (Hart Crowser 2013). All three alternatives would be designed and implemented in accordance with action- and location-specified ARARs.

5.0 DEVELOPMENT OF REMEDIATION ALTERNATIVES

The remediation alternatives combine technologies that are applicable to impacted soil and soil vapor at the Site. Candidate remedial technologies were identified and screened to develop potential cleanup alternatives for further evaluation in this FFS. The remedial technologies considered in the screening process include methodologies capable of achieving the remedial action objectives for site soil and soil vapor.

The following sections describe how the remediation alternatives are developed for the Site and a description of each alternative. The alternatives are evaluated based on MTCA criteria in Section 6.0, which includes a DCA (WAC 173-340-360[3][e]).

5.1 Remediation Technology Screening

The remedial technologies that were identified and screened for the Site are summarized in Table 2. The screening of technologies applicable to impacted soil remediation and vapor intrusion mitigation included consideration of available methodologies to address contaminants in the various media based on their expected implementability, reliability, and relative cost. Physical conditions at the Site that limit or support particular technologies, and contaminant characteristics that limit the effectiveness or feasibility of a technology, were considered for the developed remediation alternatives after the theoretical screening evaluation.

The implementability (i.e., the relative ease of installation and the time required to achieve a given level of performance) of a technology is assessed based on site conditions. Implementability considers: (1) the technology's constructability (i.e., ability to build, construct, or implement the technology under actual site conditions); (2) the time required to achieve the required level of performance as defined by the cleanup levels and points of compliance; (3) the ability of the technology to be permitted; (4) the availability of the technology; and (5) other technology-specific factors.

To assess the reliability of prospective technologies, the EPA states that an evaluator should identify the level of technology development, its performance record, and the inherent construction, operation, and maintenance problems of each technology considered. Technologies that are unreliable, perform poorly, or are not fully demonstrated should be eliminated (EPA 1988).

Table 2 indicates which technologies were retained for further evaluation in the development of the remediation alternatives in the FFS and which technologies were eliminated from consideration based on implementability, reliability, or cost. Technologies that were retained are described in Section 5.2.

5.2 Retained Technologies

Excavation with off-site disposal of impacted soil was retained as an effective, well-established remediation methodology applicable to site soil contaminants. Soil excavation and disposal have the additional benefit of reducing or eliminating potential sources of soil and groundwater contamination.

Capping technology was retained as a measure that can minimize direct soil contact risk for human receptors, in addition to minimizing the potential migration of contaminants from impacted soil to groundwater through infiltration.

A vapor intrusion mitigation system technology alternative was retained to mitigate potential intrusion of hydrocarbon vapors into the building or surrounding buildings. A passive venting system could be used in the area where gasoline-impacted soil may remain to provide a path for the soil vapor to escape before it can enter the indoor air space of a building from beneath the building floor.

Institutional controls were retained in the screening as a technology that would not be effective on its own but may be used in conjunction with other alternatives.

5.3 Remediation Alternative Descriptions

The technologies retained in the screening process were combined into three remediation alternatives for further evaluation (Alternatives 1 through 3). The components of the remediation alternatives developed for the Site are summarized below. All alternatives include compliance monitoring to meet WAC 173-340-410. The layout and components of Alternatives 1 through 3 are depicted on Figures 8 through 10.

Alternative 1 consists of the following components:

- Excavation and off-site disposal of all known impacted soil; and
- Compliance monitoring.

Alternative 2 consists of the following components:

- Excavation and off-site disposal of impacted soil within the planned development excavation;
- Implementation of a concrete cap to cover remaining impacted soil outside the proposed building footprint following shallow soil excavation;
- Institutional controls, such as a restrictive covenant; and
- Compliance monitoring and maintenance.

Alternative 3 consists of the following components:

- Excavation and off-site disposal of impacted soil within the planned development excavation;
- Implementation of a concrete cap to cover remaining impacted soil outside the proposed building footprint following shallow soil excavation;
- Installation of a passive vapor intrusion mitigation system;
- Institutional controls, such as a restrictive covenant; and
- Operation, maintenance, and monitoring.

5.3.1 Description of Alternative 1

Alternative 1 consists of excavation and off-site disposal of all known impacted material. By removing all the impacted material, this alternative will eliminate ecological and human health direct contact pathways, eliminate the potential for contaminants to migrate to groundwater, and eliminate the vapor intrusion pathways.

Excavation. Alternative 1 includes the excavation of all the known impacted soil at the Site. Lateral and vertical excavation limits will ultimately be based on the observed extent of impacted soil within each impacted area and the results of performance monitoring. For cost estimating purposes, the excavation volume is based on the inferred lateral and vertical extent of impacted soil presented in Figures 3 through 6 of the RI.

Based on the conservative lateral and vertical excavation volume estimates, approximately 2,500 cubic yards (cy) of impacted material would be excavated and disposed of in Alternative 1. Approximately two-thirds of the impacted material is located in the top 10 feet; however, soil impacts may extend to up to 40 feet deep in one isolated area (see Figure 8) based on one soil sample collected and analyzed in 1996. Additional clean material would need to be excavated to reach a depth of 40 feet throughout the entire development footprint. This alternative assumes that the excavation from 35 to 40 feet (below the proposed shored excavation depth) would include a 1:1 side slope.

Excavated impacted soil will be sent off site for disposal at a regulated landfill facility. For the purposes of this FFS, it is assumed that most of the excavated impacted soil can be characterized as non-hazardous and will be sent to a Subtitle D landfill facility for disposal. Based on historical investigations, a portion of the metal-impacted soil may exceed the TCLP and, therefore, need to be characterized as dangerous waste and be sent to a Subtitle C landfill facility for disposal. For the purpose of this FFS, 30 percent of the metals-impacted material will be considered dangerous waste (approximately 290 cubic yards). During construction, impacted material will be stockpiled and characterized before disposal or pre-characterized and directly loaded for transportation and disposal.

The excavated areas that are not within the proposed new building footprint or the proposed expanded excavation area would be backfilled to grade using clean, imported, and properly compacted fill.

The excavation work will include measures to protect the apartment building at 1512 Boylston Avenue and underground utilities. Soldier piles or other shoring will be placed next to or under the apartment building to support it while excavation activities adjacent to the building are taking place. An easement will be required for the work that will occur on adjacent property including underpinning the building and other structural supports.

Underground utilities will need to be located before excavation. Erosion control and site stabilization measures will be implemented during construction activities.

Compliance Monitoring. Compliance monitoring includes the collection and analysis of soil samples from the base and side walls of the excavations to confirm that the contaminants have been removed. Protection monitoring elements, including dust monitoring during excavation, will be addressed in the Health and Safety Plan (HASP) for the project.

5.3.2 Description of Alternative 2

Alternative 2 includes the off-site disposal of impacted material excavated as part of the planned building construction/Site redevelopment. The areas that are not excavated as part of the proposed redevelopment will be isolated under clean backfill and under either an impervious concrete cap or the proposed building. The containment of these areas will reduce the potential for direct contact and will prevent the infiltration of rainwater that could potentially cause contaminants to migrate to groundwater. The cap will be maintained and monitored. Because some contaminants will be left in place, institutional controls, such as a restrictive covenant, will be required.

Excavation. Alternative 2 includes excavation of a majority of the impacted soil in areas within the proposed development area. The extent of excavation of impacted soil within the building footprint, as outlined in the development plan, is shown on Figure 9. The depth of excavation will go to a maximum depth of 35 feet within the footprint of the building. Excavation in the areas around the proposed building where the soil is structurally unfit for redevelopment will be excavated to 4 feet, with clean backfill placed on top of encapsulated material.

Excavated impacted soil will be sent off site for disposal at a regulated landfill facility. As described in Alternative 1, the excavated impacted soil will be assumed to be non-hazardous and will be sent to a Subtitle D landfill facility for disposal, except for the 30 percent that is metals-impacted material. Based on conservative lateral and vertical excavation estimates, approximately 1,960 cy of material will be excavated and disposed of in Alternative 2 including the 280 cy of the material that is assumed to be dangerous waste.

The excavation work includes measures to protect the building and underground utilities. Underground utilities will need to be located before excavation. Erosion control and site stabilization measures will be implemented during construction activities.

Containment. In Alternative 2, the area outside of the proposed building footprint will be excavated to a planned depth of approximately 4 feet (Figure 2). This area of shallow excavation will be backfilled to grade using clean, imported, and properly compacted fill and then isolated under a cap consisting of impervious concrete. The building foundation will act as a cap for the area with TPH impacts that extend to a depth greater than the planned redevelopment.

The cap will be located at the southwest corner outside of the proposed building and encompasses an area of approximately 650 square feet (see Figure 9).

Caps for isolation of impacted 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.

Institutional Controls. Alternative 2 will use a restrictive covenant to protect to those areas of the Site where contaminants remain in place at concentrations that exceed cleanup standards. The requirements of the restrictive covenant are presented in WAC 173-340-440(9).

Compliance Monitoring and Maintenance. Compliance monitoring will include the collection and analysis of soil samples from the base and side walls of the excavation to confirm that the contaminants have been removed. Protection monitoring elements, including dust monitoring during excavation, will be addressed in the HASP for the project.

A long-term monitoring plan 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).

5.3.3 Description of Alternative 3

Alternative 3 includes the same excavation, capping, and institutional controls as Alternative 2, and also implements a vapor mitigation system. The vapor mitigation will further reduce the risk of potential residual vapors accumulating in buildings.

Excavation. Alternative 3 includes excavation of the proposed development area as described in Alternative 2. See the excavation description in Section 5.3.2 for details.

Containment. Alternative 3 includes containment measures as described in Alternative 2. See the containment description in Section 5.3.2 for details.

Vapor Intrusion Mitigation System. Vapor mitigation will include a passive venting system in the area where known TPH-G would be left in place. The passive venting system will reduce potential intrusion of residual vapors into the building. A passive venting system is designed to help soil vapors escape before they can enter the indoor air space of a building from beneath the floor.

Approximately 160 linear feet of 1-1/2-inch perforated PVC pipe will be installed under the pavement in the area where TPH-G is left in place. The perforated pipe will be connected to an exhaust stack that will be attached to the side of the proposed building.

Institutional Controls. Alternative 3 includes institutional controls as described in Alternative 2. See the containment description in Section 5.3.2 for details.

Compliance Monitoring, Operation, and Maintenance. Alternative 3 includes compliance monitoring, operation, and maintenance as described in Alternative 2. See the description in Section 5.3.2 for details. Alternative 3 also includes compliance monitoring of the vapor mitigation and operation and maintenance of the passive venting system.

6.0 EVALUATION OF REMEDIATION ALTERNATIVES

Ecology identifies the criteria that should be used to evaluate remediation alternatives within the MTCA regulation (WAC 173-340-360). The purpose of the evaluation is to identify the advantages and disadvantages of each alternative and, thereby, assist in the decision-making process. The criteria are described in section 6.1 and applied to Alternatives 1 through 3 in Section 6.2.

6.1 MTCA Evaluation Criteria

Four threshold requirements must be met for an alternative to be considered for selection as a remedy. Three “other requirements” are then used to further evaluate those alternatives that satisfy the threshold criteria. Finally, several action-specific or “pertaining to” requirements—which vary depending on the nature of the site and the alternatives being considered—are used to further refine the remedy selection.

The threshold requirements are:

- **Protect human health and the environment.** The alternative must provide for overall protection of human health and the environment.

- **Comply with cleanup standards.** The alternative must comply with cleanup standards (cleanup levels and the points of compliance where such cleanup levels must be met) as established in WAC 173-340-700 through 173-340-760.

- **Comply with applicable state and federal laws.** The alternative must comply with both applicable and requirements that are determined to be relevant and appropriate, as defined through WAC 173-340-710.

- **Provide for compliance monitoring.** The alternative must provide for compliance monitoring, as established under WAC 173-340-410 and WAC 173-340-720 through 173-340-760.

The “other requirements” are:

- **Use permanent solutions to the maximum extent practicable.** As outlined in WAC 173-340-360(3), evaluation of this requirement involves conducting a DCA wherein the costs and benefits of each alternative, as defined by several evaluation criteria, are compared and balanced. Our DCA for the Alternatives is presented below in Section 7.0.

- **Provide a reasonable restoration time frame.** As laid out in WAC 173-340-360(4), the determination of whether an alternative provides for a reasonable restoration time frame involves balancing site risks against the practicability of achieving a shorter restoration time frame. A longer restoration time frame may be selected if the remedy has a greater degree of long-term effectiveness; however, extending the restoration time frame cannot be used as a substitute for active remedial measures when such actions are practicable.

- **Consider public concerns.** Consideration of public concerns is mandated under the MTCA cleanup regulation for an Ecology-led or potentially liable person-led cleanup action under an Agreed Order or Consent Decree. This is typically implemented by Ecology through a mandatory public review and comment period on a proposed cleanup action plan. Because the public review and comment process is not implemented by the private parties responsible for the cleanup under the VCP, and because this FFS was prepared within the purview of the VCP, public comments regarding cleanup actions for the Site were not requested or evaluated in this document.

A number of action-specific or “pertaining to” requirements are also listed in WAC 173-340(2)(c) through (h), although not all of these requirements are applicable to the Site. The action-specific requirements are:

- **Groundwater cleanup actions.** This requirement is applicable to situations where cleanup levels for groundwater cannot be achieved within a reasonable restoration time frame. Groundwater has not been impacted at the Site and, therefore, this requirement is not relevant.

- **Soil at current or potential future residential areas and child care centers.** Specific requirements pertaining to soil cleanup at current or potential future residential areas and child care centers are found in WAC 173-340-360(2)(b). These requirements relate to soil cleanup levels established for human health protection.

- **Institutional controls.** Institutional controls must comply with the specific requirements of WAC 173-340-440 and should demonstrably reduce risks to ensure a protective remedy. A remedy shall not rely primarily on institutional controls and monitoring where it is technically possible to implement a more permanent cleanup action for all or part of a site. For complete detail, see WAC 173-340-360(2)(e).

- **Releases and migration.** Cleanup actions shall prevent or minimize present and future releases and migration of hazardous substances in the environment. See WAC 173-340-360(2)(f).

- **Dilution and dispersion.** Cleanup actions shall not rely primarily on dilution and dispersion unless the incremental costs of any active remedial measures over the costs of dilution and dispersion grossly exceed the incremental degree of benefits of active remedial measures over the benefits of dilution and dispersion. See WAC 173-340-360(2)(g).

- **Remediation levels.** Remediation levels are defined as the particular concentration of a hazardous substance in any media, above which a particular cleanup action component will be required as part of a cleanup action at the Site. See WAC 173-340-200. Specific requirements pertaining to the use of remediation levels are presented in WAC 173-340-360(2)(h). The alternatives being considered in this evaluation do not involve the use of remediation levels; therefore, this requirement is not relevant.

6.2 Evaluation of Alternatives

We evaluated the three alternatives against the MTCA selection requirements outlined above. This evaluation is presented in Table 3. The following sections summarize our evaluation, concentrating on the main differences between the alternatives.

6.2.1 Threshold Requirements

All three alternatives meet the MTCA threshold requirements as described below.

- **Protect human health and the environment.** All three alternatives are protective of human health and the environment. Alternative 1 prevents exposure to humans through removal of all impacted material. Alternative 2 prevents exposure through removal of most impacted material and capping. Alternative 3 prevents exposure through removal and capping of most impacted material and provides additional protection by including vapor mitigation.

- **Compliance with cleanup standards.** All three alternatives comply with cleanup standards. Alternative 1 meets this requirement by removing and permanently disposing of all hazardous substances that exceed cleanup standards. Alternatives 2 and 3 meet this requirement by fulfilling the cleanup standards set out in WAC 173-340-740(6)(f) for containment-based remedies.

- **Comply with applicable state and federal laws.** All three alternatives meet contaminant-specific ARARs (i.e., MTCA cleanup standards) as discussed above. In addition, as mentioned in Section 4.3, all three alternatives would be designed and implemented in accordance with action- and location-specific ARARs.

- **Provide for compliance monitoring.** All three alternatives provide for compliance monitoring as described in Sections 5.3.1 through 5.3.3.

6.2.2 Other Requirements

Alternatives 1 through 3 satisfy the MTCA “other requirements.”

- **Use permanent solutions to the maximum extent practicable.** As described in the DCA (Section 6.3) all three alternatives are considered to use permanent solutions to the maximum extent practicable.

- **Provide a reasonable restoration time frame.** All three alternatives provide for a reasonable restoration time frame. The proposed alternatives could probably be completed within one construction seasons and cleanup would be complete at the end of construction.

- **Consider public concerns.** As discussed in Section 6.1, consideration of public concerns was not evaluated in this FFS.

6.2.3 Action-Specific Requirements

As discussed in Section 6.1, the MTCA action-specific requirements concerning groundwater cleanup actions and remediation levels are not applicable to the alternatives under consideration. The evaluation of the alternatives against the other action-specific requirements is summarized below.

- **Soil at current or potential future residential areas and child care centers.** All three alternatives comply with this requirement; Alternative 1 removes all soil exceeding cleanup levels; Alternatives 2 and 3 remove and/or cap soils exceeding cleanup levels.

- **Institutional controls.** All three alternatives meet this requirement. Alternative 1 does not use or require institutional controls. Alternatives 2 and 3 will implement institutional controls to ensure the integrity of the cap; however, the protectiveness of this remedy does not rely primarily on institutional controls.

- **Releases and migration.** All three alternatives meet this requirement. Alternative 1 controls releases and migration by removing and permanently disposing of the impacted materials that exceed cleanup levels. Alternatives 2 and 3 control releases and migration through capping and/or removing and permanently disposing of impacted material.

- **Dilution and dispersion.** All alternatives meet this requirement; none relies primarily on dispersion and dilution to comply with cleanup levels.

6.3 Disproportionate Cost Analysis (DCA)

Under MTCA (WAC 173-340-360[3][b]), preference is given to cleanup actions that are permanent to the maximum extent practicable. A DCA is used for this assessment. The DCA compares the implementation costs versus the environmental benefits of a remedial alternative. Costs are considered to be disproportionate to benefits if the incremental cost of an alternative over that of a lower cost alternative exceeds the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative.

The most practicable permanent solution evaluated is used as the baseline cleanup action alternative against which other alternatives are compared. Of the alternatives under consideration, Alternative 1 is considered the more permanent solution. Therefore, Alternative 1 is the baseline action against which the other alternatives are compared.

6.3.1 DCA Criteria

The following criteria, listed in WAC 173-340-360(3)(f), are used to evaluate and compare cleanup action alternatives when conducting a disproportionate cost analysis:

- **Protectiveness.** Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, time required to reduce risk at the facility and attain cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality.

- **Permanence.** 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 process, and the characteristics and quantity of treatment residuals generated.

- **Cost.** The cost to implement the alternative, including the cost of construction, the net present value of any long-term costs, and agency oversight costs. Long-term costs include operation and maintenance costs, monitoring costs, and the cost of maintaining institutional controls.

- **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 cleanup action components may be used as a guide, in descending order, when assessing the relative degree of long-term effectiveness:

  - Reusing or recycling;
  - Destruction or detoxification;
  - Immobilization or solidification;
  - 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.** The risk to human health and the environment that is associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.

■ **Technical and administrative implementability**. Ability 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 and monitoring; and integration with existing facility operations and other current or potential remedial actions.

■ **Consideration of public concerns.** As discussed in Section 6.1, consideration of public concerns was not evaluated in this FFS.

6.3.2 DCA Evaluation

We evaluated the alternatives against the DCA criteria outlined above. This evaluation is presented in Table 4. The following sections summarize our evaluation.

Protectiveness. Alternatives 1, 2, and 3 are considered protective of human health and the environment. Alternative 1 prevents exposure to humans and terrestrial organisms through the removal of all impacted material. Alternatives 2 and 3 prevent exposure through removal and capping of impacted material and providing vapor mitigation. Alternative 1 is the most protective because the impacted material is removed off-site. Although the potential risk from vapor intrusion is low, Alternative 3 is slightly more protective than Alternative 2 because it includes vapor mitigation.

Permanence. Alternative 1 is considered the most permanent alternative. All three alternatives control contaminant mobility - Alternative 1 controls contaminant mobility through removal and Alternatives 2 and 3 through removal and capping. However, Alternatives 2 and 3 require institutional controls and long-term monitoring and maintenance to remain protective while Alternatives 1 does not.

Cost. One of the primary goals in developing cost estimates for alternative evaluation is to ensure that costing procedures and assumptions are consistent between alternatives. This reduces 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 FFS costs. However, because of the conservative approach to estimating mass and area, FFS 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.

The total cost of implementing Alternatives 1, 2, and 3 (over a 30-year time period) is estimated to total approximately $770,000, $580,000, and $640,000 (−35 to +50 percent), respectively (Table 5). The components of these costs and assumptions used in the estimate are shown in Tables 6 through 8.

Effectiveness over the long term. Alternative 1 is considered to be somewhat more effective over the long term than Alternatives 2 and 3. Under WAC 173-340-360(3)(f)(iv), disposal in an engineered, lined, and monitored facility is considered to be one step higher in long-term protectiveness than on-site containment. Although the alternatives all use proven cleanup approaches that are expected to be highly effective, Alternatives 2 and 3 require institutional controls and long-term maintenance and monitoring to retain its long-term effectiveness.

Management of short-term risks. Short-term risks are expected to be larger with Alternative 1 because of the age of the adjacent building and the proximity of the excavation, thus increasing the potential to damage the adjacent apartment building. Short-term risks for Alternatives 2 and 3 are expected to be lower and can be managed by following a construction health and safety plan and implementing other construction best practices (e.g., dust control and use of licensed material haulers).

Technical and administrative implementability. Alternative 1 will require an easement to complete work on adjacent property including underpinning the apartment building and other structural supports. Alternative 1 also includes technical challenges, as excavating the area directly adjacent to the apartment building will likely require the building to be supported during excavation activities. While underpinning is technically possible, the process is more complicated than traditional excavation activities. Alternatives 2 and 3 use more conventional construction methods and would be implementable.

7.0 PREFERRED REMEDIATION ALTERNATIVE

Based on the evaluation of all of the alternatives, Alternative 1 has been selected as the preferred alternative. The revised redevelopment plans include extending the excavation and shoring limits in the southwest area of the Site rather than leaving and capping known contaminated soil in this area. All of the figures show both the original excavation limits and the new extended excavation and underground parking limits in the southwest area.

The selected version of Alternative 1is considered protective of human health and the environment and meets the MTCA evaluation criteria.

Alternative 1 is considered the most permanent. Alternative 1 is implementable as the underground parking footprint is being extended into the area where impacted soil would have been left in place. Although Alternative 1 gives rise to greater short-term risks of all three alternatives because of being exposed to more impacted soil during excavation, the decision has been made to pursue this more aggressive approach to the existing soil contamination, and to address the short-term risks through appropriate shoring and construction management efforts.

In Alternative 1, the impacted soil that is being excavated as part of the proposed development would be excavated and properly disposed of at a Subtitle C or D landfill facility. Excavation is a well-established remediation technology that is effective in removing contaminant mass and concentrations from the subsurface.

The Cleanup Action Plan (CAP) being prepared for the Site will provide details on implementation of this preferred Alternative.

8.0 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 that the work was performed. This report is for the specific application to the referenced project and for the exclusive use of Seattle Core Development Site I, LLC. No other warranty, express or implied, is made.

9.0 REFERENCES

EPA 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. OSWER Directive 9355.3-01. EPA-540-G-89-004. October 1988.

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Table 2 - Remediation Technology Screening for Soil

General Response Action	Remediation Technology	Description	Implementability	Reliability	Relative Cost	Screening Comments	Technology Retained?
Institutional Controls	Governmental and proprietary controls; enforcement and permit tools; information devices	Physical and administrative measures to control access or exposure to contaminated soil. Placement of an environmental covenant on the property.	Technically implementable.	Reliable conventional administrative measures.	Low capital and O&M cost.	Applicable in combination with other technologies.	Yes
Containment	Capping	Placement of a surface cap over impacted soil areas to minimize water infiltration and mobilization of contaminants, and to minimize direct-contact risk for human and ecological receptors.	Technically implementable.	Effective for minimizing access, direct-contact risk, and mobility of contaminants. Less effective than source removal.	Low to moderate capital and O&M cost.	Applicable in locations where contaminants remain in place.	Yes
	Solidification, stabilization	Chemicals are introduced to physically bind or enclose contaminants, or to induce chemical reactions between the stabilizing agent and contaminants to reduce their mobility.	Technically implementable but limited to accessible areas at the site.	May be less effective or ineffective for treatment of organic compounds.	Moderate to high capital cost. Low O&M cost.	Inadequate effectiveness for treatment of organic compounds. Not compatible with property redevelopment plans and schedules.	No
Natural Recovery	Monitored natural attenuation (MNA)	Naturally occurring physical, chemical, and biological processes that reduce contaminant mobility or concentration.	Technically implementable. Cleanup time frame longer than for other remedial options for soil.	Not effective for treatment of inorganic compounds.	Negligible capital cost. Low O&M cost.	Inadequate effectiveness for treatment of inorganic compounds. Slow restoration timeframe for organic compounds compared to other applicable technologies. Although not retained as a possible remedy based on other suitable technologies, natural attenuation is considered complimentary to the other engineered remedial technologies.	No
***In Situ* Treatment**	*In situ* enhanced bioremediation	Enhance biodegradation through addition of nutrients and electron acceptors to stimulate microbial growth. Moisture may need to be added to provide a medium where microbes can metabolize contaminants.	Difficult to implement. Technology requires presence of moisture to be effective. Installation of infrastructure would be needed. Some process options may require saturation of vadose zone to be effective (i.e., liquid-phase bioremediation, enhanced bioremediation). Site conditions may severly limit effectiveness. Greater time required to implement than excavation or capping options.	Established technology. Effective for treatment of compounds amenable to biological degradation.	Moderate to potentially high capital and O&M costs.	Low effectiveness considering site constraints and estimated location and extent of existing soil impacts at the site. Not compatible with property redevelopment plans and schedules.	No
	Soil vapor extraction (SVE)	Removal of volatile contaminants through vacuum extraction in the vadose (unsaturated) zone. Could be used in conjunction with steam injection or six-phase soil heating. May be combined with air sparging to enhance subsurface air flow.	Technically implementable. Would require significant installation of infrastructure beneath the site building as well as above ground components (e.g., blower, compressor, emissions controls).	Moisture content, organic content, and air permeability of the soil will affect SVE effectiveness. Naturally occurring organic content in soil may reduce effectiveness. SVE is not effective in the saturated zone. Effectiveness may be improved if combined with steam injection or six-phase soil heating. Oxygen introduced through the induced air flow by SVE may promote biodegradation of organic compounds.	High capital cost for new system installation. Moderate to high O&M costs.	The majority of the site contaminants are non-volatile and not conductive to SVE treatment in the unsaturated zone.	No
	Passive soil gas venting system	Venting system consists of a series of collection pipes installed beneath the building or concrete.	Technically implementable.	Relies on convective flow of warmed air upward in the vent to draw air from beneath the slab.	Negligible capital cost. Low O&M cost.	Applicable in combination with other technologies.	Yes

Table 2 - Remediation Technology Screening for Soil

General Response Action	Remediation Technology	Description	Implementability	Reliability	Relative Cost	Screening Comments	Technology Retained?
***In Situ* Treatment**	Thermal treatment	Application of heat via subsurface steam injection to remove strippable contaminants. Volatilized compounds captured and treated at surface.	Technically implementable. Requires off-gas capture and treatment, such as an SVE system.	Not suitable for all site contaminants.	High capital and O&M costs.	High cost.	No
	Six-phase soil heating, typically combined with SVE	Application of heat via subsurface electrodes enhances volatilization rate. Volatilized compounds captured and treated at surface.	Technically implementable. Requires off-gas capture and treatment.	Not suitable for all site contaminants.	High capital and O&M costs.	High cost.	No
	Soil flushing	A surfactant or solvent solution is applied to soil in place to remove leachable contaminants. The solution and leached contaminants are recovered from the underlying aquifer and treated.	Difficult to implement. May require different types of solvents or surfactants for different contaminants. Requires capture and treatment of injected solution and leached contaminants. Regulatory concerns over complete capture of leached contaminants, which may make permitting difficult.	Effective for recovery of organic contaminants. Soil flushing is a developing technology, so evidence supporting effectiveness is limited.	High capital and O&M costs.	The technology can be used to treat site contaminants, but may be less cost-effective than alternative technologies for these contaminant groups. Difficult to implement. High cost. Not compatible with property redevelopment plans and schedules	No
	Chemical treatment	Injection of chemicals to degrade contaminants in place.	Difficult to implement. Presence of organics in soil may increase required chemical application rates. May require multiple applications of chemical. Regulatory concerns over injection of chemicals into subsurface, which may make permitting difficult. Requires handling of large quantities of hazardous chemicals.	Effective for organic site contaminants.	High capital and O&M costs.	Difficult to implement. High cost. Not compatible with property redevelopment plans and schedules.	No
	Phytoremediation	Uses growing plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. The mechanisms of phytoremediation include enhanced rhizosphere biodegradation, phyto-extraction (also called phyto-accumulation), phyto-degradation, and phyto-stabilization.	Not implementable because of current site use and limited accessibility.	Not effective for site contaminants in soil. Cleanup time frame is typically long.	Low capital and O&M cost.	Not implementable. Not compatible with property redevelopment plans and schedules.	No
Soil Removal	Soil removal	Removal of impacted soil using common excavation techniques. Excavated soil treated on site or sent off site for disposal.	Technically implementable.	Effective for all site soil contaminants.	Moderate capital cost. Negligible O&M cost.	Commonly used established technology effective for all site soil contaminants.	Yes
Off-Site Management	Land disposal	Disposal of impacted soil at an off-site, lined, permitted landfill.	Technically implementable. Impacted soil requires profiling and must meet land disposal requirements.	Effective for site soil contaminants.	Moderate capital cost, depending on type of contaminant. Negligible O&M cost.	Common disposal option for excavated soil.	Yes
***Ex Situ* Treatment**	*Ex situ* bioremediation	Biodegradation of contaminants in excavated soil is enhanced through modification of soil conditions and provision of substrate necessary for microbial growth. Soil treatment is conducted in landfarm arrangement, aboveground reactor, or in treatment cells (biopiles).	Difficult to implement. Landfarming option may require use of a large area, depending on quantity of excavated soil. Current site use not amenable to landfarming. Slurry and biopile treatment require reactor or treatment cell construction. Leachate and off-gas require collection and treatment. Additives may increase total bulk volume of treated soil.	Aerobic treatment may not be effective for all site contaminants.	Moderate to high capital and O&M costs.	Difficult to implement. Not effective for all site contaminants. Potential space limitations. Low cost effectiveness. Not compatible with property redevelopment plans and schedules.	No

Table 2 - Remediation Technology Screening for Soil

General Response Action	Remediation Technology	Description	Implementability	Reliability	Relative Cost	Screening Comments	Technology Retained?
***Ex Situ* Treatment**	Low- or high-temperature thermal desorption	Heat excavated soil to 90 to 320 degrees Celsius (low temperature) or to 320 to 560 degrees Celsius (high temperature) to volatilize organic contaminants. Volatilized contaminants are recovered and treated.	Potentially difficult to implement. Limited space on site for treatment system. Off-gas capture and treatment is required.	May not be effective for all site contaminants.	High capital and O&M costs.	High cost relative to other ex situ treatment technologies. Not effective for all site contaminants. May not provide added incremental benefit. Not compatible with property redevelopment plans and schedules	No
	Incineration	Heat excavated soil above 1,600 degrees Fahrenheit to volatilize and combust organic contaminants. Incinerator off-gas is treated in an air pollution control system.	Potentially difficult to implement. Limited space for on-site treatment system and staging. Specific feed size and material handling requirements may impact implementability.	Effective for treatment of site soil contaminants.	High capital and O&M costs.	High cost relative to other *ex situ* treatment technologies. May not provide added incremental benefit.	No
	Soil washing	Removal of leachable contaminants from excavated soil using water and surfactants in an aboveground reactor with subsequent treatment of residual fluids.	Difficult to implement. Complex mixtures of contaminants would make formulation of washing liquid difficult. Residuals that are difficult to extract from the soil matrix may require additional treatment. Limited space on site for treatment system.	Effective for site soil contaminants.	High capital and O&M costs.	Difficult to implement. High cost. May not provide added incremental benefit. Not compatible with property redevelopment plans and schedules.	No
	Chemical treatment	Treatment of impacted soil in aboveground reactor to degrade contaminants into nonhazardous or less toxic compounds.	Potentially difficult to implement. Limited space on site for treatment system. Presence of organics in soil may increase required chemical application rates.	Effective for site soil contaminants.	High capital and O&M costs.	High cost relative to other *ex situ* treatment technologies. May not provide added incremental benefit. Not compatible with property redevelopment plans and schedules.	No
	Solidification, stabilization	Reagents are introduced to excavated soil to physically bind or enclose contaminants, or to induce chemical reactions between the stabilizing agent and contaminants to reduce their mobility. Resultant materials are typically disposed of.	Potentially difficult to implement. Limited space on site for treatment system. Can result in significant increase in volume of treated material.	May be less effective or ineffective for treatment of organic compounds.	Moderate to high capital cost. Low O&M cost.	Potentially difficult to implement. May not be effective for site soil contaminants. Not compatible with property redevelopment plans and schedules.	No
	Slurry Phase Biological Treatment	Treatment of excavated soil in a bioreactor. Contaminated soil is mixed with water to a predetermined concentration dependent upon the concentration of the contaminants, the rate of biodegradation, and the physical nature of the soils. When biodegradation is complete, the soil slurry is dewatered.	Slurry-phase bioreactors containing cometabolites and specially adapted microorganisms are both used to treat site contaminants in excavated soils.	Slurry-phase bioreactors may be classified as short- to medium-term technologies. Sizing of materials prior to putting them into the reactor can be difficult and expensive.	High capital cost. High O&M cost.	Potentially difficult to implement. Not cost effective for treatment of site soil contaminants.	No

Table 3 – Alternative Evaluation

Selection Criteria	Alternative 1: Excavation and Off-Site Disposal	Alternative 2: Limited Excavation, Capping, and Institutional Controls	Alternative 3: Limited Excavation, Capping, Institutional Controls, and Vapor Mitigation
Threshold Requirements: WAC 173-340-360(2)(a)			
Protect Human Health and the Environment	Protective. Directly eliminates the quantity of contaminants in soil at the Site through excavation and off-site disposal of the known soil contaminants.	Protective. Excavation reduces quantity of contaminants. Capping prevents direct contact risks to humans and infiltration to groundwater. There is minimal potential for vapors from residual TPH-G impacts in soil to accumulate in buildings.	Protective. Excavation reduces quantity of contaminants. Capping prevents direct contact risks to humans and infiltration to groundwater. Vapor mitigation prevents potential TPH-G related vapors from accumulating in buildings.
Comply with Cleanup Standards	Would comply. Following removal, no hazardous substances exceeding cleanup levels would remain at the point(s) of compliance.	Would comply. The material left in place above cleanup levels will be capped (contained). As described below, 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. There is minimal potential for vapors from residual TPH-G impacts in soil to accumulate in buildings. Containment requirements: • Cleanup action must be permanent to the maximum extent practicable per WAC 173-340-360: Compliance with this criterion is described in Section 7.2.1 and Table 4. • Cleanup action must be protective of human health: Capping prevents direct contact risks to humans and infiltration to groundwater. • Institutional controls to limit activities that could interfere with the long-term	Would comply. The material left in place about cleanup levels will be capped (contained). As described below, 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. Vapor mitigation would prevent soil vapors from accumulating in buildings. Containment requirements: • Cleanup action must be permanent to the maximum extent practicable per WAC 173-340-360: Compliance with this criterion is described in Section 7.2.1 and Table 4. • Cleanup action must be protective of human health: Capping prevents direct contact risks to humans and infiltration to groundwater. • Institutional controls to limit activities that could interfere with the long-term integrity of the containment system

Selection Criteria	Alternative 1: Excavation and Off-Site Disposal	Alternative 2: Limited Excavation, Capping, and Institutional Controls	Alternative 3: Limited Excavation, Capping, Institutional Controls, and Vapor Mitigation
Comply with Cleanup Standards (continued)		integrity of the containment system must be put in place per WAC 173-340-440: Alternative 2 provides for appropriate institutional controls as described in Section 5.3.2. • Compliance monitoring to ensure the long-term integrity of the containment system and periodic reviews must be implemented per WAC 173-340-410 and WAC 173-340-430: Alternative 2 provides for appropriate compliance monitoring as described in Section 5.3.2. • 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 must be specified in a cleanup action plan.	must be put in place per WAC 173-340-440: Alternative 2 provides for appropriate institutional controls as described in Section 5.3.2. • Compliance monitoring to ensure the long-term integrity of the containment system and periodic reviews must be implemented per WAC 173-340-410 and WAC 173-340-430: Alternative 2 provides for appropriate compliance monitoring as described in Section 5.3.2. • 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 must be specified in a cleanup action plan.
Comply with Applicable State and Federal Law	Would comply. ARARs are judged to be attainable and do not affect the alternative selection process.	Would comply. ARARs are judged to be attainable and do not affect the alternative selection process.	Would comply. ARARs are judged to be attainable and do not affect the alternative selection process.
Provide for Compliance Monitoring	Provides for compliance monitoring in accordance with WAC 173-340-410 as described in Section 5.3.1.	Provides for compliance monitoring in accordance with WAC 173-340-410 as described in Section 5.3.2.	Provides for compliance monitoring in accordance with WAC 173-340-410 as described in Section 5.3.3.

Table 3 – Alternative Evaluation

Selection Criteria	Alternative 1: Excavation and Off-Site Disposal	Alternative 2: Limited Excavation, Capping, and Institutional Controls	Alternative 3: Limited Excavation, Capping, Institutional Controls, and Vapor Mitigation
Other Requirements: WAC 173-340-360(2)(b)			
Use Permanent Solutions to the Maximum Extent Practicable	Uses permanent solutions to the maximum extent practicable as described in Section 7.1.3 and Table 4.	Does not use permanent solutions to the maximum extent practicable as described in Section 7.3.1 and Table 4.	Uses permanent solutions to the maximum extent practicable as described in Section 7.3.1 and Table 4.
Provide for a Reasonable Restoration Time Frame	Provides reasonable restoration timeframe. The work could be completed within one construction season.	Provides reasonable restoration timeframe. The work could be completed within one construction season.	Provides reasonable restoration timeframe. The work could be completed within one construction season.
Consider Public Concerns	Consideration of public concerns was not evaluated in this document because the public review and comment process is not implemented by the private parties responsible for the cleanup under the VCP, and because this FFS was prepared within the purview of the VCP. However, if the current restrictive covenant is removed or modified, a public review period will be conducted per MTCA.		
Action-Specific Requirements: WAC 173-340-360(2)(c) through (h)			
Groundwater Cleanup Actions, WAC 173-340-360(2)(c)	Not applicable. There are not known groundwater impacts at the site.		
Cleanup Actions for Soils at Current or Potential Future Residential Areas and for Soils at Schools and Child Care Centers, WAC 173-340-360(2)(d)	Complies. Alternative 1 meets the requirement because soils exceeding cleanup levels will be removed.	Complies. Alternative 2 meets the requirement because soils exceeding cleanup levels will either be removed or contained.	Complies. Alternative 3 meets the requirement because soils exceeding cleanup levels will either be removed or contained.

Table 3 – Alternative Evaluation

Selection Criteria	Alternative 1: Excavation and Off-Site Disposal	Alternative 2: Limited Excavation, Capping, and Institutional Controls	Alternative 3: Limited Excavation, Capping, Institutional Controls, and Vapor Mitigation
Institutional Controls WAC 173-340-360(2)(e)	Not applicable. Institutional controls are in not a component of Alternative 1.	Complies. Alternative 2 only uses institutional controls (restrictive covenant) to maintain the protectiveness of the cap; it does not rely primarily on institutional controls and monitoring.	Complies. Alternative 3 only uses institutional controls (restrictive covenant) to maintain the protectiveness of the cap; it does not rely primarily on institutional controls and monitoring.
Releases and Migration WAC 173-340-360(2)(f)	Complies. Alternative 1 minimizes releases and migration of hazardous substances by excavation and disposal.	Complies. Alternative 2 minimizes releases and migration of hazardous substances through the use of excavation and capping.	Complies. Alternative 3 minimizes releases and migration of hazardous substances through the use of excavation and capping.
Dilution and Dispersion WAC 173-340-360(2)(g)	Complies. Alternative 1 does not rely primarily on dilution and dispersion.	Complies. Alternative 2 does not rely primarily on dilution and dispersion.	Complies. Alternative 3 does not rely primarily on dilution and dispersion.
Remediation Levels WAC 173-340-360(2)(h)	Not applicable. The alternatives do not involve remediation levels.		

Table 4 - Disproportionate Cost Analysis

DCA Criteria	Alternative 1: Excavation and Off-Site Disposal	Alternative 2: Limited Excavation, Capping, and Institutional Controls	Alternative 3: Limited Excavation, Capping, Institutional Controls, and Vapor Mitigation
Protectiveness	Removal of hazardous substances would eliminate direct contact risks to humans. Protectiveness would be achieved immediately upon completion of remedy. Slightly more protective than Alternatives 2 and 3.	Removal of hazardous substances would eliminate direct contact risks to humans. Capping would prevent direct contact risks to humans. Protectiveness would be achieved immediately upon completion of remedy. Slightly less protective than Alternatives 1 and 3.	Removal of hazardous substances would eliminate direct contact risks to humans. Capping would prevent direct contact risks to humans. Vapor mitigation would minimize the risk of potential TPH-G vapors in buildings. Protectiveness would be achieved immediately upon completion of remedy. Slightly less protective than Alternative 1, slightly more protective than Alternative 2.
Permanence	Provides no reduction in toxicity or volume of contaminants. Risk of contaminant mobility would be greatly reduced by removing the waste and placing it in an off-site engineered, lined, and monitored facility. Alternative 1 is considered somewhat more permanent than Alternatives 2 and 3.	Provides no reduction in toxicity or volume of contaminants. Risk of contaminant mobility would be greatly reduced by removing the waste and placing it in an off-site engineered, lined, and monitored facility and capping. Long-term monitoring and maintenance required. Alternative 2 is considered somewhat less permanent than Alternative 1.	Provides no reduction in toxicity or volume of contaminants. Risk of contaminant mobility would be greatly reduced by removing the waste and placing it in an off-site engineered, lined, and monitored facility and capping. Long-term monitoring and maintenance required. Alternative 3 is considered somewhat less permanent than Alternative 1.
Cost	$770,000	$580,000	$640,000

Table 4 - Disproportionate Cost Analysis

DCA Criteria	Alternative 1: Excavation and Off-Site Disposal	Alternative 2: Limited Excavation, Capping, and Institutional Controls	Alternative 3: Limited Excavation, Capping, Institutional Controls, and Vapor Mitigation
Effectiveness over the Long Term	Subtitle C and D landfills are proven and expected to be effective over the long term. Alternative 1 is considered somewhat more effective over the long term than Alternatives 2 and 3.	Subtitle C and D landfills are proven and expected to be effective over the long term. Capping is a proven technology that is expected to be highly effective over the long term. Long-term effectiveness relies on maintenance, monitoring, and institutional controls. Alternative 2 is considered somewhat less effective over the long term than Alternative 1.	Subtitle C and D landfills are proven and expected to be effective over the long term. Capping and passive vapor venting systems are proven technologies that are expected to be highly effective over the long term. Long-term effectiveness relies on maintenance, monitoring, and institutional controls. Alternative 3 is considered somewhat less effective over the long term than Alternative 1.
Management of Short-Term Risks	Significant short-term risks are present because of the excavation directly next to the adjacent apartment building. Because of the age of the building and the proximity of the excavation, the risk of damage to neighboring property is significant. Other short term risks include waste excavation, and over-the-road transport to landfill. Risks can be managed by implementing structural protections, following construction health and safety plan, implementing dust suppression measures, using property licensed material haulers, etc. Alternative 1 is considered to have greater short-term risks than Alternatives 2 and 3.	Short-term risks are expected to be minimal and primarily associated with limited waste excavation, over-the-road transport to landfill, and construction of the cap. Risks will be managed by following construction health and safety plan, implementing dust suppression measures, using property licensed material haulers etc. Alternative 2 is considered to have fewer short-term risks as Alternative 1.	Short-term risks are expected to be minimal and primarily associated with limited waste excavation, over-the-road transport to landfill, construction of the cap, and passive vapor venting system. Risks will be managed by following construction health and safety plan, implementing dust suppression measures, using property licensed material haulers etc. Alternative 3 is considered to have fewer short-term risks as Alternative 1.

Table 4 - Disproportionate Cost Analysis

DCA Criteria	Alternative 1: Excavation and Off-Site Disposal	Alternative 2: Limited Excavation, Capping, and Institutional Controls	Alternative 3: Limited Excavation, Capping, Institutional Controls, and Vapor Mitigation
Technical and Administrative Implementability	Administrative challenges including obtaining an easement to complete work on adjacent property including under the apartment building. Excavating the area directly adjacent to the apartment building will require the building to be supported during excavation activities. While underpinning is technically possible, it is significantly more complicated, expensive, and time consuming (obtaining the easement) than traditional excavation activities. Alternative 1 is less implementable than Alternatives 2 and 3.	Uses typical construction practices and equipment. Highly implementable. Alternative 2 is more implementable than Alternative 1.	Uses typical construction practices and equipment. Highly implementable. Alternative 3 is more implementable than Alternative 1.
Consideration of Public Concerns	Consideration of public concerns was not evaluated in this document because the public review and comment process is not implemented by the private parties responsible for the cleanup under the VCP, and because this FFS was prepared within the purview of the VCP. However, if the current restrictive covenant is removed or modified, a public review will be conducted per MTCA.		

Table 5 - Summary of Remediation Alternative Estimated Costs

Location: Boylston Property, Seattle, WA **Phase:** Feasibility Study (-35% to +50%) **Base Year:** 2012 **Date:** February 2013	**Description:** Cost comparison of the total costs of Alternatives 1 through 3.

DESCRIPTION	TOTAL NET PRESENT VALUE	INCREMENTAL COST	COST TABLE REFERENCE
Alternative 1	$770,000	Baseline Cost	Table A2
Alternative 2	$580,000	-$190,000	Table A3
Alternative 3	$640,000	-$130,000	Table A4

Table 6 - Remediation Alternative 1 Estimated Cost Summary

Location:	Boylston Property Seattle, WA	**Description:** Alternative 1 consists of excavation of all known contaminated soil and compliance monitoring.
Phase:	Feasibility Study (-35% to +50%)	
Base Year:	2012	
Date:	February 2013	

CAPITAL COSTS

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
Excavation					
Mob/demob	1	LS	$2,000	$2,000	
Excavation, stockpiling, loading	2,928	BCY	$12	$36,534	
Additional shoring costs	1	LS	$21,728	$21,728	Assumed 25% additonal costs because of complications of apartment building.
Underpinning apartment bldg	1	LS	$8,633	$8,633	
Transportation and disposal (Subtitle C)	504	ton	$200	$100,740	Assume 30 percent of metal-impacted soil
Transportation and disposal (Subtitle D)	3,735	ton	$75	$280,097	
Stockpile characterization	1	LS	$2,914	$2,914	
Confirmation monitoring	1	LS	$19,825	$19,825	Soil samples from base and sidewalls of excavation
Import and placement of backfill and compaction	500	BCY	$25	$12,500	
Site Restoration	1	LS	$8,000	$8,000	
Excavation Subtotal				**$492,972**	
Submittals, Plans, Site Preparation, Permits	1	LS	$15,000	**$15,000**	Pre- and post-construction submittals, implementation plans.
Contingency	20%	--	--	**$101,594**	Scope and bid contingency. Percentage of capital costs.
Professional/Technical Services					
Project management	6%	--	--	$36,574	Percentage of capital cost + contingency. EPA 540-R-00-002.
Remedial design	12%	--	--	$73,148	EPA 540-R-00-002.
Construction oversight & management	8%	--	--	$48,765	EPA 540-R-00-002.
Professional/Technical Services Subtotal				**$158,487**	
TOTAL CAPITAL COST				**$768,053**	

ANNUAL O&M COSTS

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES

PERIODIC COSTS

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
Professional/Technical Services					
Closure report	1	EA	$20,000	$20,000	Year 30
Professional/Technical Services Subtotal				**$20,000**	

Table 6 - Remediation Alternative 1 Estimated Cost Summary

Location:	Boylston Property Seattle, WA	**Description:** Alternative 1 consists of excavation of all known contaminated soil and compliance monitoring.
Phase:	Feasibility Study (-35% to +50%)	
Base Year:	2012	
Date:	February 2013	

TOTAL COST SUMMARY

NOTES

Total years 30

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR
Capital	0	$768,053	$768,053
Annual O&M	1 - 30	$0	$0
Periodic	30	$20,000	$20,000
TOTAL COST OF ALTERNATIVE 1		**$788,053**	

PRESENT VALUE ANALYSIS

NOTES

Discount rate 7.0% — OMB 2010.

Total years 30

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	NET PRESENT VALUE
Capital	0	$768,053	$768,053	1.000	$768,053
Annual O&M	1 - 30	$0	$0	12.409	$0
Periodic	30	$20,000	$20,000	0.131	$2,627
		$788,053			$770,681
TOTAL NET PRESENT VALUE OF ALTERNATIVE 1					**$770,681**

Table 7 - Remediation Alternative 2 Estimated Cost Summary

Location: Boylston Property, Seattle, WA **Phase:** Feasibility Study (-35% to +50%) **Base Year:** 2012 **Date:** February 2013	**Description:** Alternative 2 includes excavatation of soil to a depth within the planned excavation of the development an dispose of off-site; cap the remaining contaminated soils; apply institutional controls, such as a restricted covenant, to the site; and compliance monitoring and maintenance.

CAPITAL COSTS

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
Excavation					
Mob/demob	1	LS	$2,000	$2,000	
Excavation, stockpiling, loading	1,958	BCY	$12	$24,431	
Transportation and disposal	486	ton	$200	$97,290	Disposal at Subtitle C landfill as dangerous waste.
Transportation and disposal	2,891	ton	$75	$216,833	Disposal at Subtitle D landfill as non-dangerous waste.
Stockpile characterization	1	LS	$2,692	$2,692	
Confirmation monitoring	1	LS	$15,962	$15,962	
Excavation Subtotal				**$359,207**	
Capping	637	SF	$18	**$11,231**	
Institutional Controls					
Preparation of restrictive convenant	1	EA	$9,900	$9,900	
Institutional Controls Subtotal				**$9,900**	
Submittals, Plans, Site Preparation, Permits	1	LS	$10,000	**$10,000**	Pre- and post-construction submittals, implementation plans.
Contingency	12%	--	--	**$46,841**	Scope and bid contingency. Percentage of institutional capital costs.
Professional/Technical Services					
Project management	6%	--	--	$26,231	EPA 540-R-00-002.
Remedial design	12%	--	--	$52,461	EPA 540-R-00-002.
Construction management	8%	--	--	$34,974	EPA 540-R-00-002.
Professional/Technical Services Subtotal				**$113,667**	
TOTAL CAPITAL COST				**$550,845**	

ANNUAL O&M COSTS

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
Compliance Monitoring	1	EA	$745	**$745**	Annual monitoring - visual inspection of cap.
Contingency	10%	--	--	**$75**	Percentage of annual cost.
Professional/Technical Services					
Project management	10%	--	--	$82	% of sum of annual cost and contingency. EPA 540-R-00-002.
Technical support	15%	--	--	$123	% of sum of annual cost and contingency. O&M technical support % (EPA 540-R-00-002).
Reporting	1	EA	$880	$880	Annual reporting.
Professional/Technical Services Subtotal				**$1,085**	
TOTAL ANNUAL O&M COST				**$1,904**	

PERIODIC COSTS

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
Professional/Technical Services					
Closure report	1	EA	$20,000	$20,000	Year 30.
Professional/Technical Services Subtotal				**$20,000**	

Table 7 - Remediation Alternative 2 Estimated Cost Summary

Location:	Boylston Property Seattle, WA
Phase:	Feasibility Study (-35% to +50%)
Base Year:	2012
Date:	February 2013

Description: Alternative 2 includes excavatation of soil to a depth within the planned excavation of the development an dispose of off-site; cap the remaining contaminated soils; apply institutional controls, such as a restricted covenant, to the site; and compliance monitoring and maintenance.

TOTAL COST SUMMARY

Total years 30

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR
Capital	0	$550,845	$550,845
Annual O&M	1 - 30	$57,131	$1,904
Periodic	30	$20,000	$20,000
TOTAL COST OF ALTERNATIVE 2		**$627,977**	

NOTES

PRESENT VALUE ANALYSIS

Discount rate 7.0%
Total years 30

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	NET PRESENT VALUE
Capital	0	$550,845	$550,845	1.000	$550,845
Annual O&M	1 - 30	$57,131	$1,904	12.409	$23,631
Periodic	30	$20,000	$20,000	0.131	$2,627
		$627,977			$577,104
TOTAL NET PRESENT VALUE OF ALTERNATIVE 2					**$577,104**

NOTES

OMB 2010.

Table 8 - Remediation Alternative 3 Estimated Cost Summary

Location:	Boylston Property Seattle, WA	**Description:** Alternative 3 includes excavatation of soil to a depth within the planned excavation of the development an dispose of off-site; cap the remaining contaminated soils; use a vapor intrusion mitigation; apply institutional controls, such as a restricted covenant, to the site; and operation, maintenance, and monitoring.
Phase:	Feasibility Study (-35% to +50%)	
Base Year:	2012	
Date:	February 2013	

CAPITAL COSTS

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
Excavation					
Mob/demob	1	LS	$2,000	$2,000	
Excavation, stockpiling, loading	1,958	BCY	$12	$24,431	
Transportation and disposal	486	ton	$200	$97,290	Disposal at Subtitle C landfill as dangerous waste.
Transportation and disposal	2,891	ton	$75	$216,833	Disposal at Subtitle D landfill as non-dangerous waste.
Stockpile characterization	1	LS	$2,692	$2,692	
Confirmation monitoring	1	LS	$15,962	$15,962	
Excavation Subtotal				**$359,207**	
Capping	637	SF	$18	**$11,231**	
Passive Vapor Mitigation System Installation and Startup					
Contractor mobilization/demobilization	1	LS	$1,200	$1,200	
System Installation	1	LS	$2,432	$2,432	
System startup and testing	10%	--	--	$363	Percentage of installation capital costs.
Passive Mitigation System Installation and Startup Subtotal				**$3,996**	
Institutional Controls					
Preparation of restrictive convenant	1	EA	$9,900	$9,900	
Institutional Controls Subtotal				$9,900	
Submittals, Plans, Site Preparation, Permits	1	LS	$10,000	**$10,000**	Pre- and post-construction submittals, implementation plans.
Contingency	12%	--	--	**$47,320**	Scope and bid contingency. Percentage of institutional capital costs.
Professional/Technical Services					
Project management	6%	--	--	$26,499	EPA 540-R-00-002.
Remedial design	12%	--	--	$52,998	EPA 540-R-00-002.
Construction management	8%	--	--	$35,332	EPA 540-R-00-002.
Professional/Technical Services Subtotal				**$114,830**	
TOTAL CAPITAL COST				**$556,484**	

ANNUAL O&M COSTS

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
Compliance Monitoring	1	EA	$2,405	**$2,405**	Annual monitoring
Contingency	10%	--	--	**$381**	Percentage of annual cost.
Professional/Technical Services					
Project management	10%	--	--	$419	% of sum of annual cost and contingency. EPA 540-R-00-002.
Technical support	15%	--	--	$628	% of sum of annual cost and contingency. O&M technical support % (EPA 540-R-00-002).
Reporting	1	EA	$880	$880	Annual reporting.
Professional/Technical Services Subtotal				**$1,926**	
TOTAL ANNUAL O&M COST				**$6,112**	

Table 8 - Remediation Alternative 3 Estimated Cost Summary

Location:	Boylston Property Seattle, WA	**Description:** Alternative 3 includes excavatation of soil to a depth within the planned excavation of the development an dispose of off-site; cap the remaining contaminated soils; use a vapor intrusion mitigation; apply institutional controls, such as a restricted covenant, to the site; and operation, maintenance, and monitoring.
Phase:	Feasibility Study (-35% to +50%)	
Base Year:	2012	
Date:	February 2013	

PERIODIC COSTS

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
System O&M and Monitoring	1	EA	$1,400	**$1,400**	Includes venting system operation & maintenance, monitoring, including sampling & analysis.
Professional/Technical Services					
Closure report	1	EA	$20,000	$20,000	Year 30.
Professional/Technical Services Subtotal				**$20,000**	
TOTAL PERIODIC COST				**$21,400**	

TOTAL COST SUMMARY — **NOTES**

Total years 30

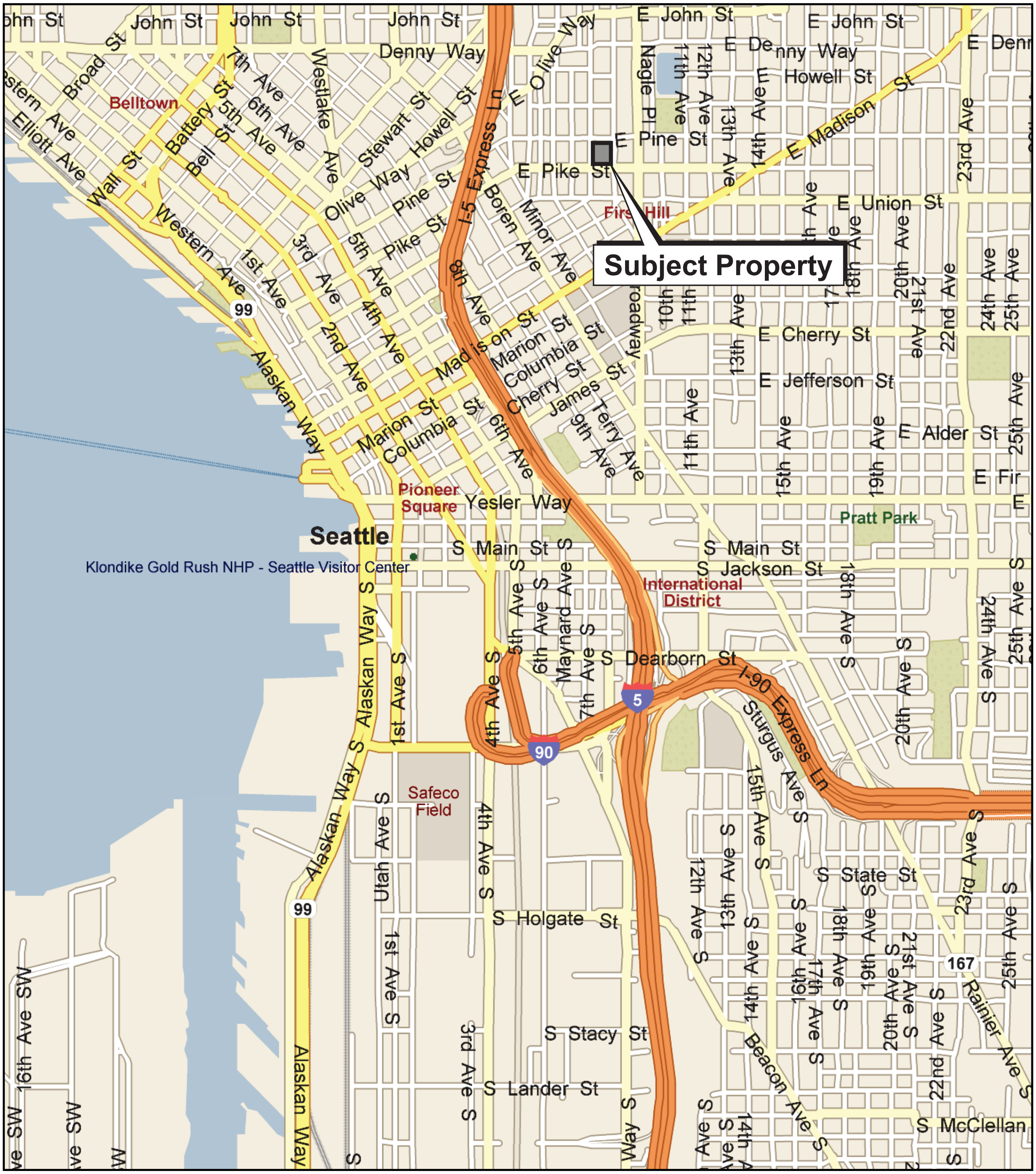
COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR
Capital	0	$556,484	$556,484
Annual O&M	1 - 30	$183,356	$6,112
Periodic	30	$21,400	$21,400
TOTAL COST OF ALTERNATIVE 3		**$761,240**	

PRESENT VALUE ANALYSIS — **NOTES**

Discount rate 7.0% — OMB 2010.

Total years 30

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	NET PRESENT VALUE
Capital	0	$556,484	$556,484	1.000	$556,484
Annual O&M	1 - 30	$183,356	$6,112	12.409	$75,843
Periodic	5	$1,400	$1,400	0.713	$998
Periodic	10	$1,400	$1,400	0.508	$712
Periodic	15	$1,400	$1,400	0.362	$507
Periodic	20	$1,400	$1,400	0.258	$362
Periodic	25	$1,400	$1,400	0.184	$258
Periodic	30	$21,400	$21,400	0.131	$2,811
		$768,240			$637,975
TOTAL NET PRESENT VALUE OF ALTERNATIVE 3					**$637,975**



Note: Base map prepared from Microsoft Streets and Trips 2002.

0 2,000 4,000

Approximate Scale in Feet

N

Seattle Core Development Site I
Seattle, Washington

Vicinity Map

17859-03 9/13

HARTCROWSER

Figure
1

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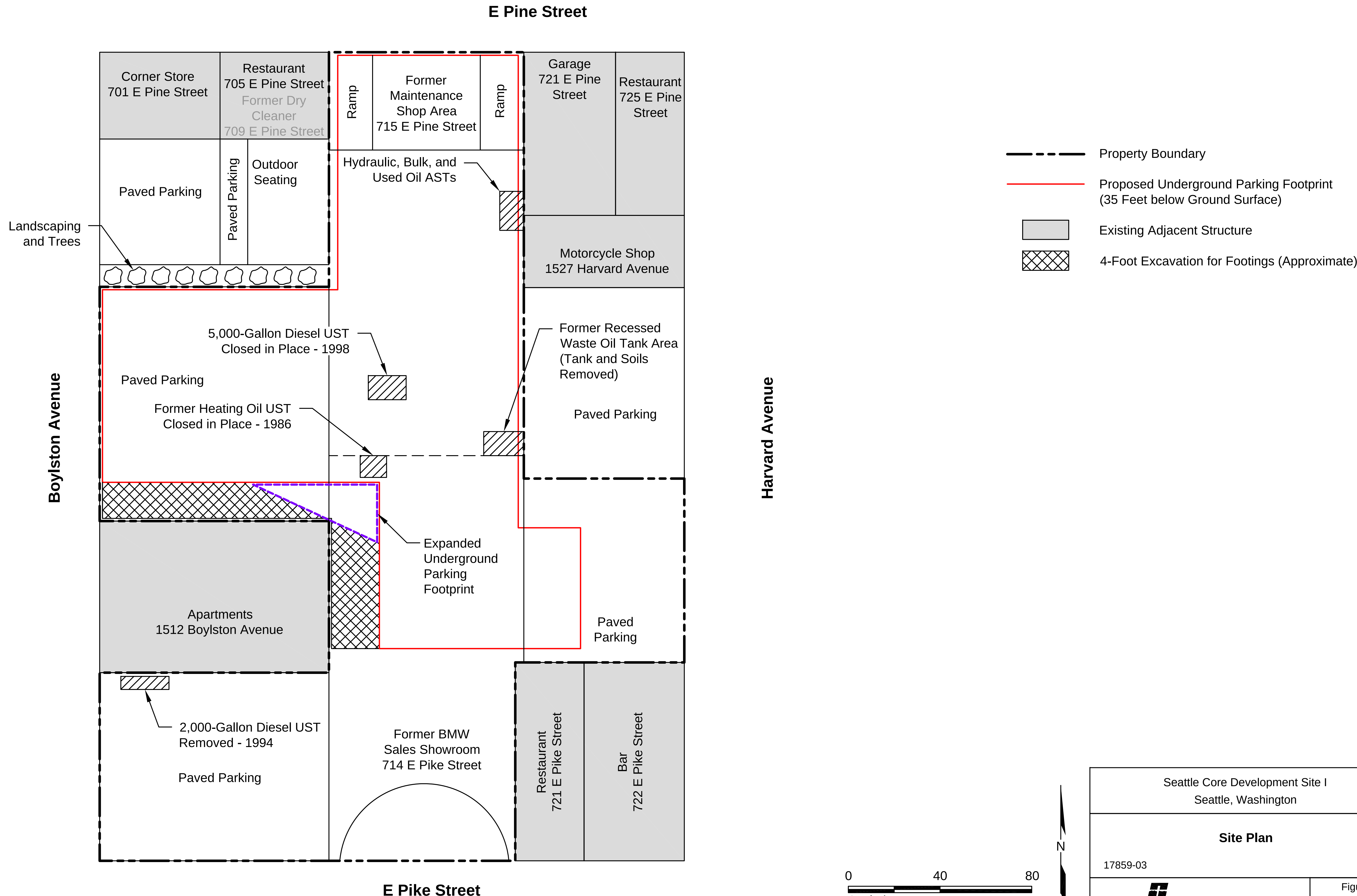

Seattle Core Development Site I
Seattle, Washington

Site Plan

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Figure 2

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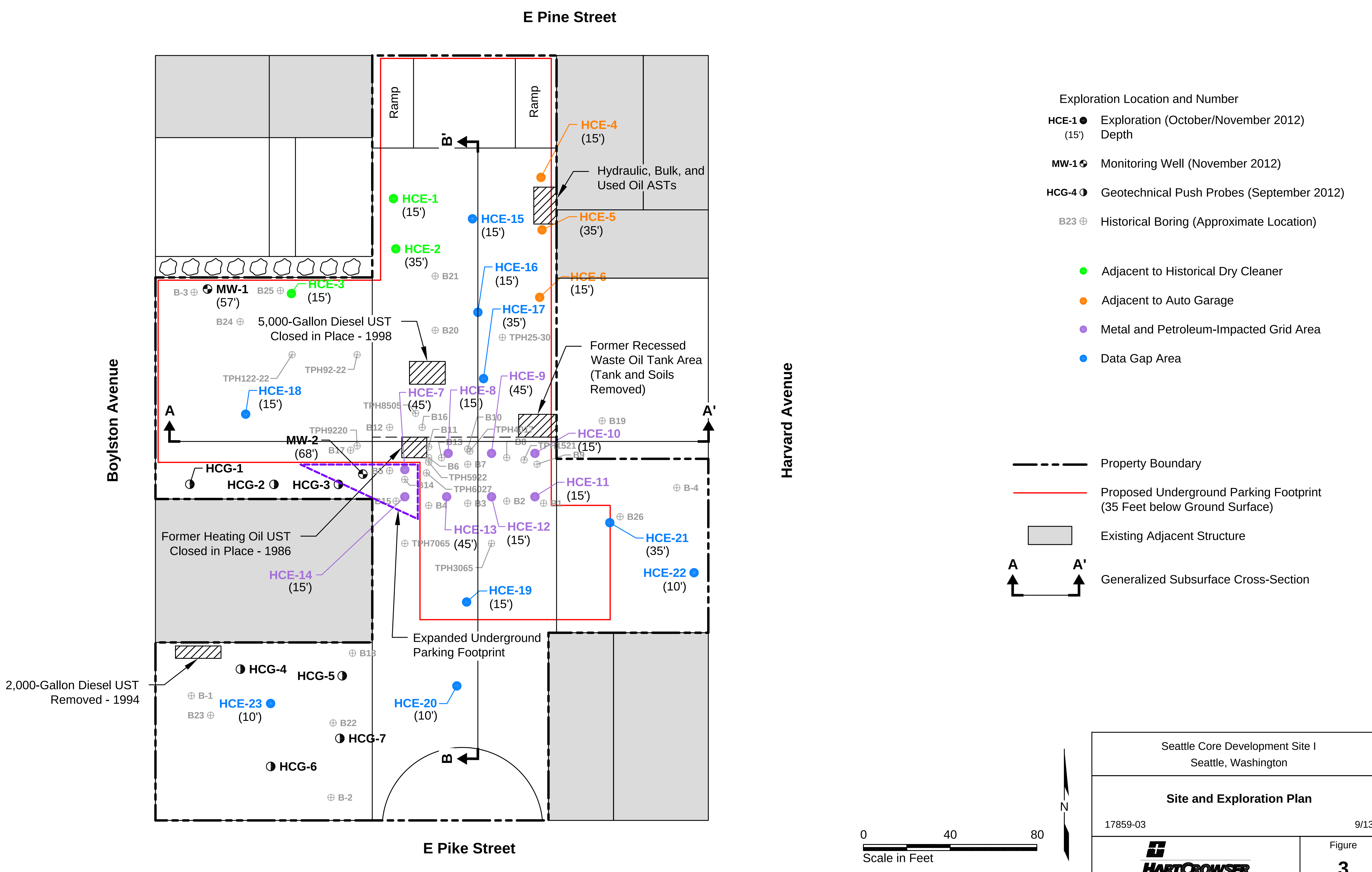

Seattle Core Development Site I
Seattle, Washington

Site and Exploration Plan

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Figure 3

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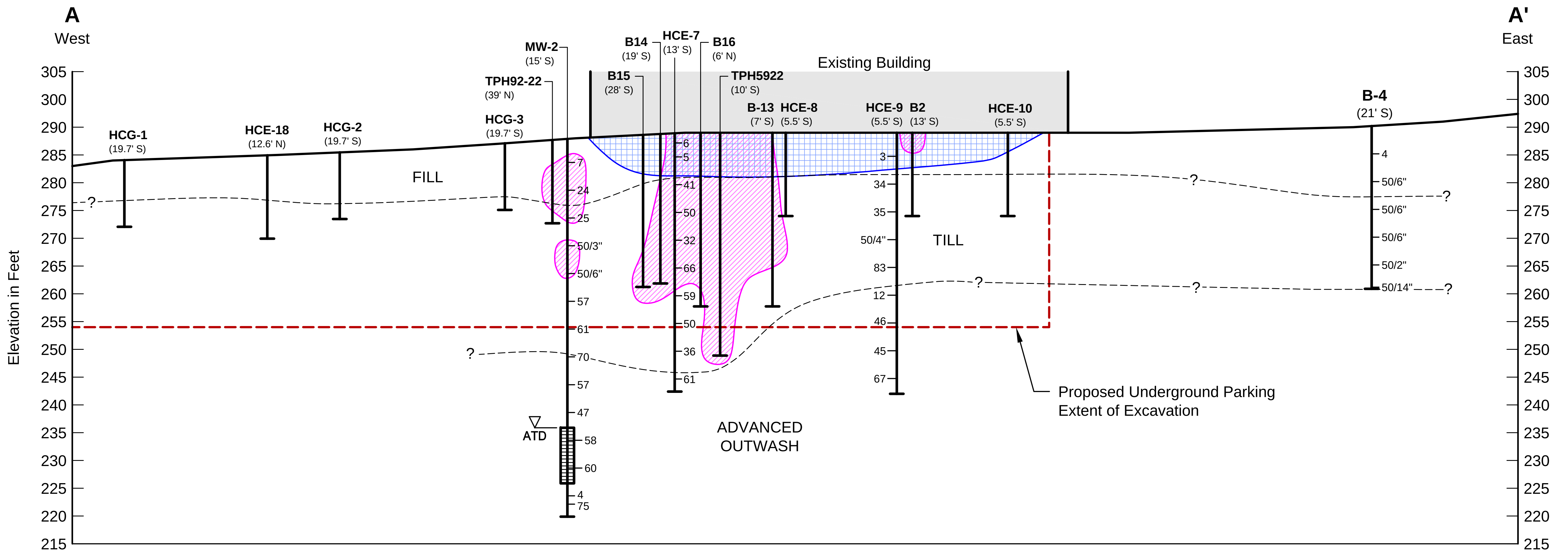

MW-2 (15' S) Exploration Number (Offset Distance and Direction)

Exploration Location

ATD Water Level

25 Standard Penetration Resistance in Blows per Foot

Screened Interval

Bottom of Boring

Approximate Area of TPH Impacts (Detections Above MTCA Method A Cleanup Levels)

Approximate Area of Metal Impacts (Above MTCA Method A Cleanup Levels)

0 20 40
Scale in Feet

Notes:

1. Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.
2. Contaminant impact boundaries are based upon interpolation of historical and current soil chemical results.

Seattle Core Development Site I
Seattle, Washington

Generalized Subsurface Cross Section A-A'

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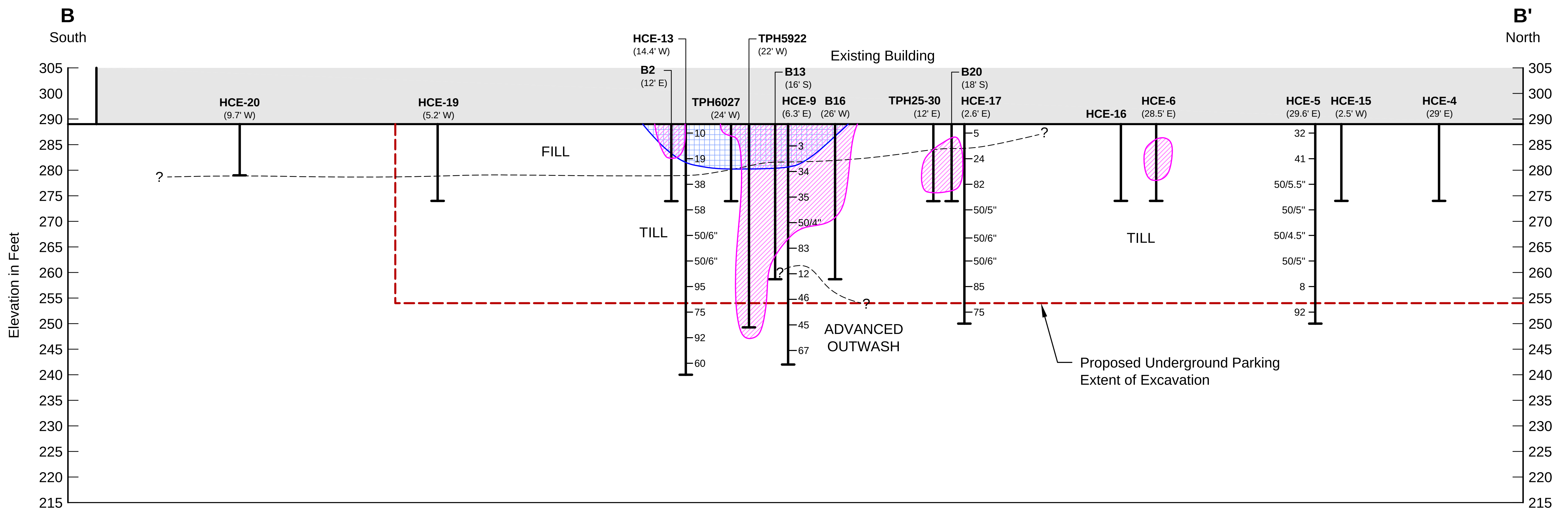
Figure
4

EAL 09/6/13 1785903-003.dwg



HCE-13 (14.4' W) — Exploration Number (Offset Distance and Direction)

Exploration Location

10 — Standard Penetration Resistance in Blows per Foot

Bottom of Boring

Approximate Area of TPH Impacts (Detections Above MTCA Method A Cleanup Levels)

Approximate Area of Metal Impacts (Above MTCA Method A Cleanup Levels)

0 20 40
Scale in Feet

Notes:

1. Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.
2. Contaminant impact boundaries are based upon interpolation of historical and current soil chemical results.

Seattle Core Development Site I
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Generalized Subsurface Cross Section B-B'

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Figure **5**

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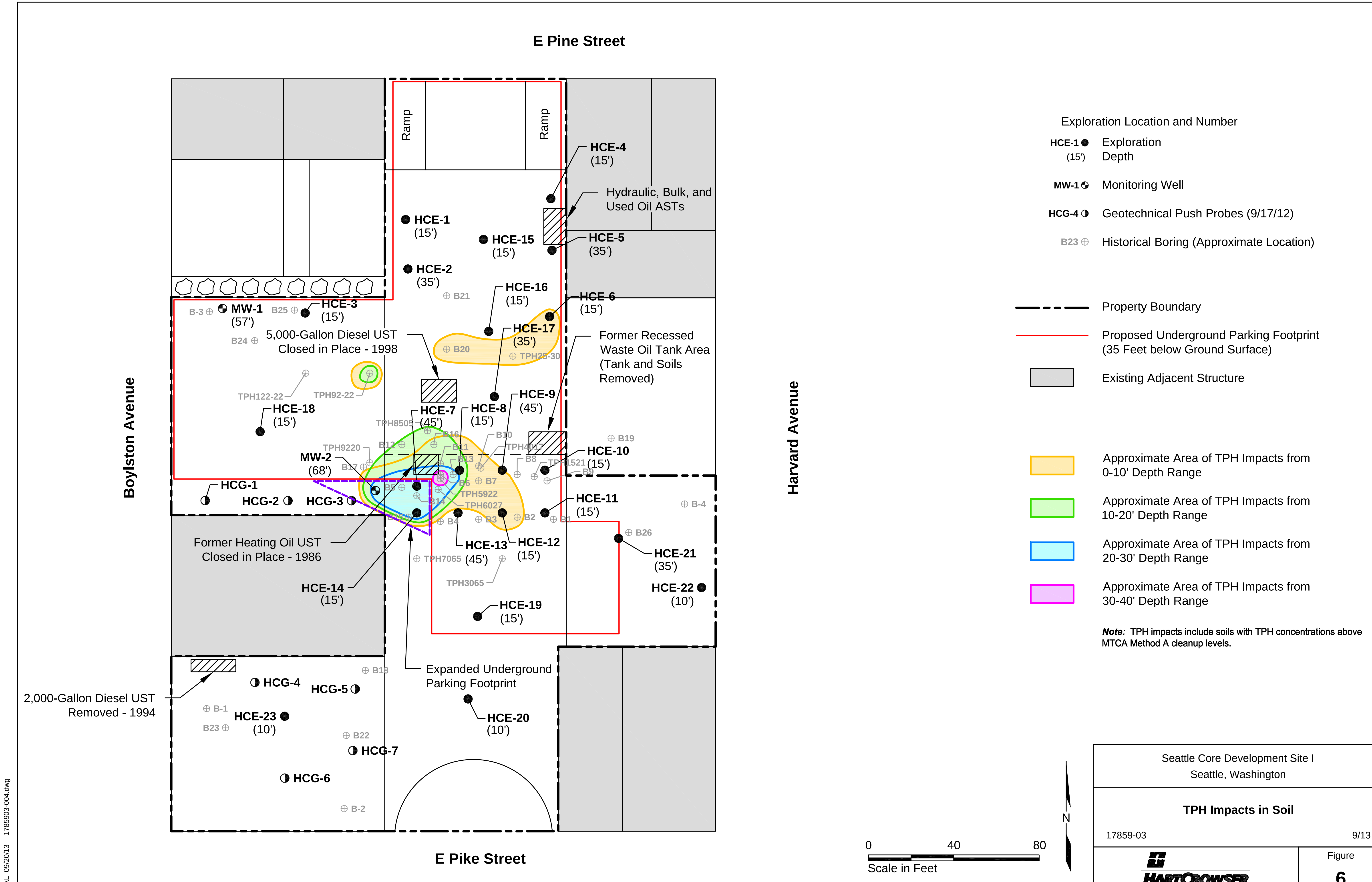

E Pine Street
E Pike Street
Boylston Avenue
Harvard Avenue
Ramp
Ramp
HCE-1 (15')
HCE-2 (35')
HCE-3 (15')
HCE-4 (15')
HCE-5 (35')
HCE-6 (15')
HCE-7 (45')
HCE-8 (15')
HCE-9 (45')
HCE-10 (15')
HCE-11 (15')
HCE-12 (15')
HCE-13 (45')
HCE-14 (15')
HCE-15 (15')
HCE-16 (15')
HCE-17 (35')
HCE-18 (15')
HCE-19 (15')
HCE-20 (10')
HCE-21 (35')
HCE-22 (10')
HCE-23 (10')
MW-1 (57')
MW-2 (68')
HCG-1
HCG-2
HCG-3
HCG-4
HCG-5
HCG-6
HCG-7
Hydraulic, Bulk, and Used Oil ASTs
5,000-Gallon Diesel UST Closed in Place - 1998
Former Recessed Waste Oil Tank Area (Tank and Soils Removed)
Former Heating Oil UST Closed in Place - 1986
Expanded Underground Parking Footprint
2,000-Gallon Diesel UST Removed - 1994
B-1
B-2
B-3
B-4
B1
B2
B3
B4
B6
B7
B8
B9
B10
B11
B12
B13
B14
B16
B17
B18
B19
B20
B21
B22
B23
B24
B25
B26
TPH122-22
TPH92-22
TPH25-30
TPH8505
TPH9220
TPH4045
TPH1521
TPH5922
TPH6027
TPH7065
TPH3065
Exploration Location and Number
HCE-1 Exploration
(15') Depth
MW-1 Monitoring Well
HCG-4 Geotechnical Push Probes (9/17/12)
B23 Historical Boring (Approximate Location)
Property Boundary
Proposed Underground Parking Footprint (35 Feet below Ground Surface)
Existing Adjacent Structure
Approximate Area of TPH Impacts from 0-10' Depth Range
Approximate Area of TPH Impacts from 10-20' Depth Range
Approximate Area of TPH Impacts from 20-30' Depth Range
Approximate Area of TPH Impacts from 30-40' Depth Range
Note: TPH impacts include soils with TPH concentrations above MTCA Method A cleanup levels.
0
40
80
Scale in Feet
N
Seattle Core Development Site I
Seattle, Washington
TPH Impacts in Soil
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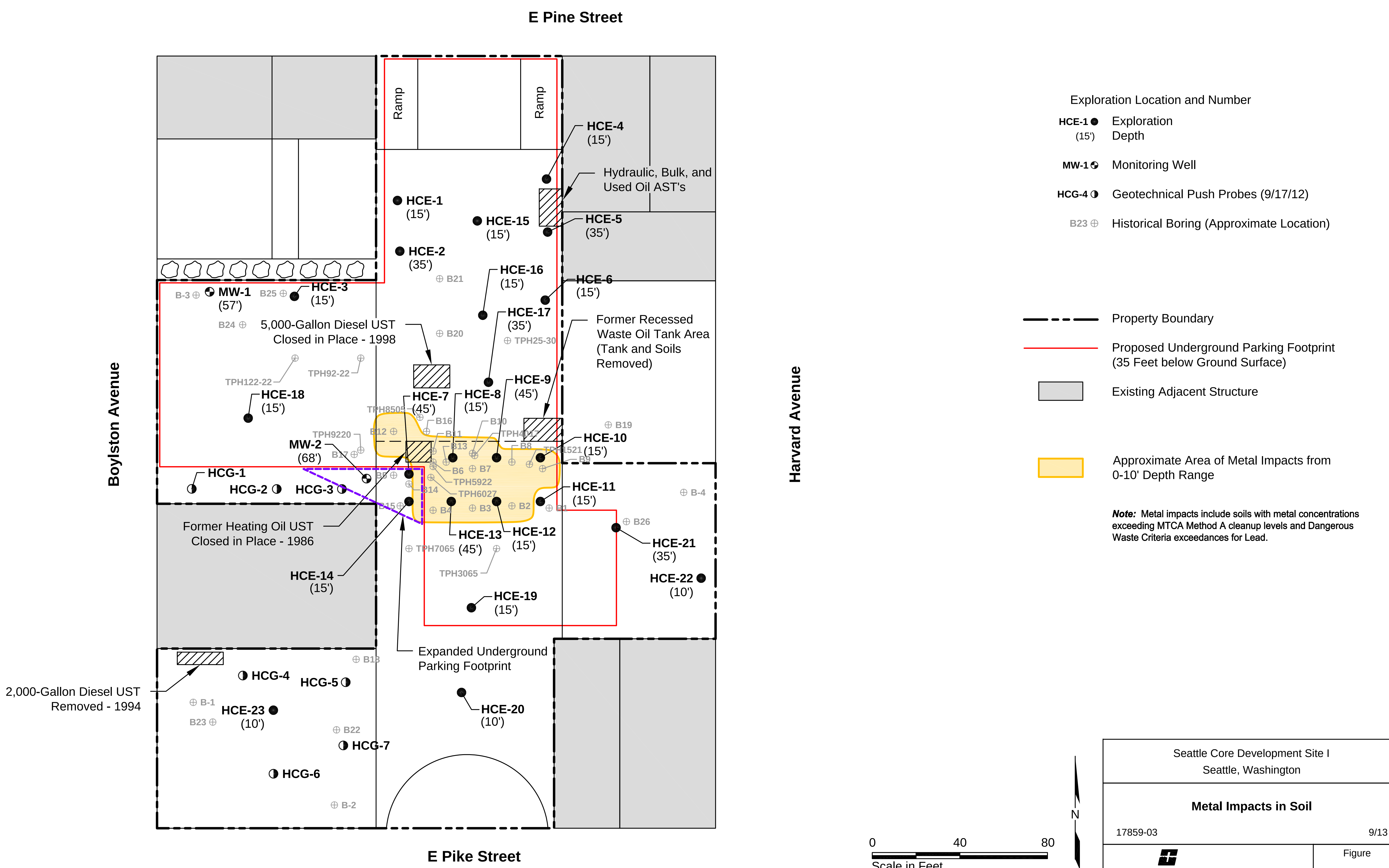
Figure
6
EAL 09/20/13 1785903-004.dwg



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Metal Impacts in Soil

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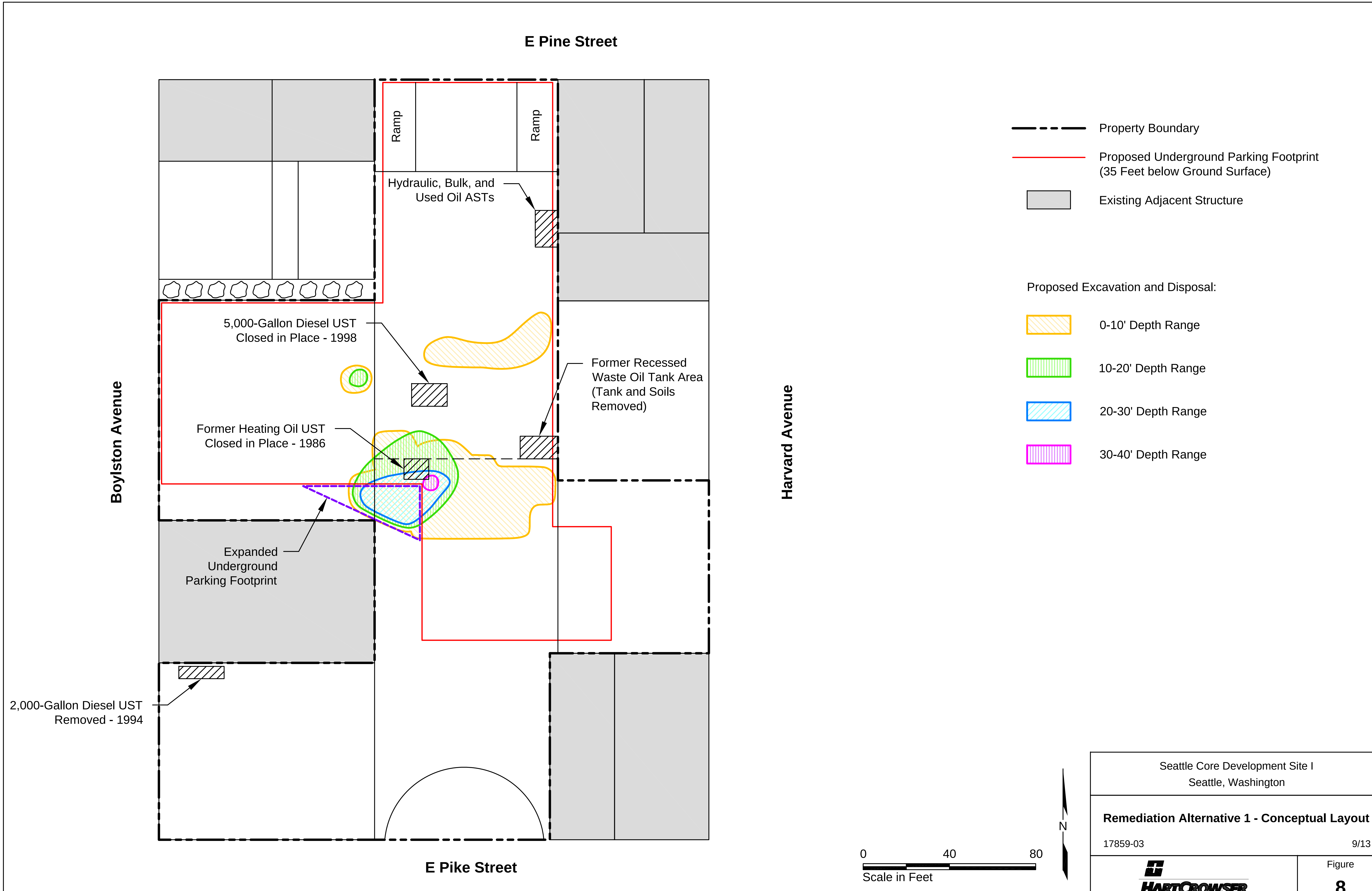
Figure 7

EAL 09/20/13 1785903-005.dwg



Seattle Core Development Site I
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Remediation Alternative 1 - Conceptual Layout

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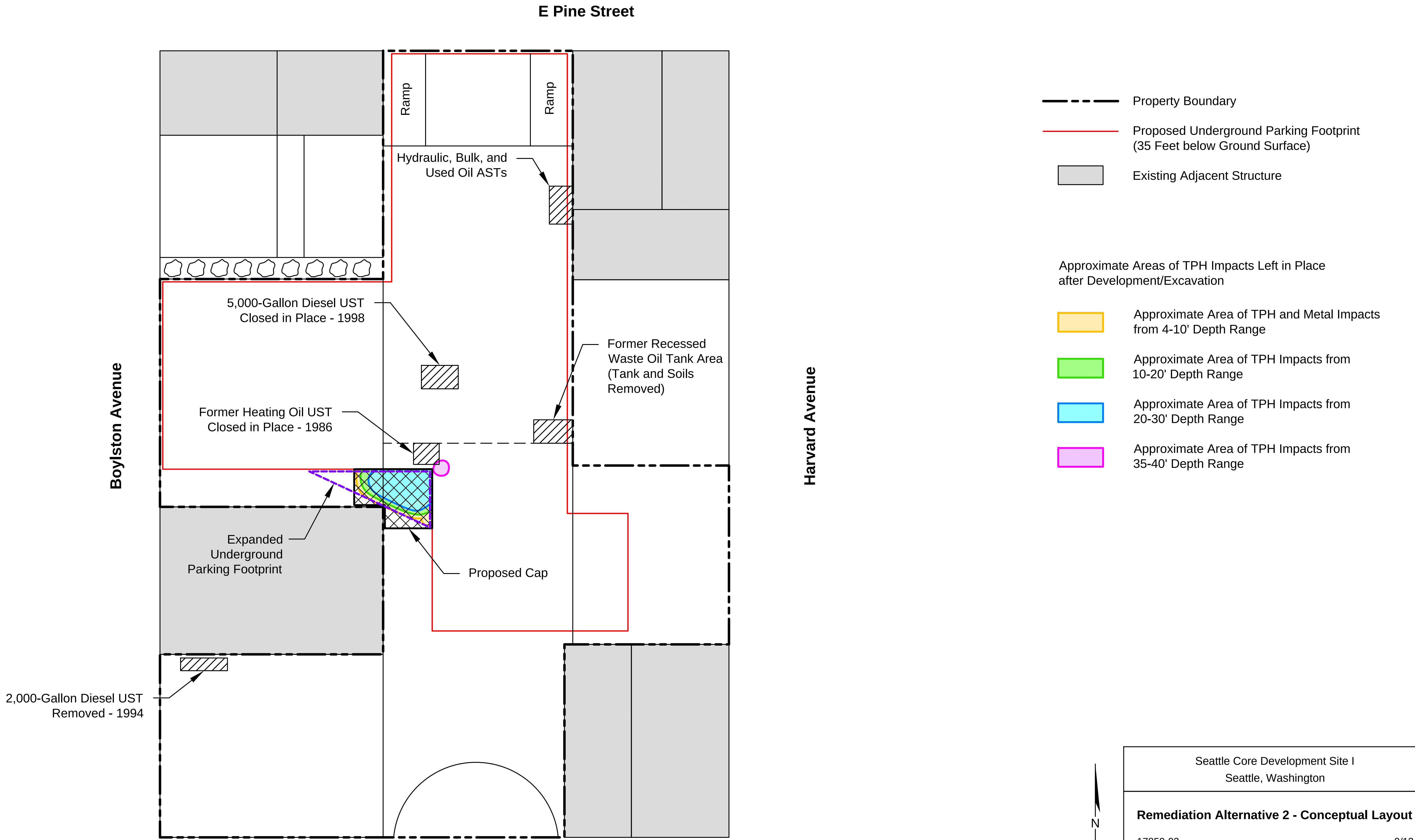
Figure 8



Seattle Core Development Site I
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Remediation Alternative 2 - Conceptual Layout

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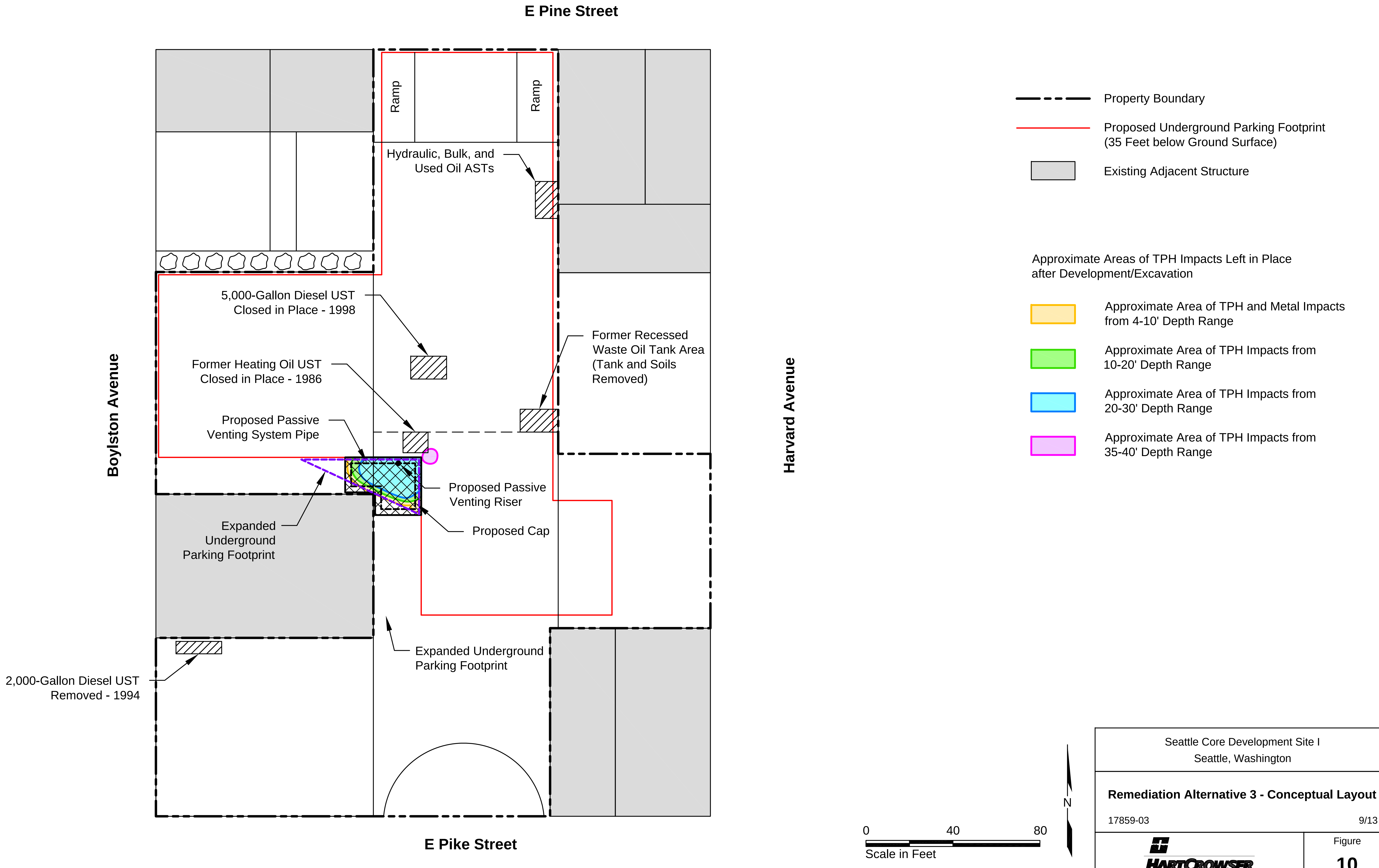
Figure 9

EAL 09/20/13 1785903-007.dwg



Seattle Core Development Site I
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Remediation Alternative 3 - Conceptual Layout

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Figure **10**

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